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Perspectives on the Attitudes of Healthcare Professionals toward Diabetes in Community Health Settings in United Arab Emirates

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Abstract

Background: Diabetes is a chronic disease that is associated with high cost and health care utilization. Attitudes of healthcare professionals (HCPs) toward diabetes have a significant impact on quality of diabetes care. Although the prevalence of diabetes in the Arabian Gulf region is alarming, little is known about attitudes of HCPs toward the disease. Methods: This study evaluates the attitudes of 337 HCPs toward diabetes in United Arab Emirates (UAE) including physicians, pharmacists, nurses and dietitians using the Diabetes Attitudes Scale (DAS-3). Data were analyzed descriptively and one way analysis of variance (ANOVA) was used for comparative analyses. Overall, HCPs groups demonstrated relatively adequate attitudes toward diabetes (mean = 3.80, SD = 0.45). Results: The highest score reported by HCPs groups was on the need for special training subscale (M = 4.49, SD = 0.38) and the lowest score was seen on patient autonomy subscale (M = 3.31, SD = 0.45). Physicians showed significantly higher positive attitudes on need for special training, seriousness of diabetes, value of tight glycemic control, and psychosocial aspects of diabetes than other HCPs groups (P values < 0.005); whereas nurses scored the highest on patient autonomy subscale. Pharmacists demonstrated the lowest negative attitudes among HCPs groups on all diabetes attitudes subscales. Conclusions: We recommend conducting more continuing education programs (CEPs) on diabetes care in the UAE, with greater emphasis on patient autonomy. An interdisciplinary approach that is patients' centered is needed to provide efficient diabetes care.

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Keywords

Diabetes Attitudes, Healthcare Professionals, Nurses, Pharmacists, Physicians, Dietitians, Continuing Education Programs

1. Introduction

Diabetes is one of the fastest growing chronic health conditions in the world [1]. It is estimated that the prevalence of diabetes in adults will increase worldwide from 6.4% in 2010 to 7.7% in 2030 [2]. In Arabian Gulf countries, diabetes is a major health problem affecting 23.9%, 23.1%, and 22.9% of the populations of Saudi Arabia, Kuwait and Qatar, respectively, with evidence showing an upward trend in the prevalence of the disease [1]. Similar trends have been observed in the United Arab Emirates (UAE), in which the prevalence of diabetes is very high and continues to increase overtime with an estimated prevalence of 19.3% [3]. High and increasing rates of diabetes in the UAE and other Gulf countries could be attributed, in part, to the adoption of westernized diet and lack of physical activity that followed the discovery of oil and the subsequent urbanization of those societies. These lifestyle changes also contributed to high rates of obesity and other metabolic related disorders associated with diabetes [4].

Patients with diabetes make a wide range of routine self-care complex decisions involving medication, nutrition, physical activity, blood glucose monitoring, and stress management. Patient adherence to treatment regimens is crucial to control diabetes and its complications. The high prevalence of diabetes in the UAE, the seriousness of the disease, the high cost and complexity of diabetes care and management mandate a good understanding of factors that influence patients' adherence to diabetes care and self-management regimens. Healthcare professionals (HCPs) play a vital role in fostering a lasting change in patient behaviors, motivating patients toward adherence to diabetes related regimens and helping them to make proper decisions leading to favorable health outcomes [5] [6]. For example, studies have shown that misconceptions of HCPs about diabetes had a negative impact on quality of care provided to patients with diabetes. Aspects of diabetes care including tight glycemic control and patient autonomy are influenced most by the attitudes of HCPs because these aspects depend on the communication patterns between patients and HCPs [7] [8].

It is widely reported that diabetes complications could be prevented or delayed with proper self-management that is influenced by attitudes of HCPs toward the disease [9]-[11]. There is evidence that HCPs' negative and misguided attitudes toward diabetes screening and management have negative impact on adherence of patients to diabetes related regimens [10]. Gagliardino, *et al.*, (2007) stated that misconceptions of HCPs about diabetes, especially with regards to patient autonomy, seriousness of diabetes, and the value of tight glycemic control; contribute to poor quality of care provided to patients with diabetes [8].

Studies on the attitudes of HCPs toward diabetes have demonstrated different attitude patterns across different parts of the world. For example, Odili and Oparah (2012) used the Diabetes Attitudes Scale (DAS-3) and found that although HCPs (nurses, physicians, pharmacists) in Nigeria were in agreement regarding the benefits of diabetes special training programs for HCPs, significant differences with regards to other attitude subscales were noted among participants with nurses demonstrating low attitudes toward seriousness of diabetes, value of tight glycemic control, and patient autonomy [12]. Whereas, doctors and pharmacists had higher attitudes toward the value of tight glycemic control than nurses. Physicians had greater attitudes about the seriousness of type 2 diabetes than nurses and pharmacists.

In a cross-sectional study in Yemen, Babelgaith *et al.* (2013) found that nurses and pharmacists demonstrated lower attitudes than physicians with regards to the seriousness of diabetes whereas physicians had higher attitudes toward the value of tight glycemic control followed by nurses and pharmacists [10]. In that study, nurses had lower attitudes on all subscales than physicians and pharmacists and All HCPs surveyed were in agreement regarding the importance of empowering patients toward self-management of diabetes [10].

In a multinational survey to assess attitudes of HCPs toward diabetes in eight countries (France, Germany, United Kingdom (UK), Italy, Netherlands, Spain, Sweden, and United States), it was found that physicians tended to have high attitudes toward seriousness of diabetes and psychosocial impact of the disease [13]. An

earlier study indicated that diabetes related attitudes of nurses and dieticians in the US were consistently more positive than the attitudes of physicians, especially regarding the seriousness aspects of the disease [14]. Anderson and Donnelly (1990) found that physicians tended to view themselves as in control of diabetes with less appreciation of patients' autonomy unlike nurses and dietitians who valued patients' involvement in decisions related to diabetes [15]. Both studies underscored the importance of interdisciplinary team work in diabetes management and the values of understanding patients' perceptions and emotional status by HCPs to establish therapeutic relationship and enhance patients' coping and emotional well-being [14] [15].

Stansfield, Fitzgerald, Oh, and Gruppen (2007) reported that HCPs underestimated patient autonomy and emotions related to diabetes but overestimated the challenge patients associate with the cost of diabetes [6]. Similar results were noted in a later study in the US which found that HCPs had negative attitudes toward patient ability to handle low blood sugar and the psychosocial aspects of diabetes [16].

Although high rates of diabetes have been reported in the UAE, there is limited research on attitudes of HCPs toward diabetes in the country. Despite the recent emphasis on the need for "interdisciplinary teams and "total-care management" in which all categories of HCPs must directly coordinate and plan care for diabetic patients [17], many of the existing studies related to attitudes of HCPs toward diabetes were limited to one category of HCPs such as physicians [18], pharmacists [17]-[19] and nurses [20] with little focus on the role of dietitians. Hence, this study attempts to assess attitudes of all HCPs related to diabetes and compare those attitudes among subgroups of HCPs. Results of this study will assist in guiding the development of interventions and programs to ensure that HCPs have the necessary training and appropriate attitudes to be able to provide better diabetes care.

2. Methods

2.1. Design and Sample

This cross-sectional study was conducted with a convenience sample 337 HCPs working in community healthcare settings in the UAE. For this study, all physicians, nurses, pharmacists and dietitians working at primary healthcare centers, outpatients' clinics and community-based pharmacies in Northern Emirates of UAE including Dubai, Ajman, Sharjah, and Ras Al khaimah. Four trained research assistants collected data over six months through face-to-face interviews to ensure quality and completeness of data collected. Consent forms were presented and signed by participants prior to data collection.

Participants were identified through direct visits by the research team to potential study sites where participants were practicing. These sites included primary healthcare centers, outpatients' clinics and community-based pharmacies in the Northern Emirates. After obtaining the permission of the administration of the sites, the research team approached HCPs and invited them to participate. The study was ethically approved by the ethical committee at the researchers' institution.

This sampling frame was selected because it is less complicated and more economical than random sampling and there is a possibility of polling the desired number of participants in the nearby population [21]. Inclusion criteria included practicing in community based healthcare settings and having at least two years of experience caring for patients with diabetes. Sample size was determined based on the review of previous similar studies [10] [22].

2.2. Data Collection Instrument

The Diabetes Attitudes Scale version 3 (DAS-3) was used to assess attitudes of HCPs toward diabetes [9] [22]. The DAS-3 is a self-reported instrument used to assess general scientific knowledge and attitudes of HCPs and patients toward diabetes and diabetes management. The current scale is based on an earlier version which was developed through Delphi method [23]. The new version (DAS 3) was revised by a panel of diabetes experts, including physicians, nurses, dietitians, and patients associated with the University of Michigan Diabetes Research and Training Center [9]. The scale consists of 33 items and includes five discrete subscales assessing HCPs attitudes with regards to diabetes care. Participants responded on a 5-point Likert scale where 1 = strongly agree, and 5 = strongly disagree. The coding for negatively stated statements was reversed. Higher score indicating more positive attitudes in the examined area of diabetes care. In our study, the English version of DAS-3 was administered to participants because English is the commonly used language by HCPs in the UAEs and participants speak and understand English adequately.

The scale consists of 33 items and includes five discrete subscales assessing HCPs attitudes with regards to diabetes. The first subscale assesses attitudes toward the need for special training and includes 5 items on communication, patient education, and counseling. For example, one of the statements is: "In general, I believe that health care professionals who treat people with diabetes should be trained to communicate well with their patients." The second subscale includes 7 items assessing HCPs attitudes toward the seriousness of type 2 diabetes. For example, one statement is: "In general, I believe that people who do not need to take insulin to treat their diabetes have a pretty mild disease." The third subscale includes 7 items on attitudes toward the value of tight glucose control for the prevention of late complications. For instance, one of the statements is: "In general, I believe that most people can enjoy life and still keep tight blood sugar control." In the 4th subscale, HCPs respond to 6 items about their attitudes on the psychosocial impact of diabetes such as, one statement is: "In general, I believe that diabetes is hard because you never get a break from it." While the 5th subscale includes 8 item on HCPs attitudes toward encouraging patient autonomy and the need to involve patients in daily decision related to diabetes. For instance, one of the statements is: "In general, I believe that people with diabetes have a right to decide how hard they will work to control their blood sugar."

The DAS-3 was found to have adequate psychometric properties with internal consistency reliability of Chronbach's alpha ranging from 0.65 for psychosocial impact of diabetes to 0.80 for seriousness of diabetes [9]. Validity of the DAS-3 was supported through consistency of findings with previous DAS surveys and through content validity established by the rigorous new Delphi revision process [9]. Anderson and colleagues (1998) concluded that the DAS-3 is superior to other previous measures of diabetes attitudes, applicable, and suitable for assessing attitudes of patients and HCPs toward diabetes [9].

2.3. Data Analysis and Procedure

Statistical analysis was conducted using the Statistical Analysis System (SAS) version 9.3. For descriptive statistics, all study variables were analyzed including percentages and means. Analysis of variance (ANOVA) was used to test difference in mean attitude scores among four HCPs groups and by demographic characteristics as well as other factors (Training and certifications). The significance level was set at p value of less than 0.05.

3. Results

3.1. Response Rate and Descriptive Statistics

Of the five hundred potential HCPs who were invited to participate in the study, a total of 337 (67.4%) completed the survey; 96 physicians (28.5%), 127 nurses (37.7%), 62 (18.4%) pharmacists and 52 (15.4%) dietitians. Participants came from Northern Emirates of the UAE as follows: Sharjah (n = 160, 47.48%), Dubai (n = 97, 28.78%), Ajman (n = 64, 19%), and Ras Al khaimah (n =16, 4.74).

