

Hierarchical clusters in families with type 2 diabetes

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Abstract

Families represent more than a set of individuals; family is more than a sum of its individual members. With this classification, nurses can identify the family health-illness beliefs obey family as a unit concept, and plan family inclusion into the type 2 diabetes treatment, whom is not considered in public policy, despite families share diet, exercise, and self-monitoring with a member who suffers type 2 diabetes. The aim of this study was to determine whether the characteristics, functionality, routines, and family and individual health in type 2 diabetes describes the differences and similarities between families to consider them as a unit. We performed an exploratory, descriptive hierarchical cluster analysis of 61 families using three instruments and a questionnaire, in addition to weight, height, body fat percentage, hemoglobin A1c, total cholesterol, triglycerides, low-density lipoprotein and high-density lipoprotein. The analysis produced three groups of families. Wilk's lambda demonstrated statistically significant differences provided by age ($F=0.778$, $F=2.098$, $p=0.010$) and family health ($\Lambda=0.813$, $F=2.650$, $p=0.023$). A post hoc Tukey test coincided with the three subsets. Families with type 2 diabetes have common elements that make them similar, while sharing differences that make them unique.

Keywords

Family as a unit, family health, family characteristics, family medicine, family composition

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Introduction

Diabetes is the second leading cause of death in México.¹ Of the total deaths, 28.71% are attributed to this disease.² Between 2000 and 2006, the prevalence of type 2 diabetes (T2D) doubled from 7.5% to 14.4%. Lately, the prevalence indicates that 7.3 million Mexicans suffer from this disease; of these, only 5.3% have good glycemic control (a glycated hemoglobin A1c (HbA1c) < 7%).³⁻⁵

Standard treatment for T2D includes diet, exercise, drugs, ongoing medical care, education, and self-monitoring of disease progression according to the Mexican Official Standard for the prevention, treatment and control of diabetes (NOM-015-SSA2-2010).⁶ This implies that the individual is responsible for his/her care, which eventually will make it easier for them to manage their disease.⁷ An HbA1c level below 7% indicates good glycemic control according to the American Diabetes Association (ADA)³ and contributes to the delay or prevention of microvascular and macrovascular complications including cardiovascular, cerebrovascular disease, retinopathy, neuropathy and nephropathy.

Experience shows that meeting this expectation means that patients need their families to successfully manage the disease because its management is complex and goes beyond glycemic control; however, inclusion of the family is not considered in the treatment of T2D—not in ADA³ nor NOM-015-SSA2-2010.⁶ Healthcare organizations continuously

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encourage the individual to make lifestyle changes ignoring the complex context associated with family life. So the family is the closest social context affected by T2D when one of its members suffers the disease.⁸ Because behavioral patterns are acquired and shared with the family, it is possible that some aspects such as diet, physical activity or monitoring disease progression, impact family routines and eventually family health.^{9,10}

For Marcellus,⁸ the study of families represents a methodological challenge that studies in individuals do not have. Family researchers try to ensure that the unit of analysis reflects the family as such, in other words, they try to correctly choose the family member who will answer the study questions.^{11,12} In addition, researchers face the difficulty of deciding on a statistical method that can analyze data from multiple family members simultaneously, especially when a single family variable is explored,^{13–15} both were opportunity areas to develop in this study.

The Pan American Health Organization (PAHO)¹⁶ mentions that the approach to studying the family resides in interpersonal relationships more than isolated individuals. The PAHO defines family health as “the adjustment or balance between internal and external elements of the family group.” The ability to accentuate this definition has generated studies with a functionalist approach and of the ability of the family to adapt or overcome the health crisis in one of its members,^{13,14,16,17} a task that is usually accomplished with family therapy.

