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The Relationship between Food Security and Blood Glucose Control in Type 2 Diabetes Mellitus among Jordanian Population: Northern Aghawar

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Abstract
Food insecurity is associated with the increased incidence of chronic diseases related to food; most notably type 2 diabetes mellitus. This study aimed to determine the effect of food insecurity on blood glucose levels in patients with type 2 diabetes mellitus. A cross-sectional study was conducted in the Northern Aghawar region of Jordan (n= 310): 55.8% male and 44.2% female. A questionnaire was used to determine the participants' socioeconomic features and food security levels. Food security indicators were adopted from World Food Program indicators. The results showed that 17.4% of the participants had food security, 25.8% had mild food insecurity, and 34.8% and 21.9% had moderate and severe food insecurity, respectively. It was found a statistical correlation between food insecurity level and the prevalence of type 2 diabetes mellitus. The results also showed a significant positive moderate correlation (r = 0.613, P = 0.000) between levels of food insecurity and the ability to control blood glucose levels and the prevalence of type 2 diabetes mellitus. Further, longitudinal studies must be conducted to assess the impact of sociodemographic features among food insecurity families on the control of blood glucose levels among participants with type 2 diabetes mellitus.

Keywords: food consumption, food security, glycemic control

Introduction

Food security is achieved when people have continuous and permanent physical, economic, and social access to nutritious food that allows them to live healthy lives [1]. Food insecurity, on the other hand, refers to the limited ability of individuals and families to obtain food in quantities and qualities that meet their needs and are socially acceptable [2]. In addition, Food insecurity is associated with a decrease in quantity and quality of food intake [3], exposing individuals to nutrient deficiency [4].

Food insecurity also forces individuals and families to consume cheap, high-energy-dense foods. As well as they change their food consumption patterns, such as overeating food when it is plentiful, becoming hungry, skipping some meals, or reducing portion sizes when it is scarce [5]; increasing the incidence of chronic diseases related to food, most notably type 2 diabetes mellitus [6]. Type 2 diabetes mellitus is one of the most common diseases in the world. According to the most recent International Diabetes Federation (2021) [7] statistics, the world's diabetic population has reached 537 million people, with more than 90% of them having type 2 diabetes mellitus, and diabetes-related deaths account for about 10% of all deaths (International Diabetes Federation, 2021) [7].

People who are food insecure are two to three times more likely to develop type 2 diabetes mellitus than people who are food secure [8] because their diets are high in refined carbohydrates, which raises the glycemic load and thus the risk of developing diabetes type 2 [9]. Moreover, food-insecure diabetic patients have high levels of glycated hemoglobin (HbAIc), making them more vulnerable to poor control of blood glucose levels [10], thus avoiding serious diabetes complications [11].

Food security and diabetes are among the twenty-first century's most fpressing global and national challenges. According to the results of a survey conducted by the Department of Statistics in collaboration with the World Food Program on Jordan's food security situation, 0.5% of Jordanians are nutritionally poor and 5.7% are vulnerable to food insecurity [12].

According to a recent International Diabetes Federation report, the prevalence of diabetes in Jordan has reached (14.2%), ranking tenth in the Arab world in the first and second types of diabetes [7]. Little is known about the association between household food insecurity access and percent of spending on food and control of blood glucose; therefore, the goal of this study was to determine the effect of food insecurity on the control of blood glucose in type 2 diabetes mellitus patients.

Material and Methods

Study Design

A cross-sectional study was conducted in the Northern Jordan Valley District from mid-November 2022 to the end of January 2023. The study protocol was approved by the Institutional Review Board of Jerash University, and the study was conducted following the Helsinki Declaration. All participants were informed of the study objectives and significance, and written consent was obtained from all participants.

According to the Ministry of Health records, the Northern Jordan Valley Health Directorate has approximately 1,370 type 2 diabetes mellitus patients; thus, the sample size was calculated using an equation [13] with a margin of error of (5%), and a total of 310 patients were recruited for the study. The inclusion criteria included patients diagnosed with type I or II diabetes mellitus, age ≥18 years, and approval to participate in the study.

Data Collection

Data were collected using a structured questionnaire based on personal interviews. The questionnaire contained socio demographic data, such as age, gender, family size, level of education, household monthly average income, and family head.

