jcrpe-2019-0014.R2
research article
Doi: 10.4274/jcrpe.galenos.2019.2019.0014

Impact of Socioeconomic Characteristics on Metabolic Control in Children with Type One Diabetes in a Developing Country

Running title: Socioeconomic Predictors of Diabetes Outcomes

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What is already known on this topic?
Several predictors of type 1 diabetes mellitus outcomes in children were studied including socioeconomic factors, in order to understand the universal challenge of achieving adequate metabolic control despite all recent advancement in diabetes care.

What this study adds?
Our study adds to the scarce studies in developing countries, by assessing the impact of socioeconomic factors on metabolic control in children from Jordan, which would add more insight –worldwide- to the effect of these factors on achieving adequate metabolic control.

Abstract
Background: Adequate glycemic control in children with type 1 diabetes reduces the risk of future complications. Identifying factors affecting HbA1c is crucial to achieve adequate metabolic control. We aim to identify possible socioeconomic predictors of poor metabolic control in children with type 1 diabetes in Jordan; which resembles a developing country with limited resources.
Methods: Medical charts were reviewed for patients attending the pediatric endocrine clinics in two major diabetes centers. HbA1c ≥ 7.5% (58 mmol/mol) was considered as poor metabolic control. Logistic regression analysis was performed to identify predictors of poor glycemic control. Visual association between the socioeconomic characteristics and metabolic control was evaluated using multiple correspondence analysis (MCA).
Results: Two hundred and fifty-nine children were enrolled in the study, one fifth of patients (20.5%) achieved HbA1c < 7.5%. Dietary non-compliance (OR: 3.533, CI: 1.803- 6.926, p < 0.001), and being overweight (OR: 3.869, CI: 1.218- 12.294, p = 0.022) were more likely to have poor metabolic control. Children whose mothers have bachelor's degree or higher were less likely to have poor metabolic control compared to children whose mothers had only elementary education (OR: 0.241, CI: 0.079 - 0.734, p = 0.012). Multiple correspondence analysis revealed an association between low socioeconomic status and poor metabolic control. Children with deceased mothers had significantly higher HbA1c levels than any other subgroup.
Conclusion: Certain socioeconomic characteristics were associated with poor metabolic control. Identifying children with these risk factors might play an important role in optimizing metabolic control and provide better diabetes care.
Keywords: Type 1 diabetes. HbA1c. Metabolic control. Socioeconomic status. Jordan.

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Conflict of interest: None declared
Submitted: 01-Feb-2019
Accept: 14-Apr-2019

Introduction

Type 1 diabetes is associated with microvascular and macrovascular complications including diabetic retinopathy and nephropathy (1, 2). The Diabetes Control and Complications Trial (DCCT) and the Epidemiology of Diabetes Interventions and Complications (EDIC) study showed that the progression of microvascular complications can be reduced by strict glycemic control (3). Adequate glycemic control especially in the first five years of diabetes, slows the development of microvascular complications (4). These findings support the importance of maintaining low HbA1c [<7.5% (58 mmol/mol)] which is recommended by the International Society for Pediatric and Adolescent Diabetes (ISPAD) in children and adolescents (5). Achieving adequate metabolic control is a universal challenge worldwide. Identifying possible predictors of metabolic control will help in adapting appropriate strategies employed to optimize outcomes.

Socioeconomic characteristics of patients are associated with glycemic control. Low socioeconomic class, single-parent family structure, and lower parental supervision were predictors of poor metabolic control (6). Socioeconomic characteristics are variable among different communities. It is crucial to assess these factors in diabetic children in both developed and developing countries, and to examine the association between those socioeconomic characteristics and metabolic control.

The aim of this study was to identify socioeconomic determinants of metabolic control in children with type 1 diabetes in the Jordanian population, which would help in developing appropriate strategies for diabetes care and education, in addition to adapting an individualized approach to high-risk patients.