The study of the family has been linked to care from a nursing perspective. In this, the family persists beyond living at home. Here, the family is seen as an integrated unit or as the object of care.¹⁸ Family theories postulate the family as the unit of care or analysis (clinical, practice or research); however, in practice the individual or some of its members are approached. This causes a loss of perspective of the family as a whole. Therefore, the focus of a family as the unit of analysis is disrupted; however, there is very preliminary data from theoretical and methodological approaches that approximate the family as a unit and its health as a dimension that impacts individual health.¹⁹

The Family Health Model (FHM),²⁰ selected as the theoretical basis for this research, was built from a perspective of nursing, asserting that family health responds to a process of social construction, whose inputs are from the context, role and structure of the family. This model addresses family health in a way that is positive, healthy and inclusive of the family group as a whole, considering it as a unit of analysis.

The FHM argues family health is a collective experience that affects the health of the family member suffering from T2D. For Åstedt-Kurki et al.,²¹ values, feelings of comfort or discomfort, knowledge regarding the condition of the member who suffers T2D, and everyday experiences and activities in health, can form the concept of family health at an abstract level. Family functionality is the process developed by family members to interact with each other. These processes include

those aimed at maintaining or restoring the health of sick members as in the case of T2D. It also includes those established outside the family, its organization and the interactions that strengthen the family. Family health routines in T2D are behaviors that the family regularly performs in order to help prevent the progression of disease. The concept of routine, according to Zisberg et al.,²² is attributed to concise patterns used to coordinate activities with respect to timing, duration, social and physical context, sequence and order. Routines emerge as a family strategy due to the need in general to adapt or face any changes or stressful situations. Individual health in T2D is the result of the dynamics that exist between self-perception of general health and the metabolic variables that are altered in T2D. Individual health is combined with family health since it shares common elements with all family members and with the processes of interaction in health.

For González-Benítez,²³ individual health is developed in the context of a family with the formation of habits, lifestyles, value systems, norms, attitudes and behaviors toward health. With these elements, both the biological and psychosocial health of each member of the family is built. Family health problems exert their influence on the health of the member with T2D, determining it through healthy practices. A healthy family life promotes the health of the project, while an unhealthy way of family life can sicken family members.

Purpose

The purpose of this study was to investigate whether the family characteristics, functionality, routines, and family and individual health, describes the differences and similarities between families with T2D to consider them as a unit.

Materials and methods

We used a descriptive, exploratory design.²⁴ The population of interest were families with two to five members living in Nuevo León, México urban area with at least one adult member between 18 and 65 years old suffering from T2D, supplementing his/her medical treatment on an outpatient basis. The population was a convenience sample of 61 families, so 222 of its members. Sample size was calculated using nQuery Advisor 4.0, with a significance level of 0.05, an effect of 0.40 and a power of 90%.

Participants were recruited by telephone and the availability of the participant with T2D and his family was investigated; appointments were scheduled for filling out instruments and taking anthropometric and biochemical measurements with prior informed consent. Multivariate statistical analysis was made by hierarchical clusters and Wilk's lambda distribution as a discriminant analysis. A post hoc Tukey test was used in order to confirm the number of clusters previously selected.

This research adhered to current legal provisions concerning research,²⁵ Regulations of the Mexican General Law of

Health in Research Matters, and was previously approved by the ethics and biosafety committees (Comisión Federal para la Protección contra Riesgos Sanitarios (COFEPRIS) registered number: 123301538X0071/2/3).

Biochemical measurements were performed only on the individual or family members diagnosed with T2D. The determination of HbA1c and lipid profile (total cholesterol, triglycerides, low-density lipoprotein (LDL) and high-density lipoprotein (HDL)) was included. Based on these results, participants were classified according to ADA³ criteria for HbA1c ($\leq 7\%$ controlled) and the criteria established by the Adult Treatment Panel III (ATP III)²⁶ for lipids.

The FAFHES Instrument by Åstedt-Kurki et al.²¹ was used to measure family functioning and family health. Cronbach's alpha for this sample was 0.88 and 0.79, respectively. To measure family health routines, the scale by Kanjanawetang et al.²⁷ was used, which presents a Cronbach's alpha of 0.63. The 12-Item Short-Form Health Survey (SF-12) developed by Ware et al.²⁸ was used to measure the perception of the individual health, the entire instrument has a Cronbach's alpha of 0.73. The instruments had good internal reliability by principal component analysis with varimax rotation. Back translation technique English-Spanish, and cultural adequacy was used in each Likert response scale. For purposes of this study, each instrument was transformed to values ranging from 1 to 100, in order to facilitate interpretation of the data.