As shown in **Table 1**, the age of the participants ranged from 19 to 61 years with physicians being the oldest group followed by nurses while pharmacists were the youngest group. Females represented 70% of participants; 83% of nurses, 61.46% of physicians, and 53.23% of pharmacists. Years of experiences of participants significantly varied from less than a year (n = 68, 20.18%) to more than 15 years (n = 47, 13.95%). Pharmacists had the least while physicians had the most experience working with patients with diabetes.

Surprisingly, more than half of the participants (n =179, 53.12%) did not receive any kinds of training by diabetes experts anywhere. Pharmacists were the least likely to had training related to diabetes than the professionals from the other groups while physicians were the most trained group. Further, 78.93% (n = 266) were not certified diabetes educators with more certified physicians than other HCPs (see **Table 1**).

3.2. Healthcare Professionals' Attitudes toward Diabetes

Attitudes toward diabetes were divided into five subscales, as described earlier in the data collection instrument including 1) the need for special training; 2) the seriousness of diabetes; 3) the value of tight glycemic control; 4) the psychosocial impact of diabetes on the patient's life; and 5) and patient autonomy. As shown in **Table 2**, the mean scores for all subscales was 3.80 (SD = 0.45). The highest attitude score was on the need for special training subscale (M = 4.50, SD = 0.38). Specifically, participants scored higher on items related to the need for training, such as need to be trained to communicate well with patients, taught how daily diabetes care affects pa-

Table 1. Distribution of demographic data of healthcare professionals per groups (N = 337).

	Physicians (*n* = 96)	Dietitians (*n* = 52)	Nurses (*n* = 127)	Pharmacists (*n* = 62)	P-value[a]
Age group (years)					
19 - 30	16.67	19.23	27.56	51.61	<0.0001
31 - 40	26.04	63.46	37.01	38.71	
41 - 61	57.29	17.31	35.43	9.68	
Gender					
Females	61.46	75	83.46	53.23	<0.0001
Males	38.54	25	16.54	46.77	
Nationality					
Emirati	16.67	21.15	4.72	22.58	0.0013
Non-Emirati	83.33	78.85	95.28	77.42	
Years of experience					
<1 year	9.38	15.38	24.41	32.26	0.0024
1 - 5	32.29	25	29.92	24.19	
6 - 10	20.83	34.62	19.69	22.58	
11 - 15	16.67	19.23	9.45	16.13	
More than 15	20.83	5.77	16.54	4.84	
Diabetes training					
Yes	64.58	42.31	48.82	19.35	<0.0001
No	35.42	57.69	51.18	80.65	
Diabetes certification					
Yes	26.04	21.15	18.11	19.35	0.5308
No	73.96	78.85	81.89	80.65	

[a]based on Chi square test.

Table 2. Overall diabetes attitudes scores for healthcare professionals (N = 337).

Subscale	Number of items	Mean (M)	Standard deviation (±SD)
Special training	5	4.50	0.38
Seriousness of diabetes	7	3.84	0.48
Value of tight glycemic control	7	3.50	0.43
Psychosocial impact of diabetes	6	3.85	0.49
Patient autonomy	8	3.31	0.45
Total	33	3.80	0.45

tients' lives, learn counseling skills, and set goals for patients and not just tell them what to do. Participants differed significantly in their attitude toward the need for special training with the highest need expressed by physicians followed by dietitians, nurses, and pharmacists (P = 0.005) (see **Table 3**).

On the other hand, the lowest attitude score was for the patient autonomy subscale (M = 3.31, SD = 0.45). Specifically, HCPs scored less on items related to patient autonomy such as having persons with diabetes make

Table 3. Comparison of diabetes attitude score between healthcare professional groups (N = 337).

Subscale	HCPs category	Mean (M)	Standard deviation (±SD)	P value[a]
Special training	Physicians	4.60	0.33	0.005
	Dietitians	4.47	0.42	
	Nurses	4.44	0.36	
	Pharmacists	4.41	0.44	
Seriousness of diabetes	Physicians	4.15	0.51	<0.0001
	Dietitians	3.68	0.40	
	Nurses	3.80	0.54	
	Pharmacists	3.56	0.48	
Value of tight glyemic control	Physicians	3.68	0.46	<0.0001
	Dietitians	3.48	0.43	
	Nurses	3.51	0.43	
	Pharmacists	3.34	0.40	
Psychosocial impact of diabetes	Physicians	4.03	0.48	<0.0001
	Dietitians	3.73	0.41	
	Nurses	3.88	0.46	
	Pharmacists	3.63	0.50	
Patient autonomy	Physicians	3.30	0.45	0.2438
	Nurses	3.60	0.50	
	Dietitians	3.34	0.40	
	Pharmacists	3.00	0.46	

[a]based on ANOVA.

important decisions about their care. As shown in **Table 3**, HCPs did not differ significantly in their attitude score related to patient autonomy with nurses scored the highest (M = 3.60, SD = 0.50) and pharmacists scored the lowest (M = 3.00, SD = 0.46).

The overall mean attitude score toward the value of tight glycemic control was higher than that reported for patient autonomy (M = 3.50, SD = 0.43). We found significant differences in attitudes toward the value of tight glycemic control for preventing late complications by type of health profession with physicians scoring the highest mean score (M = 3.68, SD = 0.46) and pharmacists scoring the lowest (M = 3.34, SD = 0.40) (See **Table 3**).

Comparisons among different groups of HCPs revealed significant differences in their attitudes toward the seriousness of diabetes (P < 0.0001) with physicians scoring the highest and pharmacists scoring the lowest. HCPs also varied on their attitude toward the psychosocial impact of diabetes based on their profession (P = 0.0001) with the highest score attained by physicians and the lowest by pharmacists (See **Table 3**).

Our results indicated that pharmacists had the least favorable attitudes toward diabetes, especially in the domains of patient autonomy and the value of tight glycemic control. Whereas, physicians had the most favorable attitudes toward diabetes on all subscales compared to all HCPs groups, except for patient autonomy where nurses had greater attitudes to patients' involvement in their own diabetes care decisions than other HCPs groups.

Results of our study also indicated that special training by diabetes experts had a positive impact on the attitudes toward diabetes; HCPs who received training by diabetes experts had more desirable attitudes toward diabetes compared to those who did not receive training; as shown in **Table 4**, significant differences were rec-

Table 4. Comparison of diabetes attitude scores by training in the area of diabetes (N = 337).

Subscale	Training	Mean (*M*)	Standard deviation (±SD)	P value[a]
Special training	NO	3.72	0.46	0.014
	Yes	4.54	0.37	
Seriousness of diabetes	NO	4.43	0.39	
	Yes	3.93	0.57	0.004
Value of tight glycemic control	NO	3.75	0.51	
	Yes	3.61	0.43	0.0003
Psychosocial impact of diabetes	NO	3.44	0.44	
	Yes	3.92	0.51	0.01
Patient autonomy	NO	3.79	0.45	
	Yes	3.78	0.50	0.26

[a]based on ANOVA.

orded on the four subscales including the need for special training, seriousness of diabetes, value of tight glycemic control, and psychosocial impact of diabetes (all P values were less than 0.05). Similarly, HCPs who were certified diabetes educators scored significantly higher than those without certifications on all five diabetes attitudes subscales (all P values were less than 0.05) (See **Table 5**).

4. Discussion

To the best of our knowledge, the current study is the first to assess attitudes of HCPs toward diabetes in the Arabian Gulf region. Unlike previous studies which focused on a particular category of HCPs [17]-[20], the current study is unique as our sample included most categories of HCPs with different specialties and backgrounds.

One of the important findings of our study was the great need for special training expressed by all categories of HCPs. These findings were consistent with those from previous studies in which HCPs requested more diabetes related training [9] [10] [12]. The need for special training by HCPs in our study was slightly higher than that reported in similar investigations utilizing the DAS-3 scale in different countries such as Yemen (M = 4.2, SD = 0.47) [10], Argentina (M = 4.5, SD = 0.35) [8] and Nigeria (M = 4.5, SD = 0.64) [12]. Physicians, in our study, scored slightly higher than other groups of HCPs on the need for special training which is consistent with scores attained by physicians in the USA (M = 4.66, SD = 0.36) [24]. Yet, in other studies, other HCPs groups (allied providers, nurse practitioners, nurses, physicians assistants) scored higher than physicians [25].

Our findings suggest that HCPs in the UAE understand the burdens and complexity of diabetes as well as their own shortfall in handling a wide range of clinical, psychosocial, and financial issues associated with the management of diabetes. Therefore, the UAE health government should target all categories of HCPs in continuing education programs (CEPs). This is supported by our findings and those of others demonstrating the positive impact of special training on attitudes of HCPs related to diabetes care [8] [12] [25].

With regards to the seriousness of diabetes, results indicated that physicians perceived diabetes as a serious disease more than other HCPs groups (M = 4.15, SD = 0.51) which is in agreement with finding from other studies [12]. Yet, unlike our results, physicians were more likely to underestimate the seriousness of diabetes than other categories of HCPs in some other studies [13].

For the psychosocial impact subscale, scores attained in our study were lower than those reported by the study of Odili and Oparah (2012) (M = 4.07, SD = 0.93) and higher than the findings obtained in the study by Babelgaith *et al.* (2012) (M = 3.7, SD = 0.42) [10] [12]. Consistent with our findings, other studies found that physicians scored the highest among all HCPs groups on the psychosocial aspects of diabetes [10] [12] [13].

The findings regarding the seriousness of diabetes and psychosocial impact of diabetes in patients were expected as most CEPs related to diabetes focus on clinical guidelines, biological, pathophysiological, psychosocial, and aggressive treatment to prevent late complications aspects of disease [12] [24]. Although little data are

Table 5. Comparison of diabetes attitude score by diabetes certification (N = 337).

Subscale	Certification	Mean (M)	Standard deviation (±SD)	P value[a]
Special training	NO	3.67	0.46	0.0022
	Yes	4.60	0.34	
Seriousness of diabetes	NO	4.45	0.38	
	Yes	4.04	0.57	0.0006
Value of tight glycemic control	NO	3.787	0.53	
	Yes	3.70	0.42	<0.0001
Psychosocial impact of diabetes	NO	3.47	0.44	
	Yes	4.10	0.454	<0.0001
Patient autonomy	NO	3.78	0.47	
	Yes	4.04	0.43	<0.0001

[a]based on ANOVA.

available on the nature of diabetes education in UAE, it is known that most CEPs attract physicians more than other HCPs groups. This might explain the highest score reported by physicians on the seriousness of diabetes and the psychosocial impact of diabetes. HCPs from all professions, and not only medicine, should be required to participate in CEPs related to diabetes to improve their attitudes toward diabetes care and management. This is especially important as more health care entities move to the interdisciplinary approach in improving diabetes control and management [8].

Results of our study indicated that nurses had the highest positive attitude on patient autonomy subscale followed by dietitians, pharmacists and physicians. Nurses in our study believe that diabetic patients should be given the choice and greater autonomy in care related decisions. This is consistent with findings from the studies [6] [16]. Researchers agree that nurses are more committed to helping patients through her supportive educational role and are valuing patients' involvement in care related decisions more than physicians who view themselves as in control of diabetes and trained to make decisions for patients [12] [14] [15] [26]. Hajos *et al.* (2011) highlighted the need for patient involvement and shared decision making in diabetes care as suggested by their findings showing that patients seek active involvement in daily decisions related to diabetes [13].