Methods

Data were collected by medical chart review of patients seen at pediatric endocrine clinics of two institutions: Jordan University Hospital (JUH) and the National Centre for Diabetes, Endocrinology and Genetics (NCDEG) from February 2012 through December 2017. The University of Jordan Research Ethics Board approval was obtained (no: 51/2014-2015). Informed consent was not required as it is a chart review retrospective study. Patients were eligible for the study if they had type 1 diabetes, age <18 years, and had at least one year of follow up. **Diagnosis of Type 1 diabetes in our cohort was made mainly based on clinical picture. Variable antibodies were positive in variable percentages, with highest positive percentage was for glutamic acid decarboxylase antibodies, followed by insulin autoantibodies (IAA) and insulinoma antigen 2 antibodies (IA2). Antibodies' status supported the diagnosis of type 1 diabetes, but diagnosis mainly was based on clinical presentation with exclusion of patients with type 2 diabetes, maturity onset diabetes of the young and neonatal diabetes.**

Body Mass Index (BMI) was used to categorize patients into two groups; normal and overweight using the Centre for Disease Control and Prevention (CDC) growth charts (7). Children with BMI values less than 85th percentile were categorized as normal, and those with BMI values equal or above the 85th percentile were categorized as overweight.

Children with HbA1c value of < 7.5% (58 mmol/mol) were considered metabolically- controlled; while those with HbA1c ≥ 7.5% were not controlled. Dietary compliance was reflected by counting carbohydrates or determining portions.

When assessing the effect of place of residence, the participants were categorized into four groups depending on the distance from both institutions since they are adjacent to each other.

The socioeconomic status was expressed in terms of: 1) paternal and maternal level of education categorized into three groups: illiterate or elementary school, high school or diploma (college) and bachelor's degree or higher (Master's degree and PhD), 2) paternal and maternal occupation was categorized into three groups: professional job, manual job and unemployed, 3) total family monthly income categorized into three groups: less than 400 Jordanian dinars (JDs), 400 – 800 JDs, and more than 800 JDs.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, N.Y., USA).

Characteristics of the patients in the two metabolic groups [Hba1c < 7.5% (58 mmol/mol) and HbA1c ≥ 7.5% were compared using Pearson Chi-Square and Fisher's exact test. Comparison of Continuous variables among groups was conducted using one-way ANOVA. Scheffe post hoc analysis was used to identify the groups that were significantly different from each other.

Possible predictors of poor metabolic control were analyzed using multiple logistic regression (forward method). Metabolic control expressed as HbA1c values categorized as a dichotomous nominal variable was considered the dependent variable.

When logistic regression analysis was conducted, children with deceased mothers and/or fathers (11 cases) were excluded from regression analysis. We removed those cases to avoid large odds ratio (more than 6 digits) with inapplicable confidence intervals, a condition known as complete separation..

Multiple correspondence analysis (MCA) was conducted to analyze the association between socioeconomic characteristics and metabolic control. MCA allows researchers to analyze the pattern of relationships of several categorical dependent variables and detect underlying structures. P values less than 0.05 were considered statistically significant.

Results

A total number of two hundred and fifty-nine children were enrolled in the study, with a mean age of 11.14 years ± 3.61. One hundred and forty participants (54.1%) were males and 119 (45.9%) were females. The mean HbA1c for patients was 8.77% ± 1.48, fifty- three participants (20.5%) had HbA1c less than 7.5%, while two hundred and six children (79.5%) had HbA1c ≥ 7.5%.

The main characteristics of participants in the two metabolic groups are shown in Table 1. There were no significant differences between the two metabolic control groups concerning gender, age at diagnosis, type of current insulin regimen and whether the child lived with both parents or with either one of them. Children who achieved their target HbA1c; had less than five siblings, normal body mass index and adequate dietary compliance.

The socioeconomic characteristics are shown in Table 2. Among those, both maternal and paternal educational levels were significantly different between the two metabolic groups. Participants in the metabolically controlled group had a higher percentage of parents with a bachelor's degree or higher. There were no significant differences between the two groups in terms of monthly income, parental job, parental age and medical condition.

The percentage of patients who experienced at least one episode of diabetic ketoacidosis, hospitalization and/ or emergency room (ER) visits due to hyperglycemia in the metabolically- controlled group was significantly different from the metabolically-uncontrolled group (0% vs 9.2% p= 0.022, 3.8% vs 17.5% p=0.012, 0% vs 9.2% p=0.022, respectively). However, hospitalization and ER visits due to hypoglycemia were not statistically different among the two groups (0% vs 2.9% p=0.209, 1.9% vs 3.4% p=0.571, respectively).

The association of the participants' socioeconomic characteristics with metabolic control was investigated by conducting logistic regression analysis using the forward method, Table 3.