Results

The sample consisted of 222 participants from 61 families. Of these, 58.1% (n=129) were women. The mean age of participants was 43 (standard deviation (SD)=6.2) years. Mean education level was 11.5 (SD=3.1) years. Of the respondents, 54.1% (n=120) were employed and 39.2% (n=87) reported being unemployed. Regarding the use of health services, 65.3% (n=145) reported attending social security institutions. Of the 61 families recruited, the majority were nuclear with four members (19 families) (Table 1). Each family had at least one member with T2D.

The family member with T2D (proband) from which the other members were recruited constituted 27.5% (n=61) of the population; from among the family, the greatest participation occurred in the sons of the proband in 32.9% (n=73), the rest were consanguineous as well as relatives-in-law.

Of the 222 participants, 36% (n=80) suffered T2D (proband and family members). Mean time since diagnosis was 8.8 (SD=7.4) years, and being on medical treatment 7 (SD=7.2) years. The presence of a heart condition was reported in 13.7% (n=11).

Anthropometric measurements were obtained in 86.93% (n=193) and biochemical measurements in 35.5% (n=79). Only 19.2% (n=37) of the participants had normal weight parameters. Of the 79 subjects for whom biochemical measurements were performed, 73.4% (n=58) had HbA1c levels

Table 1. Type and number of family members.

Family	Number of members				Total (%)
	2	3	4	5	
Monoparental	0	3	2	0	5 (8.4)
Nuclear	3	8	19	0	30 (49.1)
Amplified	0	7	16	3	26 (42.5)
Total (%)	3 (4.9)	18 (29.5)	37 (60.7)	3 (4.9)	61 (100)

Classification of family based on INEGI.

Table 2. Description of family characteristics, functionality, routines, and family and individual health in T2D.

Variable	M	Mdn	SD	Min	Max
Family characteristics					
Age	43.32	42.50	6.26	32.50	61.50
Formal education	11.51	11.33	3.11	5.33	18.33
Family functionality					
Family functionality	76.08	75.00	9.32	41.40	95.26
Family health routines					
Family health routines	69.14	69.14	3.13	62.54	75.95
Family health					
Family health	75.42	76.52	6.72	50.72	92.17
Individual health					
HbA1c	8.62	8.30	2.40	4.70	14.00
Triglycerides	223.66	179.0	148.33	12.00	888.00
Total cholesterol	178.10	184.66	39.97	21.00	252.00
HDL	44.81	42.00	10.52	31.00	81.00
LDL	98.31	99.66	28.93	15.00	158.00

T2D: type 2 diabetes; M: mean; Mdn: median; SD: standard deviation; Min: minimum; Max: maximum; HbA1c: glycated hemoglobin A1c; HDL: high-density lipoprotein; LDL: low-density lipoprotein.
n=61 families.

greater than 7%, above the level recommended by the ADA.³ Of the participants, 65.8% (n=52) had desirable total cholesterol levels; high triglycerides occurred in 34.2% (n=27). Optimal LDL levels were present in 44.3% (n=45) and in 46.8% (n=37) participants had poor control of HDL, using the ATP III²⁶ as a reference.

In order to have household data, means were determined prior to multivariate analysis by 61 families, obtaining values greater than 69 points (range: 0–100) for the general scales of family functioning, routines and family health, in contrast to individual health status (Table 2).

The multivariate analysis of hierarchical clusters was performed to outline the differences and similarities between the families in the study, to define their structure and then place them in groups. This technique of interdependence agglomerates each case and combines clusters into a different one until there is just one. Its primary purpose is to group families with a high degree of internal homogeneity (within the cluster) and a high external heterogeneity (between clusters).