Importantly, we found that the overall score on patients autonomy subscale was the lowest of all the attitude subscales (M = 3.31, SD = 0.45). This observation is consistent with results from prior studies [6] [10] [12] [13] [19]. The lowest score was reported by Gagliardino's *et al.* (2007) study where HCPS scored 2.79 on patient autonomy using the DAS-3 scale [8]. Odili and Oparah (2012) attributed the low score on patient autonomy subscale observed in their study to the fact that all HCPs do not feel that patients are knowledgeable enough about the disease to make decisions [12].

Support for patients' autonomy and involvement in their own diabetes management decisions and collaboration with HCPs was found to be the strongest predictor of patient-reported outcomes as indicated by the worldwide Diabetes Attitudes, Wishes, and Needs (DAWN) study involving 3170 patients with type 2 diabetes [27]. Therefore, CEPs need to boost HCPs attitudes toward patient autonomy to assist patient make informed choices about their care plans and daily self-care of diabetes [12]. It is important that CEPs include specific sessions on the importance of empowering patients and involving them in the decision making process related to diabetes.

For the fifth subscale of the values of tight glycemic control, all HCPs scored higher than their score on patient autonomy (M = 3.50, SD = 0.43) with physicians scored the highest and pharmacists scored the lowest. These results are almost consistent with findings from others study (M = 3.3, SD = 0.67) [10]. In other studies, nurses showed the most significant negative attitudes toward the value of tight glycemic control than physicians and pharmacists [10] [12]. Pharmacists in our study scored less than physicians on the attitudes toward the value of tight glycemic control unlike what was found in other [10] [12] [19]. As the value of tight glycemic control is very important to prevent diabetes complications (UK Perspective Diabetes Study, 1989), the attitudes of HCPs toward tight glycemic control should be improved to ensure proper management of the disease [28].

It was evident in our study that training has a significant impact on diabetes attitude subscale, except for autonomy. Therefore, it is important that HCPs receive adequate training on diabetes care. It is important that diabetes training programs should be expanded to include not only the biological content of diabetes, but should integrate concepts of patient autonomy and empowerment to be involved in all health related decisions to successfully perform desired self management activities [24] [29]. The American Diabetes Association (ADA) (2014) advocates that people with diabetes must assume an active role in their care [30]. Patient autonomy needs to be integrated earlier in educational preparation of all healthcare specialties prior to clinical practice to provide a more successful approach that is patient-centered and interdisciplinary for diabetic patients [12].

Our results indicated that there is a great need for certification in the area of diabetes in UAE. Diabetes certification is important as it was found to influence significantly attitudes toward diabetes [12]. It is common that only nurses are certified diabetes educators (CDEs), but it is important that pharmacists and dietitians should also be CDEs to provide the best care possible for diabetic patients.

5. Conclusion

This study was a preliminary effort to understand the attitudes of HCPs toward diabetes in UAE. The inclusion of all categories of HCPs adds value to our study. The addition of dietitian represents a strength since they are less likely to be included in similar studies. Further studies are needed to explore the interventions needed for achieving clinically significant attitude changes. Our study was a cross sectional study and included HCPs from Northern Emirates only of UAE. Future studies should include larger samples from other Emirates and countries to allow for comparisons across different Arabian gulf countries. Perspectives of patients on aspects of diabetes care need to be examined and compared with those of HCPs to determine areas for improvement for better health outcomes. As a strong theoretical support and correlational evidence exist for the attitude-behavior relationship, future research should focus on behavioral outcomes to validate the use of HCPs attitudes as a proxy for the real behavior change. Improving HCPs attitudes is important, yet it is not the only factor that impacts care for diabetic patients. CEPs should assist in translating these attitudes into the quality of healthcare. Our study assessed HCPs attitudes and indicated that CEPs are needed by all groups of HCPs to change the attitudes and subsequently their behaviors toward diabetes. There is an urgent need for interdisciplinary work that is geared toward boosting patient autonomy to empower them toward diabetes related decisions.

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Conflict of Interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research. We fully declare that no financial or other potential conflict of interest.

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Clinical Audit on the Provision of Diabetes Care in the Primary Care Setting by United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA)

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Abstract

OBJECTIVE: United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) provides primary health care services including care for diabetes and hypertension, with limited resources under difficult circumstances in Gaza, West Bank, Jordan, Lebanon and Syria. A total of 114,911 people with diabetes were registered with UNRWA health centres in 2011. The aim of this cross-sectional observational study was to assess the quality of diabetes care in the UNRWA primary health care centres. METHOD: The study population consisted of 1600 people with diabetes attending the 32 largest UNRWA health centres and treated there for at least one year. Between April and Sept. 2012 data from medical records, including results of clinical examinations and laboratory tests performed during the last one year, current management including self-care education and evidence of diabetes complications were collected and recorded in a previously validated data collection form (DCF). Patients were interviewed and clinically examined on the day of the

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audit and blood collected for HbA1c testing which was done at a central lab using High-performance liquid chromatography (HPLC) method (HLC®-723G8 Tosoh Corporation, Japan). Data was transferred from paper records into a computer and analysed with Epi-info 2000. RESULTS: Type 1 diabetes was present in 4.3% and type 2 diabetes in 95.7%. Co-morbid hypertension was present in 68.5%; 90.3% were either obese (64.0%) or overweight (26.3%). Clinical management of diabetes was largely in line with UNRWA's technical instructions (TI) for diabetes. Records for 2 hour postprandial glucose (2 h PPG), serum cholesterol, serum creatinine, and urine protein analysis were available in 94.7%, 96.4%, 91.4% and 87.5%, cases, respectively. Records of annual fundoscopic eye examination were available in 47.3% cases but foot examinations were less well documented. Most patients (95.6%) were on anti-diabetic drugs—68.2% oral anti diabetic drugs (OAD) only, 14.4% combination of OAD and insulin, and 12.9% insulin only. While 44.8% patients had 2 h PPG ≤ 180 mg/dl, only 28.2% had HbA1c ≤ 7%; 55.5% and 28.2% had BP ≤ 140/90 and ≤130/80 mm of Hg respectively. Serum cholesterol ≥ 200 mg/dl, serum creatinine ≥ 1.2 mg/dl and macro albuminuria were noted in 39.8%, 6.4% and 10.3% cases respectively. Peripheral neuropathy (52.6%), foot infections (17%), diabetic retinopathy (11%) and myocardial infarction (9.6%) were the most common long term complications. One or more episodes of hypoglycaemia were reported by 25% cases in total and in 48% of those using insulin. 17.7% and 22.6% cases received no or ≥4 self-care education sessions respectively. CONCLUSION: The study confirmed that UNRWA doctors and nurses follow TI for diabetes and hypertension fairly well. Financial constraints and the consequent effects on UNRWA TI and policies related to diabetes care were important constraints. Key challenges identified were: reliance on 2 h PPG to measure control; non-availability of routine HbA1c testing, self-monitoring of blood glucose (SMBG) and statins within the UNRWA system; and high levels of obesity in the community. Addressing these will further strengthen UNRWA health system's efforts of providing services for diabetes and hypertension at the primary care level. Given that most developing countries either have no or only rudimentary services for diabetes and hypertension at the primary care level, UNRWA's efforts can serve as an inspiration to others.

Keywords

Diabetes Mellitus, Hypertension, Primary Care Setting, Palestine Refugees, Quality of Care, Clinical Audit, UNRWA

1. Introduction

UNRWA has worked in the Near East for 64 years, providing health, education and social services for over 5 million Palestine refugees in Jordan, Lebanon, Syria, the West Bank and Gaza Strip. Due to the prevailing socioeconomic conditions, psychological stress and lack of access to healthy food and physical activities, non-communicable diseases (NCDs) such as, diabetes (DM), hypertension (HT), coronary artery disease (CAD) and cerebrovascular disease (CVD) are major problems for Palestine refugees The number of patients registered with DM has increased progressively and doubled in the last decade reaching 108,000 patients in 2012, without the data from Syria [1]. The exact prevalence of diabetes among Palestine refugees is not known, but may be assumed to be similar to the general population of the countries where they live, [2] *i.e.*, 10.1% in Jordan, 7.8% in Lebanon, 8.6% in Palestine and 10.8% in Syria [3]; hence, likely to be between 8% and 11% among adults 20 - 79 years of age. Around 11.0% of people ≥ 40 years attending UNRWA health facilities have DM [1].

UNRWA has provided care for DM and HT at their primary health care centres since 1992 and the NCD strategy has been revised four times with the latest revision in 2009 [4]. The current strategy is structured around three main elements—healthy life style promotion emphasizes the importance of weight control and regular exercise; early detection of diabetes by active screening of at risk individuals; and treatment protocols and effective case management with dietary management, physical exercise and risk assessment and screening for cardiovascular, cerebrovascular and peripheral vascular disease to prevent secondary complications. Another important element of the strategy is to improve record keeping, program effectiveness and quality of services. UNRWA has started to roll out an E-health initiative which allows periodic cohort monitoring and evaluation [5]-[8]. To

improve care delivery, periodic assessment of knowledge, attitudes and practices of care providers using validated questionnaires and data collection tools supplemented with clinical audit is useful [9]-[14], the aim of this cross-sectional observational study was to assess the quality of diabetes care in the UNRWA primary care centres. In addition the study also assessed the UNRWA medical officers' ability to deliver DM care by evaluating their knowledge, attitude and practice regarding patients and services, which will be presented in another paper.

2. Methods

2.1. Study Design

Cross-sectional prospective survey of patients with DM.

2.2. Setting

The study was conducted in the 32 largest PHCs, with 8 each in the following locations Gaza, Jordan, Lebanon and the West Bank. Syria was not included due to the on-going armed conflict. In 2012, UNRWA had 116 PHC clinics in these four Fields serving a population of 3,134,732 refugees. Each clinic is staffed by 2 to 6 doctors and a variable number of nurses. All screening, diagnosis and treatment services at the clinic are provided free-of-charge.

Palestine refugees who attend the clinics are screened for DM if they are ≥40 years old, at risk of non-communicable diseases, or pregnant or planning to get pregnant. Blood glucose tests are done by laboratory technicians and diagnosis is confirmed by medical officers if the fasting blood glucose (FBG) is ≥126 mg/dl on 2 separate occasions [4] [15]. If the readings are between 100 - 125 mg/dl, a 75 g oral glucose tolerance test (OGTT) is performed to confirm or exclude diabetes. If FBG results are ≤100 mg/dl the patient is checked again in the following year. In the absence of facilities for testing for autoimmune markers for type 1 diabetes, children and young adults presenting with classical symptoms of diabetes—rapid loss of body weight with polyphagia, polyuria and polyhydria with or without ketonuria in the presence of random blood glucose ≥ 200 mg/dl or fasting glucose ≥ 126 mg/dl and requiring insulin treatment to control hyperglycemia are classified as type 1 DM. Persons diagnosed with DM are clinically assessed for co-morbidities and complications and these data along with demographic and clinical information are recorded in either patient registration files (hard copy) or in the E-Health system in health centres implementing electronic medical records. At registration, information on risk factors such as smoking, alcohol intake, physical activity and obesity (defined as body mass index ≥ 30 kg/m^2) are recorded.

Patients are managed according to a standard algorithm defined in the UNRWA TI, [4] with diet and lifestyle advice and different classes of anti-diabetic drugs that include OADs namely Glibenclamide, Gliclazide and Metformin and Insulin injections. Patients with uncontrolled DM are seen weekly, fortnightly or monthly until their 2 h PPG value is ≤180 mg/dl and subsequently followed every 3 months. Once a year all DM patients undergo blood tests for total serum cholesterol and creatinine, urine examination for macro-proteinuria and dilated fundoscopic eye examination During quarterly visits, weight, blood pressure (BP), PPG value, as well as presence of complications (defined as blindness, end-stage renal failure, myocardial infarction (MI), congestive cardiac failure, stroke, and above-ankle amputation) are recorded.