Poor metabolic control was associated with dietary non-compliance, being overweight, and low maternal educational level. Participants who were overweight were three and a half times more likely to have HbA1c ≥ 7.5 % than those with normal weight. Patients with dietary non-compliance were almost four times more likely to experience poor metabolic control than those who were compliant. Participants whose mothers had a bachelor's degree or higher were less likely to have poor metabolic control than those whose mothers were illiterate or had only elementary education.

Multiple correspondence analysis was conducted to explore patterns between socioeconomic status and metabolic control. The MCA model shown in figure 1 explained 80% of total variability in the model and revealed four groups of patients. Group number 1 (G1) represented participants who were metabolically controlled (HbA1c < 7.5%), high family income (more than 800 JDs), and both parents had professional jobs with higher education level (bachelor's degree or higher). Group 2 (G2) represented participants with poor metabolic control, low-intermediate monthly family income (< 400 JDs, 400-800JDs), and both parents had manual jobs or unemployed with education level lower than bachelor's degree (no school, elementary school, high school, or diploma). Group 3 (G3) represented participants whose mothers were deceased. Finally group 4 (G4) represented participants whose fathers were deceased.

Further analysis of the group of participants whose mothers were dead (group 3) revealed that they had a significantly higher HbA1c of 10.6% ± 1.86 compared to an average of 8.7% ± 1.45 for the rest of participants (p value = 0.005). However, children whose fathers were dead had a higher HbA1c that was statistically non-significant, 9.3% ± 2.16 compared to 8.8% ± 1.46 for the rest of the children (p value = 0.523).

Discussion

The percentage of children who achieved target HbA1c (20.5%) was similar to number of studies done in developed countries (8, 9). Gender in our study was not associated with metabolic control, evidence from studies concerning gender is conflicting (10, 11, 12). Longer duration of diabetes was found to be associated with poor metabolic control similar to previous studies (13).

In our study, the multiple correspondence analysis model revealed an association between low socioeconomic status and poor metabolic control, which was also demonstrated in several studies (8, 14-16). This effect even persists through adulthood where in adults, exposure to low socioeconomic status increased mortality risk in patients with childhood-onset type 1 diabetes (17).

Poor metabolic control was associated with number of siblings exceeding four; which may be attributed to reduced attention and care that was provided to the child by the parents in presence of many siblings, as had been previously reported (18).

The rate of hypoglycemia was not significantly different in both the controlled and the uncontrolled metabolic groups, while the rate of hyperglycemia was significantly higher in the metabolically uncontrolled group, similar results were shown in another study (19). These results show that fear of hypoglycemia should not prevent families from achieving metabolic control for their children (20).

Monthly income was not significant in predicting metabolic control, unlike results in other studies that found a negative linear association between income and metabolic control (16, 21, 22). This association may be attributed to the fact that lower-income households rarely contact a primary care provider when facing a diabetes-related problem (23). However, in our study this lack of association between income and metabolic control can be explained by the fact that most of the children seen in the two institutions involved in the study were covered by insurance and had access to the same adequate diabetes care provided by specialized pediatric endocrinologists regardless of the level of income. Distance between patient's residence and the 2 adjacent diabetes centers, was not significantly related to metabolic control, probably due to the fact that 50% of our cohort live in the same city and 86% of patients live within less than 70 kilometers from the diabetes centers. In addition to the relatively easily accessible location to both personal and public transport (11).

One of the socioeconomic characteristics predicting metabolic control in our study was parental educational level. The higher the maternal and paternal education the better the metabolic control. Paternal educational level in studies like those from Italy and Saudi Arabia (8,24), has no effect on metabolic control. In our study the caregiver responsible for most of the diabetes care was the patient's mother even in the families where the patient lives with both parents (92 % of our cohort). This is understandable since mothers are usually the primary caregivers coordinating efforts and medical recommendations provided by the members of the medical team. Improving mother's knowledge and targeting those with lower educational level may improve glycemic control in this subgroup of children.

Study Limitations:

Our study was a retrospective study which mainly relied on information present in the medical records. **One of the limitations of our study is that pubertal status was not collected from the medical charts.** Another important limitation is the fact that the study involved patients registered in two centers in the capital city, despite both are major referral centers from different cities in Jordan, but still a prospective more comprehensive study involving different geographical areas with possible different socioeconomic determinants of metabolic control would help to explain the health inequalities that might exist in a society despite the presence of the same policy of medical care. It is important to evaluate the effect of socioeconomic factors in both developed and developing countries to explain the universal challenge of achieving adequate metabolic control despite all the recent advancement in the field of diabetes care.