First, each family was classified based on the relationships provided by age, formal education, family health, functionality, routines, individual health status, HbA1c, triglycerides, total cholesterol, HDL and LDL. The method used to

Table 3. Family characteristics that determined clusters.

Variable		M	SD	SE	95% CI		Min	Max
					LL	UL		
Age	First cluster	38.21	2.06	1.46	19.68	56.74	36.75	39.67
	Second cluster	45.12	5.94	2.24	39.63	50.61	39.00	57.33
	Third cluster	43.28	6.36	0.88	41.51	45.05	32.50	61.50
Formal education	First cluster	8.52	1.44	1.02	4.40	21.43	7.50	9.53
	Second cluster	12.37	2.73	1.03	9.84	14.90	9.00	16.67
	Third cluster	11.52	3.17	0.44	10.64	12.40	5.33	18.33

M: mean; SD: standard deviation; SE: standard error; CI: confidence interval; LL: lower limit; UL: Upper limit; Min: minimum; Max: maximum. n = 61 families; first cluster = 2 families, second cluster = 7 families, third cluster = 52 families.

Table 4. Description of family health, functionality and routines that determined the clusters.

Variable		M	SD	SE	95% CI		Min	Max
					LL	UL		
Family health	First cluster	78.80	0.46	0.33	74.66	82.95	78.48	79.13
	Second cluster	77.03	6.85	2.59	70.70	83.36	67.61	86.52
	Third cluster	75.08	6.83	0.95	73.17	76.98	50.72	92.17
Family functionality	First cluster	82.28	2.73	1.93	57.76	100.00	80.35	84.21
	Second cluster	76.04	11.62	4.39	65.29	86.79	60.00	89.74
	Third cluster	75.86	9.20	1.28	73.29	78.42	41.40	95.26
Family health routines	First cluster	70.28	0.62	0.44	64.73	75.82	69.84	70.71
	Second cluster	69.72	4.07	1.54	65.95	73.49	62.86	75.83
	Third cluster	69.02	3.08	0.43	68.16	69.88	62.54	75.95

M: mean; SD: standard deviation; SE: standard error; CI: confidence interval; LL: lower limit; UL: Upper limit; Min: minimum; Max: maximum. n = 61 families; first cluster = 2 families, second cluster = 7 families, third cluster = 52 families.

compare the relationship of these variables was by measuring proximity in a multidimensional space, such that the squared Euclidean distance indicated the similarity of families.

Then, the clusters were formed through a hierarchical procedure. For this, families that were closest or similar to each other—in terms of Euclidean distance—were sought and grouped in a cluster. The resulting cluster is indivisible from that moment on, which gives it a hierarchical status. At each stage, individual cases, preformed clusters (because they were merged into a single case in earlier stages), or an individual case with a previously formed cluster, can be grouped. In this way, large and increasingly heterogeneous clusters are grouped, until the last stage where all the elements are grouped into a single global cluster consisting of all families in the sample. This allowed us to appreciate the heterogeneity of clusters and how they melt into each stage of the analysis. The relatively large jumps in Euclidean distance in the clustering history helped identify the existence of three natural homogeneous groups.

Cohesion of the three clusters was considered: the first, consisting of 2 families (3.3%), the second of 7 families (11.5%) and the third of 52 families (85.2%). Then, the interdependent relationships of the clusters were described for each item studied. A description of the family characteristics

of age and formal education, which reached the highest means in the second cluster, is shown in Table 3. In Table 4, we can see that the first cluster scored the highest means in the scales of family health, functionality and routines. The highest means of health perception, triglycerides and total cholesterol were observed in the first cluster; in the second cluster, the highest means were HbA1c, HDL and LDL (Table 5).

The dendrogram in Figure 1 represents the 60 possible combinations of the 12 variables considered in the hierarchical cluster analysis. The graph shows the distance of each family when melted into each stage. Fusions occur on the left—near to the origin of the scale—indicating that the cluster formed is homogeneous. Conversely, fusions that occur at the end of the scale—right—indicate that the cluster is quite heterogeneous. You can follow the dendrogram from right to left and place your attention where the vertical lines join the origin of the short strokes (centroid). After that you just need to follow the horizontal line to the left to identify the families that compose each cluster.