2.3. Patient Population, Sampling Method and Size

There were 114,911 DM patients receiving care in UNRWA health centres at the end of 2011 [16]. A sample size of 1600 patients (50 from each selected health centre namely 400 from each field) *i.e.*, 14% of the total diabetes population in the UNRWA health system was considered sufficient to provide a representative sample. The first fifty consecutive patients visiting the selected clinic on assessment days with confirmed DM and receiving care at the same UNRWA NCD clinic for at least one year, were included in the study after they gave a written informed consent. Recruitment at the clinic was stopped on reaching the target of 50 patients.

2.4. Source of Data, Variables, Reporting Formats and Analysis

Patient data were obtained from paper and/or E-Health records and through direct interviews and recorded on the pre-tested DCF [9] [10] modified slightly to accommodate UNRWA TI and procedures. Variables included

in the DCF were DM type, risk factors, weight/height/waist measurements, blood pressure, and prior year's medical records including documented lab tests, complications, information on self-monitoring, health education and current medication.

The DCF was completed in the patient's presence. To remove bias and ensure consistency across the study sites all patients were interviewed and clinically examined by staff responsible for NCD care at UNRWA Headquarters and field offices: Chief of Disease Prevention and Control and the Field Disease Control Officer, respectively. A local staff nurse or a trained NCD nurse assisted with the examination, and the local laboratory technician withdrew blood samples and facilitated the transportation for HbA1c testing at a non UNRWA central lab at the Augusta Victoria Hospital in East Jerusalem. HbA1c test was done using the High-performance liquid chromatography (HPLC) method (HLC®-723G8 Tosoh Corporation, Japan). Data were transferred into a computer and analysed with Epi-info 2000.

2.5. Ethics Approval

Approval for the study was obtained from UNRWA Headquarters and the four Fields. Patients gave written consent for participation in the study.

3. Results

The characteristics of the 1600 patients included in the audit are shown in **Table 1**. The mean age (SD) of the patients was 56.6 (12.6) years, ranging between 2 to 90 years. 37.5% patients with type 2 diabetes were <55

Table 1. Study population characteristics and key findings.

Mean Age Years (±SD)	1600	56.6 (±12.6)
Mean Duration of DM Treatment Years (±SD)	1600	7.2 ± 4.9
Gender		
Female	1020	63.8%
Male	580	36.2%
Type of DM		
Type 1	68	4.3%
Type 2	1532	95.7%
BMI		
Underweight (<18.5)	18	1.1%
Normal weight (18.5 - 24.9)	137	8.6%
Overweight (25 - 29.9)	421	26.3%
Obese (≥30)	1024	64.0%
Comorbid hypertension	1102	68.9%
BP > 140/90 mmHg	490	44.5%
BP > 130/80 mmHg	792	71.8%
2 hr PPG result available	1515	94.7%
2 h PPG ≥ 180 mg%	799	52.7%
HbA1c tested during study	1600	100%
HbA1c ≥ 7.0%	1148	71.8%
S Cholesterol results available	1543	96.4%
S Cholesterol ≥ 200 mg%	614	39.8%
S Creatinine results available	1534	91.4%
S Creatinine > 1.2 mg%	98	6.4%
Proteinuria results available	1400	87.5%
Macro albuminuria + ve	144	10.3%
Fundoscopy results available	757	47.3%
Retinopathy + ve	83	11.0%

years. Two thirds of the entire patients were female (63.8%), which is in line with the gender distribution of patients attending UNRWA health centres (63.7%). Duration of DM treatment was used as a surrogate marker for DM duration and it varied considerably, ranging from 1 - 30 years, with a mean (SD) duration of 7.2 (4.9) years. People with type 1 DM (8.1 (4.9) years and type 2 DM with hypertension 7.8 (5.0) years) had longer treatment duration compared to type 2 DM without hypertension (5.9 (4.3) years).

Type 1 DM was seen in 68 (4.2%) cases, with a slight excess of females—37 to 31 males. Due to the selection criteria no case of gestational DM was included. Co-morbid hypertension was seen in 1102 (68.9%), all of them with type 2 DM. This data is similar to that seen in the entire UNRWA health system DM cohort in 2011.

Being overweight or obese was common in the study population, the mean (SD) BMI was 32.1 (6.4). Overall 90.3% were either overweight (26.3%) or obese (64.0%). Obesity was more common among women—73.1% compared to 47.9% among men. Smoking was more prevalent among men (34.1%) than women (11.3%). Few patients gave history of alcohol consumption.

In terms of record keeping and monitoring, data on age, gender, BMI, type of DM, duration and type of DM treatment, frequency and topic of health education sessions, and information on self-monitoring were available in all 1600 cases. Records of 2 h PPG, fasting serum cholesterol, serum creatinine and urine protein values in the previous one year were available in 94.7%, 96.4%, 91.4% and 87.5% cases respectively.

The most common treatment was OAD; 68.2% (1091) and 14.4% (231) were receiving OADs alone or in combination with insulin respectively. Insulin alone was used in 12.9% (207) cases and non-pharmacological lifestyle treatment (diet and exercise) alone in 3.9% (63) cases. Eight cases while attending the UNRWA health system were receiving treatment from outside. Of the 1322 cases on OADs, 89.3% (1181), 46.5% (615) and 18% (238) were receiving metformin, glibenclamide, and gliclazide alone or in combination respectively. Among subjects on insulin 72.5% were receiving < 60 IU/day and 77.8% were self-injecting. SMBG was reported by 32.6% of all and 66.2% with type 1 DM.

The mean (SD) 2 h PPG value for 1515 cases where information was available was 200.2 (74.5) mg/dl, with the range from 65 to 632 mg/dl. **Table 2(a)** and **Table 2(b)** show glycaemic control in relation to type of DM and type of treatment. In 44.4% cases the last recorded 2 h PPG was ≤180 mg/dl. The proportion of cases with acceptable control was similar for different types of DM and was highest among those on non-pharmacological treatment (81%), followed by those on OAD alone (47.9%); OAD in combination with insulin (31.6%) and insulin alone (30.9%)—a reflection of disease duration and severity.

Table 2. (a) Glycaemic control in relation to type of DM; (b) Glycaemic control in relation to treatment.

(a)

DM Type	Controlled		Uncontrolled		No Data		Total
	2-hr PPG (≤180 mg/dl)	HbA1c (≤7.0%)	2-hr PPG (>180 mg/dl)	HbA1c (>7.0%)	2-hr PPG	HbA1c	
Type 1	29 (42.6%)	5 (7.4%)	34 (50.0%)	63 (92.6%)	5 (7.4%)	0	68 (100%)
Type 2	183 (42.6%)	108 (25.1%)	226 (52.5%)	332 (74.9%)	21 (4.9%)	0	430(100%)
DM with HTN	504 (45.7%)	339 (30.8%)	539 (48.9%)	763 (69.2%)	59 (5.4%)	0	1102 (100%)
Total	**716 (44.8%)**	**452 (28.3%)**	**799 (49.9%)**	**1148 (71.7%)**	**85 (5.3%)**	**0**	**1600 (100%)**

(b)

Treatment	Controlled		Uncontrolled		No Data		Total
	2-hr PPG (≤180 mg/dl)	HbA1c (≤7.0%)	2-hr PPG (>180 mg/dl)	HbA1c (>7.0%)	2-hr PPG	HbA1c	
Lifestyle	51 (81.0%)	55 (87.3%)	4 (6.3%)	8 (12.7%)	8 (12.7%)	0	68 (100%)
OHA only	523 (47.9%)	355 (32.5%)	516 (47.3%)	736 (67.5%)	52 (4.8%)	0	430(100%)
OHA with insulin	73 (31.6%)	19 (8.2%)	149 (64.5%)	212 (91.8%)	9 (3.9%)	0	1102 (100%)
Insulin only	64 (30.9%)	18 (8.7%)	128 (61.8%)	189 (91.3%)	15 (7.2%)		
Total	**711 (44.4%)**	**447 (27.9%)**	**797 (49.8%)**	**1145 (71.2%)**	**92 (5.8%)***	**8 (0.5%)***	**1600 (100%)**

*Type of treatment not known in 8 cases.

The mean (SD) HbA1c was 8.3% (1.9). Using an HbA1c with cut off value of 7.0% as adequate control, only 27.9% cases were found to be under control, much lower than the 44.4% indicated by the last measured 2 h PPG value. When comparing results of HbA1c test with the last measured 2 h PPG values it was noted that while 86% of subjects with 2 h PPG ≥ 180 mg/dl had HbA1c values ≥ 7%, 56% of subjects with 2 h PPG ≤ 180 mg/dl also had HbA1c values ≥ 7%.

Results for serum cholesterol estimations were available in 96.4% (1543) cases; the mean fasting value (SD) was 191.8 (49.1) mg%. Hypercholesterolemia (≥200 mg%) was seen in 39.8% (614) cases. Results of serum creatinine test were available for 91.4% (1534) cases. The mean (SD) value was 0.865 (0.44) mg%. Elevated creatinine (≥1.2 mg%) was seen in 6.4% of all cases, 4.9% of type 1 DM cases, and 3.7% of Type 2 DM cases without hypertension but was twice as frequent in cases with hypertension - 7.5%. Urinary protein (macro albuminuria) estimation was done in 87.5% cases and was found raised in 10.3% cases.

Fundoscopy results were available for 757 cases (47.3%). UNRWA ophthalmologists had examined 408 (53.9%) and ophthalmologists from outside UNRWA had examined the remaining 349 (46.1%). There were 83 (11%) cases of retinopathy amongst those who had undergone fundoscopy.

The results of annual foot examination are shown in **Table 3**. Peripheral neuropathy was documented in 52.6% cases and was equally distributed among those with and without control based on the 2 h PPG results. Skin infections, both mycotic and bacterial, were documented in 17% cases.

There were 204 (12.8%) patients in the study population with late complications, 186 had one and 18 had two complications. No case had more than two late complications. Details of late complications are shown in **Table 4**.

4. Discussion

The clinical audit of the UNRWA Non Communicable Disease (NCD) Care Programme, with a focus on diabetes care validated the general UNRWA approach to health service delivery and confirmed its capacity to manage diabetes care in a primary health care setting. At the same time, it conducted an in depth assessment of protocols, procedures and performance in NCD care, documenting in particular the strengths of UNRWA diabetes care and more importantly, highlighting some critical shortcomings that will help define priorities for further improvement.

The clinical audit confirmed that UNRWA medical providers working in diabetes care generally follow the TI

Table 3. Results of foot examination.

Foot condition	Number (%)
Peripheral neuropathy	842 (52.6%)
Fungal skin infection	209 (13.1%)
Bacterial skin infection	63 (3.9%)
Healed ulcer/gangrene	30 (1.9%)
Absence of foot pulse	8 (0.8%)
Above ankle amputation	6 (0.4%)

Table 4. Late diabetes complications.

Late complication	Number (%)
Myocardial infarction	149 (9.3%)
Cerebral stroke	34 (2.1%)
Total blindness	23 (1.4%)
Amputation	6 (0.4%)
End stage renal disease	6 (0.4%)

rigorously. In terms of record keeping and monitoring, data on most parameters were available in over 90% cases including records of lab tests and clinical examinations performed in the last one year which is better than in similar studies done in other developing countries in tertiary care centres, albeit some years ago [10] [17].