Conclusion

Early metabolic control is essential in preventing future complications of type one diabetes. Identifying predictors of poor metabolic control might help in improving clinical care provided for patients.

Some predictors of poor glycemic control are modifiable, such as dietary non-compliance and being overweight, which can be controlled to improve glycemic control. Other predictors such as low maternal education level is non-modifiable, but these factors help in identifying those children and adolescents with type 1 diabetes at high risk of poor metabolic control. This group of children needs individualized care plans to ensure that target HbA1c levels are achieved. Children, whose mothers are dead, probably require special attention since they are at high risk of poor glycemic control. Engaging their caregivers and providing comprehensive education concerning the diabetic children care plans is of great importance. These children might also need early, intensive and more frequent education and training on personal insulin requirements and administration since they lack maternal guidance and care.

Acknowledgments: Researchers are grateful to the Scientific Research Fund / University of Jordan for providing the research grant.

Ethics

Ethics Committee Approval: The University of Jordan Research Ethics Board approval was obtained (no: 51/2014-2015).

Informed consent was not required as it is a chart review retrospective study.

Authorship Contributions

Concept: Abeer Alassaf, Rasha Odeh, Kamel Ajlouni.

Design: Abeer Alassaf, Rasha Odeh.

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Conflict of Interest: No conflict of interest

Financial Disclosure: Research grant from the Scientific Research Deanship of the University of Jordan.

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Table 1. Characteristics of participants in the two metabolic control groups (N=259)

	HbA1c		
Participant's characteristics	**< 7.5% (N=53)**	**≥ 7.5% (N=206)**	**P value**
Gender (female)	25 (47.2%)	94 (45.6%)	0.841
Current age (years)			0.053
1 - 5	5 (9.4%)	13 (6.3%)	
>5 - 10	22 (41.5%)	62 (30.1%)	
>10 - 15	24 (45.3%)	95 (46.1%)	
≥15	2 (3.8%)	36 (17.5%)	
Current insulin regimen			0.745
Multiple dose injection	34 (64.2%)	140 (68.0%)	
Triple dose injection	19 (35.8%)	65 (31.6%)	
Pump	0 (0%)	1 (0.5%)	
Number of siblings			0.036
≤ 4	43 (81.1%)	135 (65.5%)	
> 4	10 (18.9%)	71 (34.5%)	
Duration of diabetes (years)			0.001
≤5	52 (98.1%)	16 (79.1%)	
>5	1 (1.9%)	43 (20.9%)	
Count carbohydrates			
Yes	30 (56.6%)	57 (28.2%)	< 0.001
Living arrangements			0.703
Lives with both parents	50 (94.3%)	189 (91.7%)	
Lives with the mother	1 (1.9%)	9 (4.4%)	
Lives with the father	2 (3.8%)	8 (3.9%)	
Distance from the two institutions (kilometers)			0.765
Amman (city where the 2 institutions are situated)	33 (62.3%)	125 (60.7%)	
Less than 70 kilometers from Amman	14 (26.4%)	51 (24.8%)	
71- 185 kilometers from Amman	6 (11.3%)	26 (12.6%)	
More than 185 kilometers from Amman	0 (0%)	4 (1.9%)	
Type of insurance			
Ministry of health and University of Jordan (90% coverage)	17 (32.1%)	41 (19.9%)	0.088
Royal court (100 % coverage)	35 (66.0%)	146 (79.6%)	
Private (no coverage)	1 (1.9%)	1 (0.5%)	

Table 2. Parental characteristics of participants in the two metabolic control groups (N=248, 11 children with deceased father or/and mother were excluded)