Discriminant analysis was used to classify families considering the variables that best characterize them and differentiate the groups. These variables represent linear combinations and are expressed by discriminant function. Wilk's lambda distribution

Table 5. Description of individual health indicators in T2D that determined the clusters.

Variable		M	SD	SE	95% CI		Min	Max
					LL	UL		
Individual health	First cluster	37.37	5.71	4.04	0.00	88.71	33.33	41.41
	Second cluster	32.25	5.11	1.93	27.53	36.97	26.26	39.39
	Third cluster	34.38	6.60	0.91	32.54	36.21	19.7	52.27
HbA1c	First cluster	7.85	0.92	0.65	0.00	16.11	7.20	8.50
	Second cluster	9.22	1.92	0.72	7.45	10.99	7.40	12.90
	Third cluster	8.55	2.53	0.35	7.84	9.26	4.70	14.00
Triglycerides	First cluster	386.50	146.37	103.50	0.00	1701.59	283.00	490.00
	Second cluster	240.21	213.22	80.59	43.02	437.41	85.00	706.00
	Third cluster	215.52	139.06	19.47	176.40	254.63	12.00	888.00
Total cholesterol	First cluster	190.50	53.03	37.50	0.00	666.98	153.00	228.00
	Second cluster	177.14	74.19	28.04	108.53	245.76	21.00	252.00
	Third cluster	178.55	34.09	4.77	168.97	188.14	21.00	237.5
HDL	First cluster	38.00	2.83	2.00	12.59	63.41	36.00	40.00
	Second cluster	53.57	13.46	5.09	41.12	66.02	41.00	81.00
	Third cluster	43.99	9.87	1.38	41.22	46.77	31.00	73.00
LDL	First cluster	75.00	84.85	60.00	0.00	837.37	15.00	135.00
	Second cluster	119.00	31.82	12.03	89.57	148.43	60.00	158.00
	Third cluster	96.92	25.21	3.53	89.83	104.01	25.00	141.00

T2D: type 2 diabetes; M: mean; SD: standard deviation; SE: standard error; CI: confidence interval; LL: lower limit; UL: Upper limit; Min: minimum; Max: maximum; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

n=61 families; first cluster=2 families, second cluster=7 families, third cluster=52 families.

allowed us to reject the hypothesis that the centroids of the groups are equal and, therefore, that there are differences between them, thus the data provided by the different variables are statistically significant. These differences were given by age ($\Lambda=0.778$, $F=2.098$, $p=0.010$) and family health ($\Lambda=0.813$, $F=2.650$, $p=0.023$) as independent variables.

In order to identify possible differences in the family health variable, Tukey's post hoc test (honestly significant difference (HSD)) was applied obtaining three subsets of effects for the 61 families in the study, with a harmonic mean of 3.49. The means of these three subsets suggest that families—between them—had non differentiated behaviors ($p=0.070$, $p=0.076$, $p=0.060$). Family characteristics, functionality, routines, family health and individual health were the variables that identified three homogeneous and heterogeneous families at the same time which is outlined in Figure 2. The previous information confirms Mexican families can be similar and different at the same time, so consider them as a unit of analysis.

Discussion

Regarding the characteristics of the families studied, a distribution similar to that reported in the demographics in our country (Instituto Nacional de Estadística y Geografía (INEGI))²⁹ was found. About 50% are nuclear families with both parents, while just over 40% are extended. This profile of family composition is common in metropolitan areas where consanguineous families and outbred families join for economic or cultural reasons. It was positive to find in

these families a significant percentage that have health care; however, the high prevalence of T2D and the low proportion of people with good glycemic control makes one think about the effectiveness of the model of care for this condition. Another factor that stands out is the level of formal education of participants above the national average of 8.6 years.³⁰

The results of perception of health status at the individual level were low in contrast with the perception of family health status that had a mean greater than the former; these data suggest a mismatch in the conceptualization and measurement of both constructs. Studies that have used the same scale in family health^{31,32} similarly report high averages without having measured the perception of individual health status. For Denham,²⁰ it is possible to have healthy families and this relates to good individual health. It is questionable if one should expect theoretically or empirically a high ratio between the two measurements.