Several shortcomings were identified some of which relate to financial constraints and the consequent effects on UNRWA TI and policy related to diabetes care. Only 45% of people with diabetes had 2 h PPG values within acceptable control (≤180 mg/dl) as defined by UNRWA TI. The control based on HbA1c testing (≤7.0%) was even lower at 28%, with the lowest control found in patients receiving insulin treatment (7.4%) and this is a cause of concern. Relying on 2 h PPG done only during clinic visit could be misleading. Non availability of HbA1c tests to monitor control due to cost constraints means that UNRWA has systematically overestimated its quality of DM control.

Comorbid hypertension was present in 69% (1102) cases and all of them were receiving antihypertensive medications. UNRWA TI defines blood pressure ≤ 140/90 mm Hg as the control target even for people with diabetes with co morbid hypertension. This level is higher than currently recommended International Diabetes Federation (IDF) and American Diabetic Association (ADA) target of ≤130/80 mm Hg for people with diabetes. Only 55.5% of cases with co-existing hypertension had their last recorded BP ≤ 140/90 mm Hg and only 28.2% had their BP ≤ 130/80 mm Hg. Hypertension control rates in this study are lower compared to the cumulative cohort data from six clinics in Jordan that use the E health record system where 87% of all patients had BP ≤ 140/90 mm Hg [7]. Uncontrolled hypertension in the setting of relatively poor glucose control is fertile ground for macro and microvascular complications particularly myocardial infarction, stroke, nephropathy and retinopathy. The fact that raised serum creatinine was seen twice as often in type 2 patients with co morbid hypertension and that 9.3% of cases had documented MI despite the relatively younger age, low prevalence of smoking and higher female gender mix in the study population points towards the need for more aggressive control of BP.

UNRWA TI defines the control target for total serum cholesterol at <200 mg/dl or <6.5 mmol/L. Cholesterol levels were elevated in 39.8% (614) cases. Because of financial constraints UNRWA cannot provide free treatment for hyperlipidaemia and as a consequence only half the patients (53.4%) with raised cholesterol were on lipid lowering drugs, most of them paying out of pocket. Including free supply of lipid lowering drugs, in particular, a statin and paying greater attention to lifestyle counselling will be necessary to address the risk of cardiovascular disease.

Insufficient focus on lifestyle counselling was another shortcoming identified. More than 90% of people with DM within the UNRWA system are either obese (64.0%) or overweight (26.3%). Around 70% have co existing hypertension and almost 40% have hyperlipidaemia as noted above and all these conditions are amenable to prevention through lifestyle measures; requiring greater attention to lifestyle counselling. According to UNRWA TI, patients should receive at least four health education sessions during assessment visits each year. The audit revealed that 17.6% patients received no self-care education and only 361 (22.6%) received four or more health education sessions, reflecting poor adherence to guidelines. Less than half the patients (40.6%) recalled receiving relevant lifestyle health education sessions (exercise and diet). Although foot complication rates are significant (e.g. 53% peripheral neuropathy and 13% foot infections), only 16% of patients recalled receiving foot care advice. The same applies for counselling on hypoglycaemia, even though 20% - 30% of patients were receiving insulin treatment. Better training, redefining roles and skilful deployment of non-medical health professionals may help improve self-care education and patient counselling.

The most prevalent early complication among patients was peripheral neuropathy seen in 52.6%. History of MI or undergoing angioplasty was noted in 9.3% cases and is similar to the 9.7% prevalence of MI among diabetic patients from the region reported earlier [18]. The high rate of MI reflects the need to address underlying risk factors and to strictly follow UNRWA's secondary prevention strategy for people with DM and hypertension with stricter monitoring of BP and glycaemia control using HbA1c and introducing the use of statins.

The findings of this study are almost identical to those reported from tertiary care centres in other developing countries using a similar study protocol [10] [17] [19]-[22]. This indicates that in general people with type 2 DM have multiple comorbid conditions—overweight and obesity, hypertension, and dyslipidaemia. Control of hyperglycaemia, hypertension and hyperlipidaemia is less than satisfactory and complications are high. In many of these studies, the proportion of patients undergoing annual laboratory tests and examinations were much lower indicating poor adherence to protocols; level of control for glucose, blood pressure and lipids was lower and complication rates higher.

The high prevalence of overweight or obesity and other risk factors in the study population points towards a need for a more comprehensive and strategic response that goes beyond the activities of the NCD care programme alone to address such fundamental issues and the recently applied Family Health Team reform [23] offers an ideal reference framework with focus on persons and families to address early prevention of disease by addressing family and community risk factors, early detection through systematic screening and provision of comprehensive care.

While more efforts are required to raise awareness and improve lifestyles through health promotion; the prevailing socioeconomic and psychological stress from the security situation in refugee camps poses a big challenge. Limited funding and need to prioritise scarce resources also places constraints on policy recommendations.

5. Conclusion

In conclusion, UNRWA's extensive experience in DM care in primary health care settings and the capacity, experience and rigour of their medical providers are a solid foundation on which to improve DM care. This study provides a basis to guide further actions aimed at modernizing and broadening DM care and address priorities for improvement by the UNRWA Health Department.

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Conflicts of Interest

None declared.

Author Contributions

Anil Kapur, Yousef Shahin and Akihiro Seita designed the study and wrote the first draft which was further developed by other authors. All authors contributed to the writing of the subsequent drafts and revisions of the paper, and all authors have read and approved the final paper for submission.

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Progressive β Cell Failure in Type 2 Diabetes Mellitus: Microvascular Pancreatic Isletopathy?*

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Abstract

Background: UKPDS suggested relentless deterioration of β cell function as a part of natural course of type 2 diabetes mellitus. However, the course was apparently not universal since many patients maintained glycemic goal (HbA1c < 7.0%) at 9 years while receiving conventional life style programs consisting of diet and exercise or/and oral agents. Moreover, β cell failure occurred around the same time as the time of onset of microvascular complications. Finally, the exact mechanism of progressive β cell failure remains to be defined. It is plausible that β cell failure may be due to fibrosis of pancreatic islets secondary to microangiopathy since no organ or tissue is exempt from this complication. Objective: To assess epidemiologic correlation between presence of β cell failure and microvascular complications by determining the prevalence of β cell failure in subjects with type 2 diabetes with increasing number of known microvascular complications. Methods: 650 Subjects with ages 40 - 75 years and duration of DM 4 - 23 years were divided into 4 groups according to number of microvascular complications, e.g. retinopathy, nephropathy, and neuropathy. β cell failure (β − ve) is defined as HbA1c > 7.0% with any therapy or HbA1c ≤ 7.0% with insulin, either monotherapy or in combination with oral agents. β cell function is deemed "preserved" (β + ve) with HbA1c < 7.0% with treatment consisting of life style program or/and oral drugs. Results: Prevalence of β cell failure progressively rose with increasing number of microvascular complications from 0 to 2 with no further significant rise with 3 complications whereas subjects with preserved β cell function declined with increasing number of microvascular

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complications ($p < 0.01$ for both groups). Significant relationships were also noted between the age and the duration of diabetes and prevalence of β cell failure ($p < 0.01$). The relative risks rose progressively for β cell failure/β cell preserved with increasing number of microvascular complications as well as the greater duration of Diabetes. However, a significantly ($p < 0.01$) higher relative risk for β cell failure persisted for rising number of microvascular complications even after eliminating the influence of age and duration of diabetes. Conclusion: β cell failure may be a manifestation of microvascular pancreatic isletopathy similar to other microvascular complications.

Keywords

Type 2 Diabetes, Beta Cell Failure, Pancreatic Isletopathy

1. Introduction

UKPDS suggested relentless deterioration of β cell function as a part of natural course of type 2 diabetes mellitus [1]-[3]. However, beta cell function rose promptly from 50% at diagnosis to 80% following treatment with sulfonylureas indicating induction of reversal in early duration in the course of the disease [4]. Several early studies have also demonstrated that sulfonylurea drugs improve insulin secretion and thus beta cell function in subjects with type 2 diabetes in the initial stage of the disorder [5] [6]. And more recently, other newer secretogogues; e.g., DPP4 Inhibitors and GLP1 analogs are also well documented to improve insulin secretion [7]-[13]. Thus, the decline in beta cell function noted at the time of diagnosis is apparently reversible. Moreover, several recent studies have documented apparent reversal of beta cell failure by reduction in the daily dose or even elimination of the requirement of insulin and/or oral antihyperglycemic drugs while attaining and maintaining desirable glycemic control following bariatric surgery in morbidly obese subjects with type 2 diabetes [14]-[16]. Similarly, reinitiation of oral agents and implementation of life style intervention including an appropriate diet and exercise with induction of weight loss also lowers the daily dose of insulin or eliminates the need for insulin in morbidly obese subjects with type 2 diabetes [17]-[22]. Therefore, these studies indicate that beta cell failure may not be irreversible even after prolonged duration of the disorder as emphasized in UKPDS but may actually be reversible. Finally, progressive beta cell failure suggested in UKPDS may be apparent rather than real because the gradual increase in the daily dosage of oral agents and insulin or need for use of multiple drug combinations required to maintain desirable glycemic control with increasing duration of diabetes may be actually secondary to rising insulin resistance due to weight gain [2] [3]. A similar observation was also noted in another "Adopt" clinical trial [23]. Finally, maintenance of desirable glycemic control (HbA1c $\leq$ 7%) at 9 years in 25% of patients treated with SUs, 13% in metformin group and 11% managed with conventional program with life style intervention alone suggest that progressive beta cell failure may not be universal [24]. Therefore, progressive β cell failure is neither universal, nor total, nor permanent and actually may be reversible. However, the exact mechanism of progressive β cell failure remains to be defined. It is plausible that β cell failure may be secondary to microangiopathy of the islets resulting in reduction in the number of β cells as well as deranged function of the remnant since no organ or tissue is exempt from this complication. Moreover, in UKPDS, β cell failure as reflected by rising HBA1c > 7.0 on oral agents occurred around the same time as the time of onset of microvascular complications [1] [2]. Therefore, we examined epidemiologic correlation between presence of β cell failure and well established microvascular complications.

2. Subjects and Methods

A retrospective study was conducted with a review of records of 650 subjects, 400 men and 250 women with a diagnosis of type 2 diabetes attending a diabetes clinic at Veterans Affairs Medical Center, Phoenix, Arizona between January and June 1996 as well as at Endocrinology clinic at University of Iowa Hospitals and Clinics, Iowa City, Iowa between October 1998 and June 1999. The study protocol was approved by research and development committees as well as institutional review boards at both institutions. We recorded the age, the duration of type 2 diabetes, HbA1c levels, treatment regimen consisting of life style modification consisting of diet and exercise or/and oral hypoglycemic agents (OHA) or/and insulin, as well as the presence of diabetes related microvascular complications: Neuropathy Retinopathy and Nephropathy.

The subjects were divided into 4 groups according to the number of microvascular complications: 0) no complication; 1) one complication; 2) 2 complications and 3) 3 complications. Furthermore, the subjects were also divided into 2 further sub groups according to their β cell function: 1) β cell failure (β − ve) defined as HbA1c > 7.0% with any therapy or HbA1c ≤ 7.0% with insulin, either monotherapy or in combination with oral agents and 2) β cell function "preserved" (β + ve) with HbA1c ≤ 7.0% while receiving treatment consisting of lifestyle intervention including diet and exercise or/and oral drugs. Statistical methods used were continuous data analysis by parametric procedures including Student's t-test, ANOVA and as assessment of relative risks. Frequency distributions were analyzed by Chi Square procedures. Univariate and multivariate analyses were conducted for determining relative risks between two and multiple variable factors respectively. Statistical significance was defined as $p < 0.05$.