Anthropometric Measurements

Height was measured with a measuring tape to the nearest 1 cm, standing without shoes and with eyes forward (Frankfurt position), and weight was measured with a seca-type scale, approximately 100 g, standing without shoes and wearing lighter clothing. Body mass index (BMI) was measured based on the recommendations of the World Health Organization (WHO) by dividing weight (kg) by height (meters squared) [14]. Participants were classified into four groups: underweight (BMI less than 18.5 kg/m), normal weight (BMI 18.5-24.9 kg/m), overweight (BMI 25-29.9 kg/m2), and obese (BMI > 30 kg/m2).

The HbA1c test was used to assess blood sugar control, and poor blood glucose control was defined as HbA1c < 6%, which is consistent with the guidelines of the American Diabetes Association [15].

Food Security Indicator

Percentage of Spending on Food (PSF)

This indicator measures family spending on food by displaying the percentage of total income spent on food. The proportion of the total income spent on food was calculated using the following formula:

Food spending percentage = (amount of income spent on food × total income) × 100

This indicator shows that the higher the percentage of the family's total income spent on food, the more food insecure the family. The classification of food security levels was based on WFP criteria [16].

The Household Food Insecurity Access Scale (HFIAS)

This scale was used as an indicator to estimate the prevalence of food. This scale consists of nine questions that represent a generally increasing level of severity of household food insecurity (access), and nine "frequency of occurrence" questions that were asked as a follow-up to each question when the respondent answered that the condition occurred (yes) during the previous four weeks. The three response options expressed the number of times they occurred. It is rare if it occurs 1-2 times, 3-10 times, or more than 10 times in the previous four weeks. If a respondent reports that the condition described in the corresponding frequency question has not been tested, the answer is (no), and the frequency of the occurrence question is skipped [17].

HFIAS was used in this study because it provides four levels of household food insecurity, food security, moderate food insecurity, and severe food insecurity.

To assess the reliability of the questionnaire, Cronbach's alpha was calculated for the study tool variables to ensure consistency and compatibility. The Cronbach's Alpha (Cronbach's alpha) coefficient was found to be 91%, indicating that the study tool was reliable.

Results

Table 1. Shows the descriptive statistics and frequencies of the participant's socio-demographic features. The average age of the study sample participants was 50 ± 0.7 years, 38.7% were between the ages of 51- 65 years, and 9.7% were over the age of 65 years. In 84.2% of cases, the father is the family's head. While the average number of family members in the study sample was (6 ± 2), 74.8% of the families had 4-7 members. The average monthly family income in the study sample was (338 ± 10.4) dinars, with nearly half of the families (47%), earning between (261 ± 520) dinars, and 13% earning more than 520 dinars. While the average percentage of the family's monthly income spent on food was approximately 67% ± 16%. More than half of the participants (51%) had a high school degree or less. The average HbA1c test result for the study sample is (8 ± 1.4%).

Table 1: Socio demographic characteristics of the families

Variables	Percentage	
Age (years) Mean ± SD	50 ± 12	
	20 – 35	13.9%
	36 – 50	37.7%
	51 – 65	38.7%
	> 65	9.7%
Head of Household	Father	84.2%
	Mother	14.2%
	Others	1.6%

Size of the Family	6 ± 2	
	1-3	3.5%
	4-7	74.8%
	≥ 8	21.6%
Monthly Household Income (JD)	338 ± 10.4	
	< 260	39.7%
	261 – 520	47.1%
	> 520	13.2%
Percentage of total family expenditure on food	67 ± 16 %	
Level of Education	Illiterate	21.3%
	secondary school	51%
	Diploma	9.4%
	Bachelor	15.5%
	Higher education	2.9%
BMI	28.3 ± 4.2	
	18.9 – 24.9	24.2%
	25 – 29.9	45.2%
	30≥	30.6
HbA1c	8 ± 1.4%	

Data are presented as percentage, mean ± SEM
HbA1c, glycated Hemoglobin A1c; BMI, body mass index

Table 2. Shows that the majority of the families in the study sample (34.8%) are food insecure, (% 21.9) are extremely food insecure, followed by families with an average level of food security (25.8%), and food secure families makeup 17.4%.