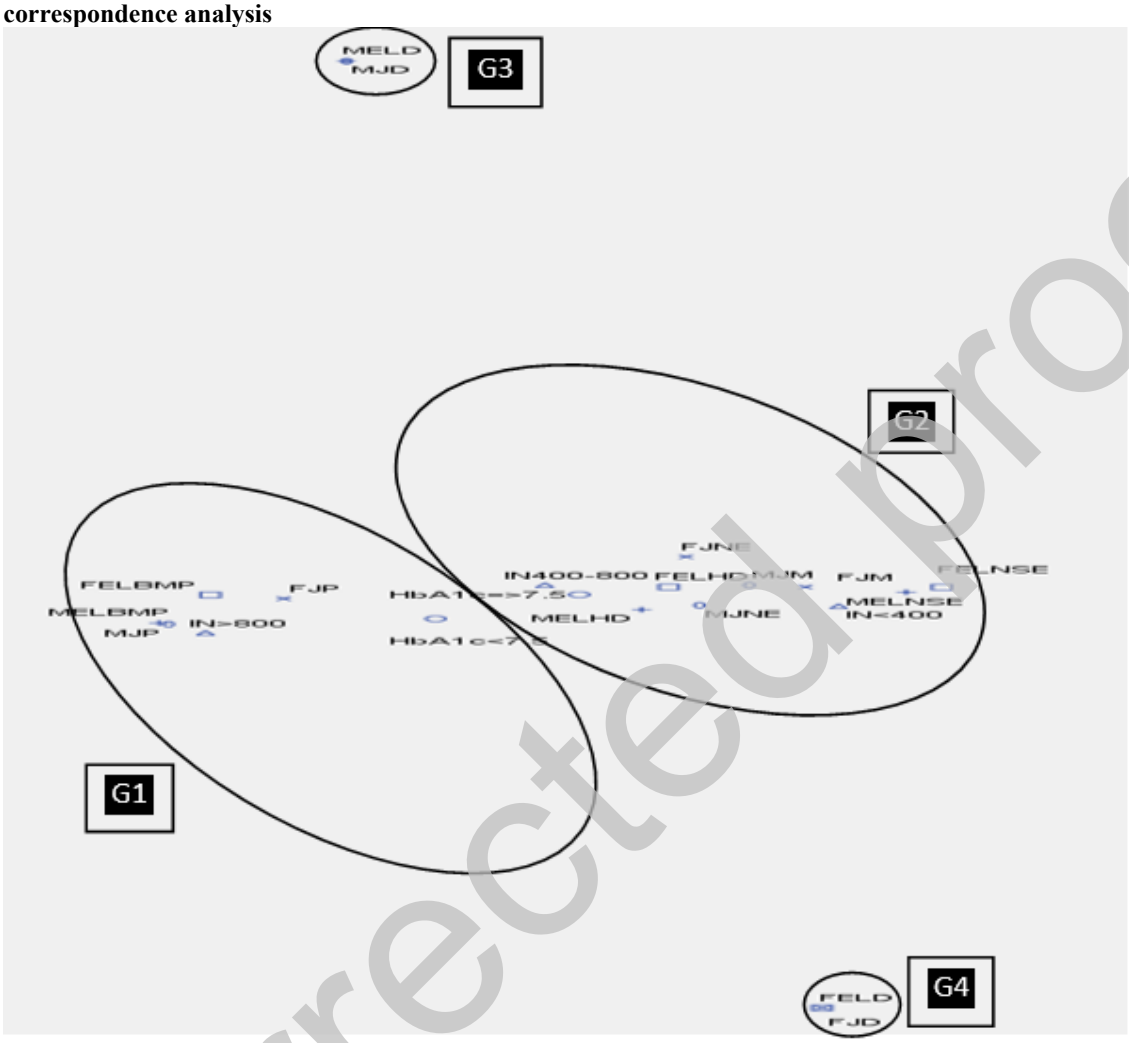
	HbA1c		
	< 7.5% (N=52)	**≥ 7.5% (N=196)**	**P value**
Consanguineous parents (yes)	8 (15.4%)	24 (12.2%)	0.548
Paternal age			0.210
<50 years	42 (80.8%)	137 (69.9%)	
≥50 years	10 (19.2%)	59 (30.1%)	
Paternal medical condition			0.356
Medically free	48 (90.6%)	177 (85.9%)	
At least one medical condition	4 (7.7%)	24 (12.2%)	
Paternal occupation			0.272
Professional	30 (57.7%)	89 (54.4%)	
Manual	19 (36.5%)	89 (45.4%)	
Non-employed	3 (5.8%)	18 (9.2%)	
Paternal education level			0.029
No school or elementary school	2 (3.8%)	33 (16.8%)	
High school or diploma	15 (28.8%)	63 (32.1%)	
Bachelor's degree or higher	35 (67.3%)	100 (51%)	
Maternal age			0.111
< 45 years	40 (76.9%)	128 (65.3%)	
≥ 45 years	12 (23.1%)	68 (34.7%)	
Maternal medical condition			0.658
Medically free	48 (92.3%)	177 (90.3%)	
At least one medical condition	4 (7.7%)	19 (9.7%)	
Maternal occupation			0.960
Professional	15 (28.8%)	54 (27.6%)	
Manual	1 (1.9%)	3 (1.5%)	
Non-employed	36 (69.2%)	139 (70.9%)	
Maternal education level			0.046
No school or elementary school	5 (9.6%)	43 (21.9%)	
High school, or diploma	26 (50.0%)	102 (52.0%)	
Bachelor's degree or higher	21 (40.4%)	51 (26.0%)	
Family monthly income in Jordanian dinars (JDs)			0.199
<400	8 (15.4%)	48 (24.5%)	
400-800	36 (69.2%)	109 (55.6%)	
>800	8 (15.4%)	39 (19.9%)	