3. Results

The mean age of the subjects was 61 ± 12 years with the subjects with beta cell failure being significantly ($p < 0.01$) older, 70 ± 8 years in comparison to subjects with preserved beta cell function, 52 ± 5 years. However, no significant correlation was observed between age and beta cell failure The average duration of type 2 diabetes for the entire cohort was 12.2 ± 8.7 years (range 5 - 45 years).However, the average duration of diabetes was significantly longer ($p < 0.001$) in patients with beta-cell failure when compared with subjects in whom beta cell function was preserved (**Figure 1**). Moreover, although no significant correlation was evident between the duration of diabetes on one aspect and number of subjects with beta cell failure on the other, beyond the duration of nine years, number of subjects with beta cell failure were significantly higher than the number of subjects with preserved beta cell function (**Table 1**). Finally, a distinct relationship was evident between the integrity of beta cell function and presence of microvascular complications (**Table 2**). The majority of subjects with no known microvascular complications manifested preserved beta cell function and the number of these subjects declined with increasing number of microvascular complications (**Table 2**). On the other hand, the number of subjects with beta cell failure progressively rose with increasing number of microvascular complications from 0 to 2 with no further significant rise with 3 complications (**Table 2**). Furthermore, the number of subjects with beta cell failure were significantly greater than number of subjects with preserved beat cell function even in presence of a single microcrovascular complication (**Table 3**). Finally, the relative risks progressively rose for the ratio, β cell failure/β cell preserved with increasing number of microvascular complications as well as the duration of diabetes (**Table 2**). However, the relative risks remained significantly higher for β cell failure with increasing number of complications even after eliminating the influence of age of the subjects and the duration of diabetes; RR ± CI vs 0 complication; 2.1 ± 0.2 for 1 complication; 3.1 ± 0.4 for 2 complications; 3.0 ± 0.3 for 3 complications ($p < 0.01$ for all correlations).

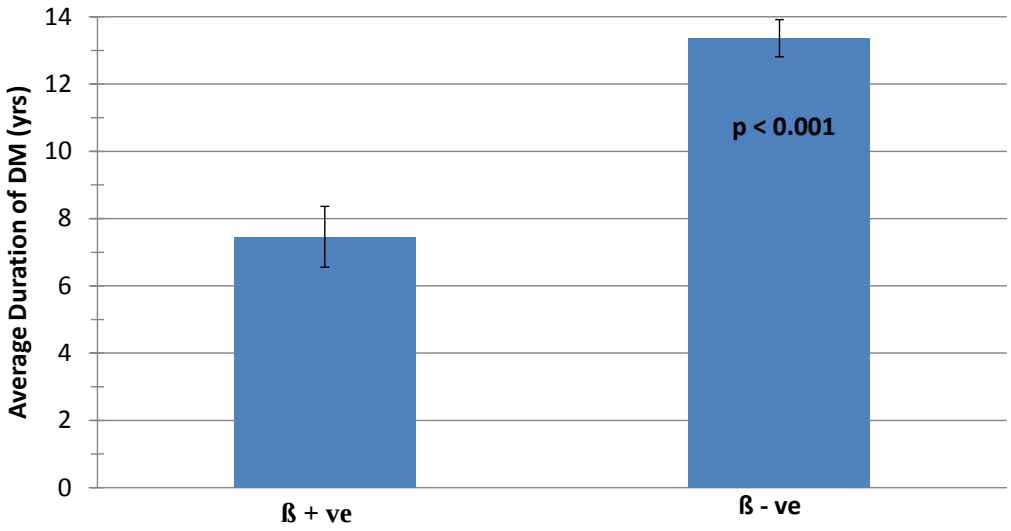

Figure 1. Duration of diabetes in subjects with preserved beta cell function (β + ve) and with Beta cell Failure (β − ve).

Table 1. Number of subjects (%) with preserved beta cell function (β + ve) and beta cell failure (β − ve) as well as proportion of β – ve/β + ve in groups divided according the duration (years) of type 2 Diabetes.

Beta cell function	0 - 9	10 - 19	20 - 29	>29
β + ve	72	18	6	2.0
β − ve	40	32	22	6.0
β − ve/β + ve	0.55	1.8*	3.6†	3.0†
RR ± CI‡		3.3 ± 0.39†	6.5 ± 0.84†	5.7 ± 0.68†

*p < 0.01 vs. group 0; †p < 0.001 vs. group 0; ‡RR (relative risk) ± CI (confidence interval) for β − ve/β + ve.

Table 2. Number of subjects with preserved beta cell function (β + ve) and beta cell failure (β − ve) as well as proportion of β − ve/ β + ve in groups divided according to number of microvascular complications (MC). % of patients are shown in parentheses.

No. of MC	0	1	2	3
β + ve	193 (65)	67 (34)*	12 (13)†	9 (14)†
β − ve	105 (35)	127 (66)*	83 (87)†	54 (86)†
Total	298 (100)	194 (100)	95 (100)	63 (100)
β − ve/β + ve	0.65	1.9*	6.7	6.2
RR ± CI‡		3.0 ± 0.22*	10.3 ± 0.77†	9.5 ± 0.65†

*p < 0.01 vs. group 0; †p < 0.001 vs. group 0; ‡RR (relative risk) ± CI (confidence interval) for β – ve/β + ve.

Table 3. Prevalence of individual microvascular complication (neuropathy, retinopathy, nephropathy) in subjects with type 2 diabetes divided according to beta cell function*.

Beta cell function	Neuropathy	retinopathy	Nephropathy
Beta cell preserved	23%	12%	15%
Beta cell failure	49%†	33%†	27%†

*Some patients manifested more than one microvascular complication. (**Table 1**) †p < 0.01.

4. Discussion

Progressive beta cell failure has been proposed to be the natural course of the disorder of type 2 diabetes [1]-[3]. However, the pathophysiologic mechanism of the progressive beta cell failure remains to be elucidated. A recent publication focused on several hypotheses regarding possible mechanisms and recommended a direction for future research [25]. Another recent study proposed oxidative stress to play a major role in induction of decline of beta cell mass via several mechanisms [26]. The average duration of diabetes in this study [26] in subjects with beta cell failure of almost 10 years is similar to the duration of diabetes over 9 years in the majority of subjects with beta cell failure in our study which demonstrated that beta cell failure may be related to the duration of diabetes as well. However, the prevalence of microvascular complications in this study [26] is not documented. We believe that the relationship between aging and duration of diabetes on one hand and beta cell failure on the other is similar to relationships between these 2 factors on one aspect and onset and progression of microvascular complications on the other [27]-[29]. Moreover, the progressive rise in number of subjects with beta cell failure and a gradual decline in number of subjects with preserved beta cell function with increasing number of microvascular complications noted in this study may indicate a distinct epidemiological relationship between beta cell failure and microvascular complications. Therefore, it is plausible that progressive beta cell failure may also be a microvascular complication involving beta cells themselves or pancreatic islets. We believe that onset and progression of beta cell failure may be secondary to by fibrosis of beta cells or pancreatic islets caused by a disruption of blood supply due to occlusion or narrowing of microvasculture of the islets as documented in an autopsy study [30]. The same mechanism may be responsible for oxidative stress in islets described in another

study [26].

Pathogenesis of microvascular complications in diabetes is attributed to deposition of advanced glycated products [31]-[33]. Deposition of Amylin, an Amyloid, a glycoprotein in pancreatic islets documented in type 2 DM [34] [35] may be similar to deposition of advanced glycated products causing microvascular involvement in other tissues and therefore may also be a causative factor in inducing fibrosis of pancreatic islets (isletopathy) with consequential reduction in beta cell mass and therefore insulin secretion.

Prevention or delay in onset of micrvascular complications by attaining and maintaining desirable glycemic control in both type 1 and type 2 diabetes is well established [36]-[42]. Therefore, achieving and preserving desirable glycemic control may also prevent and delay occurrence of beta cell failure "microvascular pancreatic isletopathy" as documented recently in subjects with type 2 diabetes treated with oral agents or insulin glargine over a 6 year period [36]-[42]. This hypothesis is also consistent with the documentation of a significantly longer period of preserved beta cell function (Honey moon Period) in subjects with type 1 diabetes in DCCT [43]. Moreover, persistent preserved beta cell function in many subjects with type 2 diabetes for upto 9 years noted in UKPDS adds credence to our hypothesis of "pancreatic isletopathy" [24]. Finally, a documentation of islet cell fibrosis in post mortem examination in subjects with type 2 diabetes [30] may be a further evidence of "macrovascular pancreatic isletopathy".

Therefore we propose that the onset and progression of beta cell failure in type 2 DM may be attributed to microvascular disease of the Pancreatic Islets (Isletopathy), similar to other microvascular complications and therefore may be influenced by glycemic control.

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Efficacy and Safety of Insulin Glulisine in Intensive Insulin Therapy: Bolus Insulin Adjust Nice Control by apiDRA Study (BANDRA Study)

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Abstract

Background: Treatment for postprandial glycemia using rapid-acting insulin analogues sometimes resulted in preprandial hypoglycemia or weight gain. Objective: This study evaluated the efficacy and safety of switching bolus insulin from insulin lispro (Lis) to insulin glulisine (Glu) in patients with inadequately controlled diabetes on intensive insulin therapy with Lis and glargine (Gla). Methods: Seventy-two outpatients with inadequate glycemic control (glycated hemoglobin [HbA1c] ≥ 7.0%, glycated albumin [GA] ≥ 20%) on intensive insulin therapy comprising Lis and Gla for ≥24 weeks were enrolled. We switched treatment from Lis to Glu with a stepwise increase in the dose by 1 unit per meal to obtain a GA level of ≤20% for 24 weeks, and the efficacy and safety were evaluated. Patients' treatment satisfaction was also evaluated using the Diabetes Treatment Satisfaction Questionnaire (DTSQ) after the treatment. Results: After switching from Lis to Glu, both HbA1c and GA levels significantly lowered from 8.26% ± 0.13% to 7.71% ± 0.13% ($P < 0.01$) and from 23.9% ± 1.8% to 21.4% ± 1.9% ($P < 0.01$), respectively. Furthermore, switching from Lis to Glu improved patients' treatment satisfaction; scores for 7 of the 8 items, such as "satisfaction" and "convenience" were significantly improved ($P < 0.001$), with no significant change in the scores for "improvement of hypoglycemia" ($P = 0.91$). Conclusions: Our present study suggests that switching bolus insulin from Lis to Glu by the addition of 1 unit of Glu per meal may be a use-

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ful treatment option for patients with inadequate glycemic control receiving intensive insulin therapy with Lis and Gla.

Keywords

Insulin Glulisine, Insulin Lispro, Intensive Insulin Therapy

1. Introduction

The purpose of diabetes management is improvement of quality of life (QOL) and healthy life expectancy by preventing the development or progression of blood vessel complications. Therefore, diabetes management is important for the management of macroangiopathy as well as microangiopathy including retinopathy, nephropathy, and neuropathy. Many studies have already reported a greater risk of coronary heart disease (CHD), including myocardial infarction and angina, in patients with diabetes than in individuals without diabetes [1] [2]. In particular, as an indicator of the risk of cardiovascular events, the 2-h postload glucose level on oral glucose tolerance test (OGTT) has been reported as important in the DECODE Study (Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe) [3], which is a meta-analysis of 13 cohort studies in the EU, and the Funagata Study [4] conducted in Funagata-cho in Japan. In contrast, in the Honolulu Heart Study [5], which included 6394 Japanese individuals living in Hawaii with no history of CHD or stroke, OGTT was performed in all cases and the 1-hour postload glucose level on OGTT results were analyzed. Results were that in the highest group of 1-h postprandial glycemia, death risk was approximately 3 times higher than the lowest group.