It is important to point out the homogeneity in most of the variables of the families studied. We observed that families with a higher mean age had more years of education and lower mean levels of family health, functionality and health routines. Younger families constituted the minority of the clusters that were formed, but also showed higher levels in family health variables, function and routines. These differences, although not significant, suggest that the stage at which families are at can make a difference in the perception of the studied variables.³⁰ Family health for Denham²⁰ is a complex variable that consists of three dimensions, which

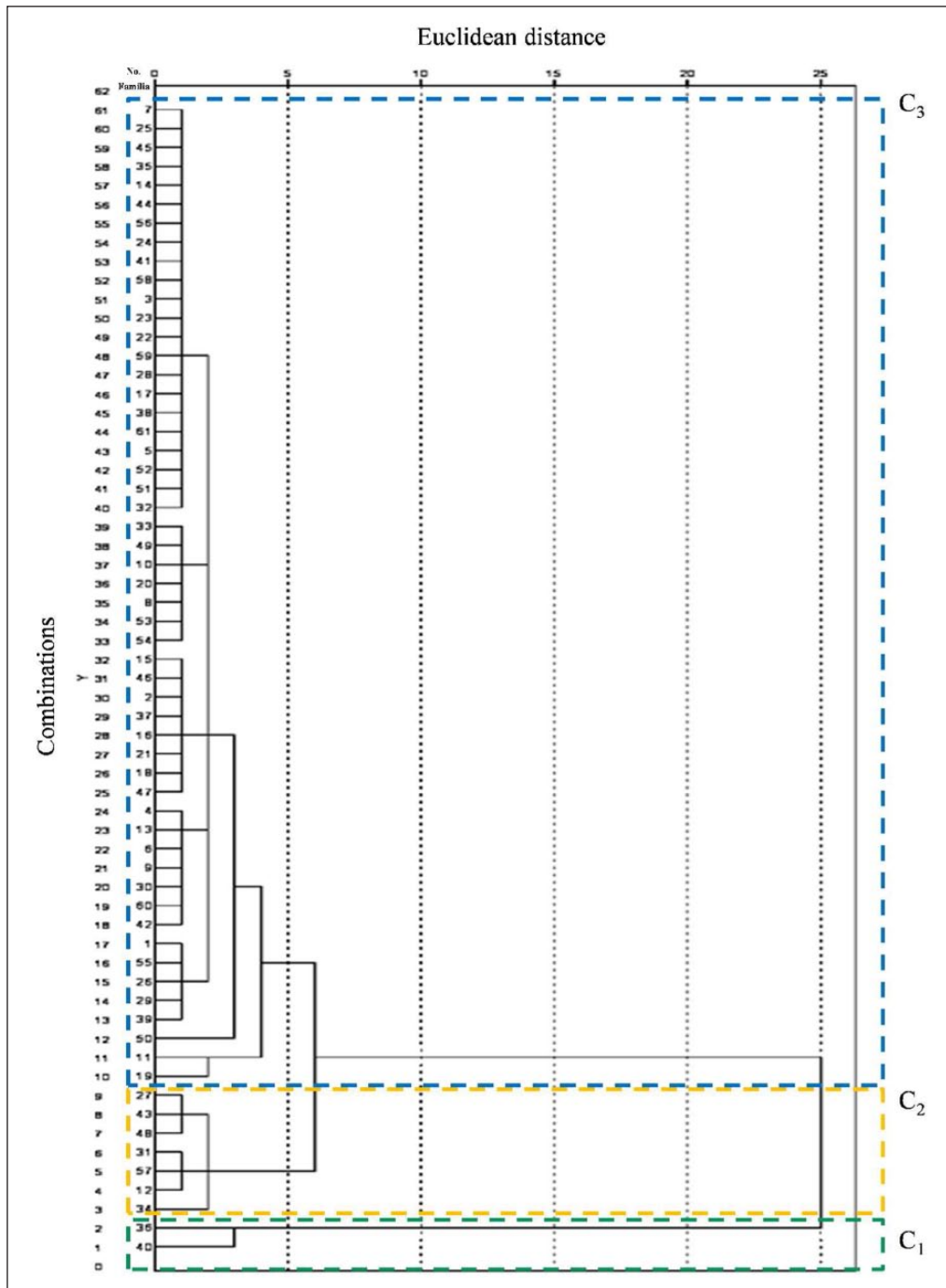


Figure 1. Dendrogram with combined rescaled distance clusters. Cluster distance is expressed as a squared Euclidean distance. C_1 , C_2 , C_3 =hierarchical clusters.

arise and are maintained by the still unclear interaction of various variables of perception and environment. If these interactions will be understood, we can value their predictive capacity for clinical variables, especially for family members with T2D, so international health public policy will be able to include family in the management of chronic diseases according to family clusters, as a result reduce the T2D

prevalence complications and the catastrophic treatment costs for families, society and health system.

This study only explored a convenience families sample in an urban geographic area at north of México, so reduce the possibilities to generalize the results. The measurement instruments were effective in Hispanic population, despite being the first time tested in its Spanish version. We

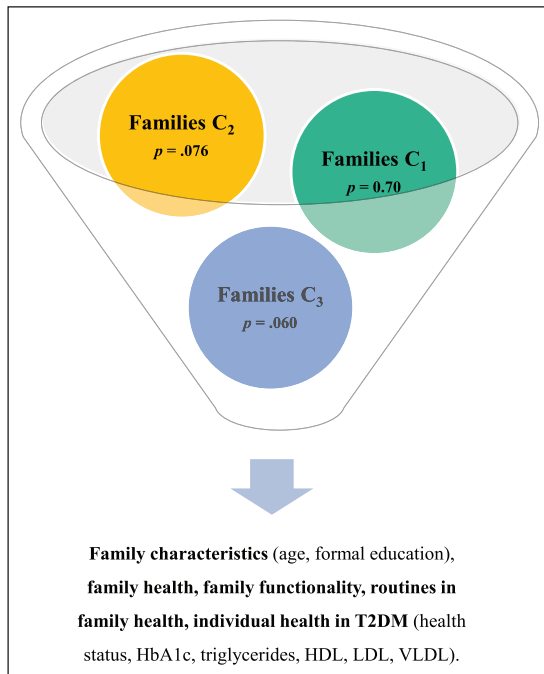


Figure 2. Empirical verification of similarities and differences in families with type 2 diabetes. Representation of internal homogeneity and external heterogeneity by cluster. C₁, C₂, C₃ = hierarchical clusters.

recommend replicating the study with random samples and rural geographic areas.

Conclusion

These findings provide greater insight that families with T2D have common elements that make them similar to each other, while sharing differences that make them unique. Since this perspective we can approach to beliefs health-illness, family suffering, family could persist more than members living together. These empirical results reflect family as an integrated unit or the care object. The hierarchical cluster analysis is able to analyze the results of the whole family and also preserve the individual information of each member. The cohesion of three clusters was obtained, given the interdependent relationships provided by age, formal education, functioning, health routines, family health, individual health status, HbA1c, triglycerides, cholesterol, HDL, LDL and very-low-density lipoprotein (VLDL), by combining the rescaled distance of the clusters.

The results suggest further study of this phenomenon by incorporating internal and external variables of family background, from a perspective of wellbeing. It is important to include variables that consider more fully the health of the member with T2D and the knowledge or involvement of the families in order to see the fusion of the individual in family health. Family inclusion could be improved the adherence to treatment in members with T2D, and prevent as complications

as new cases family members affected by this disease. To have a perspective of family health as a process of social construction, as proposed by Denham,²⁰ it is necessary to study additional indicators that involve the family's external context, such as the community, society and culture since different paradigmatic views.

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