Table 2: Household classification based on percentage of spending on food

Categories	Percentage of expenditure on food (reference)	Family food security level	Percentage
1st category	> 75%	The family is extremely food insecure	% 21.9
2nd category	65 *%* - 75%	The family is food insecure	% 34.8
3rd category	50% - 65 *%*	The family's food security is average.	% 25.8
4th category	< 50%	The family is food-secure	% 17.4

The relationship between participant socio-demographic features and percentage of spending on food was measured by multiple logistic regression analysis. About 72% of the change in the percentage of household spending on food is attributed to the age of the participant, the head of the household, the number of family members, monthly income, and educational level. Multiple regression analysis was performed in a model of dependent variables represented by the percentage of household spending on food and independent variables represented by selective socioeconomic factors. The results show that the value (R^2= 0.723; F= 158.4; P = 0.00), which means that approximately 72% of the change in the percentage of household spending on food is attributed to the participant's age, the head of the household, the number of family members, household monthly income, and educational level. It was found that the relationship between the percentage of spending on food with monthly family income, and the participant's educational level is inverse. The results also show a direct relationship between the participant's age, the head of the family, and the number of family members with the percentage of spending on food.

The results of the multiple regression model analysis are expressed as follows:

$$Y = 0.74 + 0.001X_1 + 0.025X_2 + 0.017X_3 - 0.001X_4 - 0.015X_5$$

Where Y is the percentage of spending on food (representing food security indicator), X_1: Age, $X_{2:}$ is the head of the household, $X_{3:}$ is the number of family members, $X_{4:}$ is the household monthly income, and $X_{5:}$ is participant educational level.

Table 3: Household food insecurity classification based on (HFAIS)

Category	Household food security level	Frequency	Percentage
1st category	The family is food secure	54	% 17.4
2nd category	The family is mild food insecure	80	% 25.8
3rd category	The family is moderate food insecure	108	% 34.8
4th category	The family is severe food secure	68	% 21.9

Table 4: The correlation between food security according to the HFAIS index and the prevalence of type 2 diabetes mellitus

Household food security level	Sex		p- value
	Male	Female	
The family is food-secure	74.1%	25.9%	0.001[a]
The family is mild food insecure	58.8%	41.3%	
The family is moderately food insecure	55.6%	44.4%	
The family is severely food insecure	38.2%	61.8%	

a: Correlation is significant at the 0.01 level

According to the HFIAS, 17.4% of families were food secure, 34.8% had moderate food insecurity, and 21.9% had severe food insecurity (Table 3).

The Chi-square test was used to determine the relationship between food security and the prevalence of type 2 diabetes mellitus in the study sample. Table 4 shows that 54 individuals with type 2 diabetes mellitus enjoy food security: (74.1%) are men, and (25.9%) are women. While 68 individuals with type 2 diabetes mellitus had severe food insecurity (61.8% and 38.2%) in women and men, respectively.

Table 5: The Correlation between Percentage of Spending on Food and HbA1c Levels in Participants with type 2 Diabetes Mellitus

	HbA1c	
Percentage of spending on food	Pearson Correlation	0.613**
	Sig. (2-tailed)	0.000
	F	185.6
	B	5.375

** Correlation is significant at the 0.01 level (2-tailed); HbA1c: Hemoglobin A1c

Table 5 shows the relationship between food security, as represented by the percentage of spending on food, and blood glucose control is represented by the HbA1c test. There was a significant, positive, and moderate relationship (r = 0.613, P = 0.000) between food security and HbA1c level. To demonstrate the extent of the impact of the participants' level of food security on blood glucose control, a simple regression model was used, in which HbA1c represents the dependent variable and the percentage of spending on food as an independent variable.