In this context, the International Diabetes Federation established the Guideline for Management of PostMeal Glucose that was the first guideline to emphasize the importance of the 2-h OGTT in 2007. The revised edition of the Guideline for Management of PostMeal Glucose in 2011 [6] proposed to conduct an examination of postprandial glycemia within 1 - 2 hours in order to inhibit blood vessel complications, to reduce it to less than 160 mg/dL (9.0 mmol/L) avoiding hypoglycemia. However, treatment for postprandial glycemia using rapid-acting insulin analogues such as insulin lispro (Lis) or insulin aspart (Asp) resulted in preprandial hypoglycemia or weight gain; therefore, an appropriate dose of bolus insulin could not be administered [7] [8].

On the other hand, insulin glulisine (Glu) exists largely as a monomer in products; in this form, it mimics the secretion of insulin more physiologically than Lis and Asp, as it is rapidly absorbed and immediately excreted in the bloodstream after subcutaneous injection (application document of Sanofi-Aventis: currently Sanofi).

In the Japanese clinical trial [8], it was reported that frequency of hypoglycemia decreased after switching from Lis to Glu at the same dose, and did not increase by the stepwise increase in Glu dose by 1 unit that was added to every meal. These results suggest that, by switching from Lis to Glu with 1-unit increments allows adequate bolus insulin provision to patients with inadequate postprandial glycemic control with Lis, without increasing the risk of hypoglycemia.

In this preliminary design of study, we aimed to assess the efficacy and safety of bolus insulin that was switched from Lis to Glu with an additional dose by of 1 unit per meal in patients receiving intensive insulin therapy with Lis and Gla.

2. Methods

2.1. Study Population

Subjects included 72 outpatients with type 1 (n = 21), type 2 (n = 48), and other type (n = 3) diabetes and inadequate glycemic control (glycated hemoglobin [HbA1c] $\geq$ 7.0% and glycated albumin [GA] $\geq$ 20%) despite intensive insulin therapy with Lis and Gla as bolus insulin therapy for >24 weeks under a fixed titration protocol; the dose of Lis and Gla was titrated in a stepwise manner to achieve a GA level of $\leq$20% on the discretion of the treating physician. Written informed consent was obtained from all patients.

The exclusion criteria were as follows: 1) need for hypoglycemic drug therapy besides Glu and Gla during the observation period; 2) history of hypersensitivity to Glu; 3) history of severe ketoacidosis or diabetic coma or precoma; 4) severe infectious disease or severe trauma after surgery; 5) pregnancy or suspected pregnancy; 6)

medical or family history of hypothyroidism and hereditary muscular disorders (e.g. muscular dystrophy); 7) history of drug-induced hepatic disorders; 8) drug or alcohol addiction; or 9) contraindications identified by the treating physician.

2.2. Study Design

This study was a single center, prospective, open-label, before-after study conducted from 1 April 2011 to 31 November 2013. We switched treatment from Lis to Glu with by the addition of 1 unit per meal at the time of presentation. Thereafter, the dose of Glu was increased in a stepwise manner to achieve a GA level of ≤20% on the discretion of the treating physician using the same titration protocol used for Lis. To compare the effects of Glu with those of Lis selectively, the dose of Gla was not changed for 12 weeks after switching. After improvement of HbA1c or fasting plasma glucose level was judged to be insufficient after 12 weeks, the dose of Gla was increased and levels were monitored for 24 weeks. After the insulin Gla plus Glu combination therapy, we evaluated patients' treatment satisfaction by using the Diabetes Treatment Satisfaction Questionnaire (DTSQ) [9] that included 8 items ("satisfaction", "improvement of hyperglycemia", "improvement of hypoglycemia", "convenience", "versatility", "recommendable to other patients", "understanding", and "treatment continuity") graded from −3 (mostly unsatisfied) to +3 (mostly satisfied), and compared the scores on the former treatment with insulin Gla plus Lis combination therapy. This study is registered with the University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR; Japan), number UMIN000008797.

2.3. Endpoints

The primary endpoints of this study were the change in HbA1c and GA levels after treatment, and the achievement of HbA1c level ≤ 7.0% and GA ≤ 20.0%. Secondary endpoints were the change in the GA/HbA1c ratio, body weight, insulin dose, and degree of patients' treatment satisfaction as evaluated by the DTSQ.

2.4. Statistical Analysis

The values were expressed as mean ± standard deviation (S.D.) or mean ± standard error (S.E.). Differences between two variables were examined using the two-tailed paired Student's *t* tests. $P < 0.05$ was considered statistically significant. All statistical analyses were performed with StatView version 5.0 for Windows (SAS Institute, Cary, NC).

3. Results

3.1. Patient Characteristics

Patient characteristics are shown in **Table 1**. Among the 72 patients with diabetes, 47 were men and 25 were women. Twenty-one patients had type 1 diabetes (including 1 with fulminant type 1 diabetes mellitus and 2 with

Table 1. Patient characteristics at baseline.

Characteristics	Patients (n = 72)
Sex (male/female)	47/25
Types of diabetes (type 1:type 2:other)	21:48:03
Age (years)	59.4 ± 14.0
Diabetes duration (years)	10.3 ± 6.0
BMI (kg/m^2)	22.4 ± 4.2
HbA1c (%)	8.26 ± 1.07
GA (%)	23.9 ± 6.1
Bolus insulin dose (IU/day)	22.3 ± 9.4
Basal insulin dose (IU/day)	10.1 ± 8.0

slowly progressive insulin-dependent diabetes mellitus), 48 had type 2 diabetes, and 3 had other types of diabetes (2 with post-pancreatectomy and 1 with steroid-induced diabetes). The mean age was 59.4 ± 14.0 years, mean duration of disease was 10.3 ± 6.0 years, mean body mass index (BMI) was 22.4 ± 4.2 kg/m^2, mean HbA1c level was 8.26% ± 1.07%, and mean GA level was 23.9% ± 6.1%. Before switching, the mean unit of basal insulin (Gla) was 10.1 ± 8.0 unit/day, and the mean unit of bolus insulin (Lis) was 22.3 ± 9.4 unit/day.

3.2. Changes in Clinical Parameters

Changes in HbA1c and GA levels are shown in **Figure 1** and **Figure 2**. The mean HbA1c level significantly decreased from 8.26% ± 0.13% before the switch to 7.71% ± 0.13% ($P < 0.01$) after 24 weeks. Significant decrease in the HbA1c level was seen in both type 1 and type 2 diabetic patients with levels that decreased from

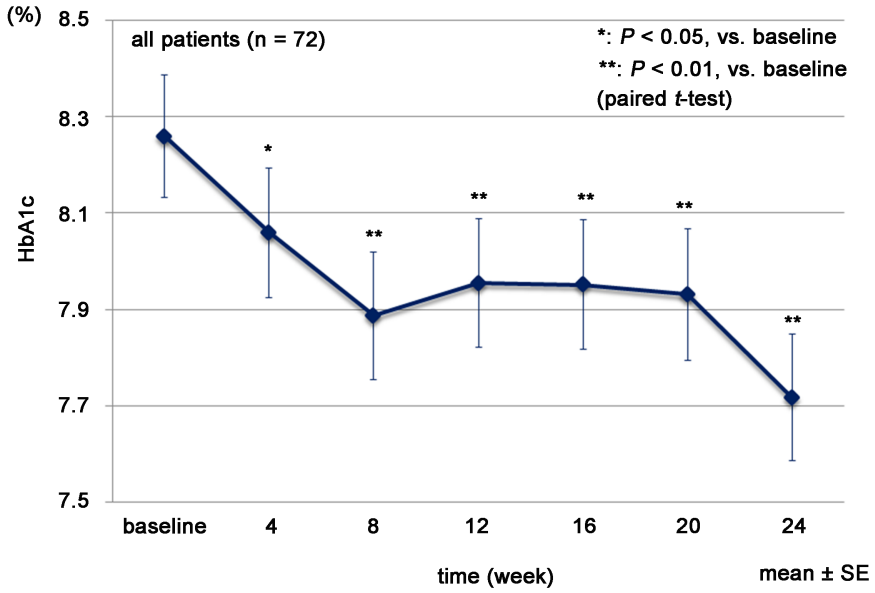

Figure 1. Changes in HbA1c from baseline after switching to insulin glulisine.

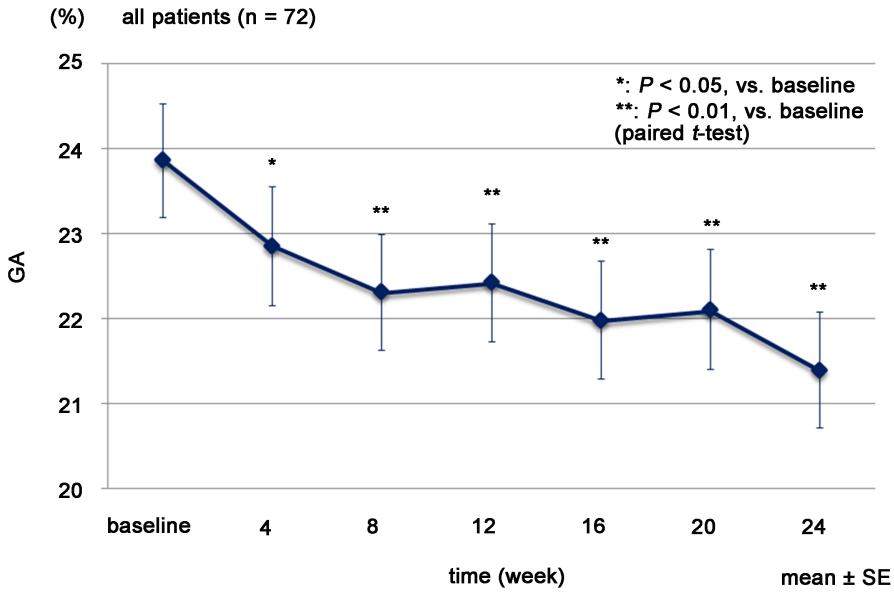

Figure 2. Changes in GA from baseline after switching to insulin glulisine. Abbreviations: GA, glycated albumin.

8.37% ± 0.26% to 7.99% ± 0.26% (P = 0.004) and from 8.20% ± 0.15% to 7.61% ± 0.16% (P < 0.001), respectively. Similarly, GA level significantly improved from 23.9% ± 1.8% to 21.4% ± 1.9% (P < 0.01). The proportion of patients who achieved HbA1c levels ≤ 7.0% and GA levels ≤ 20.0% was 24.6% (19/72) and 41.7% (30/72), respectively.

Switching from Lis to Glu did not significantly improve the GA/HbA1c ratio after 24 weeks (from 2.80 ± 0.6 to 2.68 ± 0.5, P = 0.12). Mean body weight increased significantly from 57.7 ± 2.8 kg to 58.1 ± 2.8 kg (P = 0.02) in patients with type 1 diabetes, although there was no significant change in patients with type 2 diabetes (from 69.8 ± 7.5 kg to 68.7 ± 8.5 kg, P = 0.91).

Changes in insulin dose are shown in **Figure 3**. In all patients, the bolus insulin dose significantly increased from 22.3 ± 1.2 unit/day of Lis before switching to 26.8 ± 1.2 unit/day of Glu after 24 weeks (P < 0.001). The dose of Gla as basal insulin increased significantly from 10.1 ± 1.00 unit/day to 10.6 ± 1.00 unit/day after 24 weeks (P = 0.04).