Table 3. Logistic regression analysis of possible predictors of poor metabolic control (N=248, 11 children with diseased father or/and mother were excluded)

	Simple logistic regression				Multiple logistic regression			
	B¥	**OR$^{\Delta}$**	**CI (95%)**	**P value**	**B¥**	**OR$^{\text{ʊ}}$**	**CI (95%)**	**P value**
Gender (female)	-0.107	0.898	0.487- 1.657	0.731				
Current age (years)				0.117				
1 – 5 $^{\infty}$								
>5 - 10	0.094	1.099	0.350 - 3.453	0.872				
>10 - 15	0.344	1.410	0.457 - 4.348	0.550				
≥15	1.907	6.731	1.159 - 39.085	0.034				
Paternal job				0.227				
Professional $^{\infty}$								
Manual	0.457	1.579	0.828 - 3.011	0.165				
Not employed	0.704	2.022	0.557 - 7.350	0.285				
Paternal education level				0.092				
No school or elementary school $^{\infty}$								
High school, or diploma	-1.596	0.203	0.046 - 0.896	0.035				
Bachelor's degree or higher	-1.658	0.190	0.042 - 0.862	0.031				
Maternal job				0.961				
Professional $^{\infty}$								
Manual	-0.182	0.833	0.081 - 8.602	0.878				
Not employed	0.070	1.073	0.544 - 2.116	0.840				
Maternal education level				0.054				0.043
No school or elementary school $^{\infty}$								
High school, or diploma	-0.785	0.456	0.164 - 1.267	0.132	-1.014	0.363	0.124-1.064	0.065
Bachelor's degree or higher	-1.264	0.282	0.098 - 0.812	0.019	-1.423	0.241	0.079 - 0.734	0.012
Count carbohydrate portions								
Yes $^{\infty}$								
No	1.248	3.485	1.849 - 6.568	< 0.001	1.262	3.533	1.803-6.926	< 0.001
Body mass index								
Normal $^{\infty}$								
Overweight	1.027	2.792	0.947 - 8.230	0.063	1.353	3.869	1.218-12.294	0.022

$^{\infty}$ = Reference group, ¥: regression coefficient, Δ: Unadjusted odds ratio, ʊ = Adjusted odd ratio

Figure 1. Association between socioeconomic factors and metabolic control in multiple correspondence analysis



0 MJP = Mother's job - professional	+ MELNSE = Mother's education level – no school or elementary school
0 MJM = Mother's job – manual	+ MHELHD= Mother's education level – high school or diploma
0 MJNE = Mother's job - not employed	+ MELBMP = Mother's education level – bachelor's degree or higher
0 MJD = Mother's job – dead	+ MELD = **Mo**ther's education level - dead
X FJP = Father's job – professional	□ FELNSE = Father's education level – no school or elementary school
X FJM = Father's job – manual	□ FHELHD= Father's education level – high school or diploma
X FJNE = Father's job - not employed	□ FELBMP = Father's education level – bachelor's degree or higher
X FJD = Father's job – dead	□ FELD = Father's education level - dead
O HbA1c < 7.5	Δ IN < 400 = Monthly income < 400 Jordanian Dinars
O HbA1c ≥ 7.5	Δ IN 400-800 = Monthly income 400-800 Jordanian Dinars
	Δ IN > 800 = Monthly income > 800 Jordanian Dinars
G1	**Group 1 with HbA1c < 7.5, family income > 800 JDs, both parents had professional jobs and bachelor's degree or higher educational level.**
G2	**Group 2 with HbA1c ≥ 7.5, family income < 800 JDs, both parents had manual jobs or unemployed with educational level of diploma or less.**
G3	**Group 3 with deceased mothers.**
G4	**Group 4 with deceased fathers.**