The results of the simple regression model analysis show the value of (F = 185.6) is high, which increases the likelihood of relying on the regression model to indicate the extent to which the dependent variable affects the independent variable. In addition, there is a significant direct positive relationship between (HbA1c%) and the percentage of spending on food, that is, any increase in the percentage of food expenditure by one unit (%), raises the results of the (HBA1C%) by 0.05375 units. The following formula can be expressed based on the results of the simple regression model analysis presented in Table (7).

$$Y = 4.360 + 5.375X$$

Where Y= (HbA1c %), X= the percentage of spending on food

Discussion

Type 2 diabetes mellitus is a major public health concern, accounting for 90% of all diabetes cases worldwide [18]. The prevalence of diabetes cases in Jordan is projected to be 20.6% by 2050 [19]. Food security and diabetes are two of the twenty-first century's most pressing global and national issues. Food security refers to the availability of physical, economic, and social access to food for all people at all times to meet nutritional needs and allow people to live safe and healthy life [20].

According to the HFIAS, more than half (56.7%) of the study sample suffered from moderate to severe food insecurity, and (25.8%) are families experiencing mild food insecurity. According to the Department of General Statistics, Jordanian families in the northern Jordan Valley region approximately 0.5% of families with food insecurity and 1.9% are vulnerable to food insecurity [12]. This is because the study community is an agricultural community with seasonal job opportunities due to the nature of agricultural production, and it has been classified as one of Jordan's poverty pockets since 2008 [21].

The study found that there is an inverse association between the percentage of spending on food, educational level, and family income. In other words, the higher the educational level of the participant, the lower the percentage of spending on food. This was attributed to the greater opportunities to obtain secure jobs and fixed income. Regarding family income, the higher the family's monthly income, the lower the percentage of food spending; thus, the family is more secure. The percentage of unemployed people in the study sample was approximately 42%. The Lack of investments and factories in this region and its impact on the availability of job opportunities all contributed to the decline in income levels, where 40% of the families' monthly income was less than 260 dinars (the minimum wage), thus affecting the level of food security in the study area. The family's low monthly income, on the other hand, forces them to spend a larger proportion of their money on food at the expense of other necessities, which reduces their food security level. Additionally, the percentage of spending on food is directly proportional to the size of the family, represented by the number of members. The greater the number of family members, the greater the requirements and needs for food and drinks, which causes an increase in the percentage of spending on food.

Furthermore, people who belong to families that suffer from food insecurity are more likely to become obese and overweight than are those who belong to families that enjoy food security. Families with food insecurity depend on their diet for carbohydrates and deficiency or insufficient nutrients and other food groups [22]. Reported that children with food insecure families were 78% more likely to be obese than children with food-secure families. Moreover, mild food insecurity was associated with the prevalence of obesity [23], and food-insecure families had a significantly lower intake of fruits and vegetables and a higher intake of added sugars than food-secure families [24, 25]. Moreover, food-insecure adolescents experience greater consumption of food of animal origin and are more likely to develop abdominal obesity [26].

According to the results, people from food-insecure families are more likely to develop type 2 diabetes mellitus than people from food-secure families. Therefore, inappropriate quality and quantity of food and lack of physical activity may contribute to weight gain and obesity, which reached 75.8% among participants. The results of our study were consistent with those of previous studies [27-29, 8].

There is a direct relationship between food security, as represented by the percentage of spending on food and the level of HbA1c, which indicates that the higher the percentage of spending on food, the higher the level of HbA1c. People who are food insecure have a lower ability to control blood glucose levels than those who are food secure. Diabetes management requires a healthy diet, and food-insecure families cannot afford it because of a lack of financial resources [30]. Moreover, adults with food insecurity were 80% more likely to have high HbA1c levels and poor glucose control [31] and they were significantly associated with poor metabolic control [10].

Conclusion and Recommendations

In conclusion, food security is associated with improved blood glucose levels. Food security must be considered a key component in assessing patients with diabetes. Therefore, supportive policies and interventions must be developed to overcome the consequences of food insecurity in patients with diabetes. Further, longitudinal studies should be conducted to determine the association between blood glucose control and other food security indicators.

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Competıng Interests

The authors declare that they have no conflict of interest in preparing the manuscript.

Authors' contribution

Baha'a M. Abu Salma: Conceptualization, data collection, methodology, data analysis, writing of the original manuscript, review, and editing. Yousef Moghrabi and Saif Elmoumani, acquisition of data, manuscript writing, and data analysis. Alanoud Elmoumani, acquisition of data and edited the original manuscript. All authors have read and approved the final version of the manuscript.

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