3.3. DTSQ

Although the scores of the DTSQ questionnaire did not significantly improve for "improvement of hypoglycemia" after switching (P = 0.901), all other 7 scores, namely "satisfaction", "improvement of hyperglycemia", "convenience", "versatility", "recommendable to other patients", "understanding", and "treatment continuity" significantly improved (P < 0.001).

4. Discussion

The therapeutic concept of intensive insulin therapy is aimed to substitute the complex pattern of endogenous insulin secretion in patients with diabetes. The key features of a normal insulin profile include a sustained and relatively constant basal level of insulin secretion, along with a meal-stimulated peak (30 - 60 min) of insulin secretion that slowly decays over the subsequent 2 - 3 h [10]. The aim of subcutaneous injections of rapid-acting insulin before meals (bolus injection) is to mirror this meal-stimulated insulin secretion, whereas the aim of retarded insulin preparations is to substitute the basal level of insulin secretion. However, regarding bolus injections in particular, it was reported that rapid-acting insulin analogues such as insulin Lis or insulin Asp result in preprandial hypoglycemia or weight gain [7] [8], which could be attributable to the pharmacokinetic (PK) and pharmacodynamic (PD) properties of these two rapid-acting insulin analogues. Namely, these subcutaneously injected rapid-acting insulin analogues have slow onset of action compared with physiological endogenous insulin secretion (with a peak metabolic effect at approximately 1 h post-administration) and a prolonged duration of action beyond 3 h [11] [12], which inhibits achievement of good postprandial blood glucose control without development of preprandial hypoglycemia.

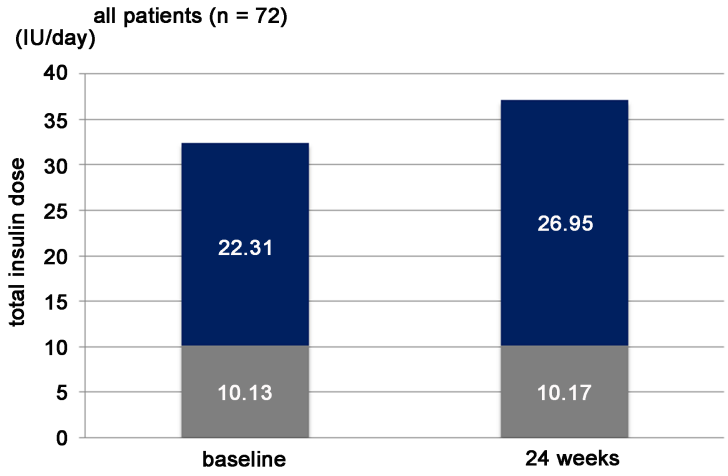

Figure 3. Changes in daily insulin dose from baseline after switching to insulin glulisine. Black and grey columns represent the mean total doses of bolus and basal insulin, respectively.

Glu (B3-Lys-29B-Glu-insulin) is a rapid-acting insulin analogue developed to more closely resemble the physiological post-prandial insulin release and therefore, improve prandial glycemic control [13]. Glu has a unique zinc-free molecular structure that differs from other rapid-acting insulin analogues by the replacement of asparagine at position B3 by lysine, and of lysine at position B29 by glutamic acid of the human insulin molecule, and exists largely as a monomer in products, which are key features for rapid absorption from subcutaneous tissues [14] [15]. Glu is rapidly absorbed and immediately excreted in the bloodstream after subcutaneous injection, has a shorter time to peak metabolic effect (approximately 30 - 60 min after administration) and a reduced duration of action within 3 h (application document of Sanofi-Aventis: currently Sanofi). Therefore, Glu could ensure a good postprandial blood glucose control without development of preprandial hypoglycemia. Some previous reports described Glu to have a faster onset of action than Lis, independent of BMI and dose, in non-diabetic subjects [16] [17], and to achieve significant lower glucose level deviations than Lis in patients with type 2 diabetes [10].

In this study, we enrolled 72 outpatients with diabetes with inadequate glycemic control despite intensive insulin therapy with Gla plus Lis for >24 weeks. Treatment was switched from Lis to Glu by the addition of 1 unit of Glu at every meal that was increased in a stepwise manner thereafter to achieve a GA level $\leq$ 20%. Six months after switching, both HbA1c and GA levels significantly lowered without any change in body weight. Furthermore, switching from Lis to Glu significantly improved patients' treatment satisfaction based on DTSQ, except for the "improvement of hypoglycemia", which did not show any significant changes despite the increase in bolus and basal insulin doses. We believe that the improved glycemic control after switching from Lis to Glu is mainly attributable to the reduced postprandial glucose deviations owing to the above-mentioned differences in the PK and PD properties between Lis and Glu. Our hypothesis is also partly supported by the non-significant reduction in the GA/HbA1c ratio, known to be a marker for postprandial glycemic excursion [18] [19]. The significant improvement in patients' satisfaction indicated by the DTSQ was probably associated with the improvement in blood glucose level control and the convenience of the simultaneous injection of Glu and Gla using the same injection devices (SoloSTAR®).

Study Limitations

The first one is the one-arm, open-label, before-after study design and the limited number of subjects studied. Therefore, the possibility that the *Hawthorn* effect was partly associated with favorable effects after switching from Lis to Glu cannot be excluded. Furthermore, the 6-months study duration may be a second limitation because we are unable to sufficiently assess the effect of seasonal variation in glycemic control [20], despite the relatively long-term entry period of this study protocol (2 years). The third limitation is that the titration protocol used before and after the switching could bring bias results because of the subjective decision-making by the treating physician, despite the four treating physicians and target GA level that they aimed were all same before and after the switching. The fourth limitation is that change in the frequency of hypoglycemia was only evaluated using the score of "improvement of hypoglycemia" obtained by the DTSQ. Self-monitoring of blood glucose or continuous glucose monitoring CGM [21] data are required for a more accurate comparison.

5. Conclusion

Our present preliminary design of study suggests that switching bolus insulin from Lis to Glu by the addition of 1 unit of Glu per meal may be a useful treatment option for type 1 and type 2 diabetic patients with inadequate glycemic control receiving intensive insulin therapy with Lis and Gla, and can improve patients' treatment satisfaction without increasing the risk of hypoglycemia. However, to confirm these findings, a parallel-group comparison analysis in a larger population for a longer duration and using more detailed clinical parameters is warranted.

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Conflict of Interest

Y. Bando has received honoraria for consulting and lecturing from Sanofi-Aventis, Novartis and Eli Lilly. Other authors have no conflict of interest statement.

Compliance with Ethics Guidelines

The study was approved by the Ethics Committee of Fukui-ken Saiseikai Hospital.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 and 2008. Informed consent was obtained from all patients for being included in the study.

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Holistic Evaluation of the Morbidity Due to Diabetes Mellitus Type 2 and Its Main Risk Factors in the State of San Luis Potosi, Mexico

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Abstract

Objective: To evaluate the morbidity due to diabetes mellitus type 2 within the State of San Luis Potosí, México, through a strong methodology, through which the multivariate relations were identified of the main social and environmental determiners in the disease, thus managing to quantify their respective levels of responsibility. Material and Methods: This evaluation began as a hypothesis of a multicasual theoretical model on diabetes mellitus and its main determining factors, which was analyzed through the application of multivariate exploratory statistical methodologies and confirmed as it is the case of the principal components analysis and the structural equation models. Results: Three components were extracted that explain the 96% of the total variance of the indicators; the main risk factors which were identified in the first component were, the use of the car, age, homes with TV use, urban life and feminine population; the indicators from the second and third component have little influence in the impact of the disease. Conclusions: the study shows the usefulness of the model for the analysis and prioritization of the environmental and social determiners of the disease, information that could sustain the design of public guidelines for the prevention and control of the analyzed disease.

Keywords

Diabetes Mellitus, Risk Factors, Multivariate Analysis

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1. Introduction

Diabetes Mellitus is a chronic illness that appears when the pancreas does not produce sufficient insulin or when the body does not use it effectively [1]. Diabetes mellitus type 2 represents a serious health problem in the world; there were 387 million people with diabetes in 2014 and 4.9 million died due to this [2]; in Mexico there were 6.4 million adults with diabetes [3].

There are multiple risk factors that have been associated with diabetes, such as obesity, age, gender, belonging to a certain ethnic race, level of education, income, life conditions, access to health services and urbanization [4]. Also it is associated with factors as family history of diabetes, overweight, unhealthy diet and physical inactivity among others [5].

Several factors associated to diabetes mellitus type 2 have been analyzed (MDMT2); such is the case of an ecological study in obese adults older than 20 from 183 countries in which a positive relation between diabetes prevalence and a low income was found ($p = 0.011$) [6]. This was also confirmed by another transversal study in which it was identified a prevalence in diabetes mellitus type 2, 4.11 times higher in the group with a low income than that of a high income [7]. At the same time, it was found a higher prevalence of diabetes in people with a lower educational level ($p < 0.001$) [8]; as well as in people who belong in a 65 to 74 years old range ($p < 0.001$) [9]. Deo and Col [10], found that the percentage of diabetics increased systematically with the age, finding a 1.69% of diabetics in the age group of 21 to 30 and a 20.9% in the 61 years and more group. Also, it is reported that obese people have a higher risk of suffering from diabetes than those at an average weight, basically women, (2.52 times) as for men (2.13) [11]. At the same time, it is described that some people with a family history of diabetes have a 2.9 times higher risk than those who do not have it and those with no physical activity have a 1.6 times higher risk than those that do some type of exercise [8]. On the other hand, it was identified that the residents of urban areas have more prevalence in diabetes than those on rural areas ($p < 0.002$) [6] [9].

Hu and Col [12] reported that spending two or more hours per week watching television represents a risk factor to acquire diabetes. They also estimated that the risk increases 1.23 times for five hours and two times more for 40 hours ($p = 0.000$).

The cited studies show an analysis of different risks factors and their relation with MDMT2 from a lineal perspective, without taking into account the possible multivariate relations, as a whole and simultaneously among them.

The present work proposes a robust methodology from of which we can achieve the integration of two multivariate methodologies: the principal components analysis components (PCA) to explore and identify latent variables and reduce the dimension of indicators; and a structural equation model (SEM) to confirm the identified structure through PCA as well organizes hierarchically the load of the factors upon MDMT2; which can generate integral information to support more effectively decision making, that incite in the decrease of this illness. Successful analysis have been carried out using this methodological tool in different fields of study as the confirmation of an explicative model of stress and its relation with psychosomatic symptoms trough structural equations [13], as well as to predict the well-being and the functional dependence of elderly people [14].

In accordance with the previous paragraph, the objective of the present research consists in evaluating MDMT2 in the State of San Luis Potosi, Mexico, with a methodological approach that would allow identifying the main social and environmental determiners of the illness, as well as their multivariate relations for the generation of integral proposals for prevention and effective actions directed to the solution of this health problem.

The basis for this study is the design of a theoretical model, of the main factors that determine MDMT2 (**Figure 1**); this model reflects the observable factors diversity and/or measurable as well as latent variables that are not observable nor measurable directly, due to the nature of the problem; it is necessary the use of specific multivariate techniques that would allow carrying out the analysis as the PCA and SEM.

2. Material and Methods

The State of San Luis Potosí is located in the North central region of the Mexican republic, it has a territorial span of 60,933 km^2 and it is the Fifthteen State to its extension of the Mexican Republic. It has 58 counties with are distributed in four main geographical regions: Altiplano, Centre, Huasteca and Media [15].

A study was carried out to identify the main social and environmental determiners of the MDMT2 and their multivariate relations in the State. A theoretical multicasual model was designed of the MDMT2 and its main

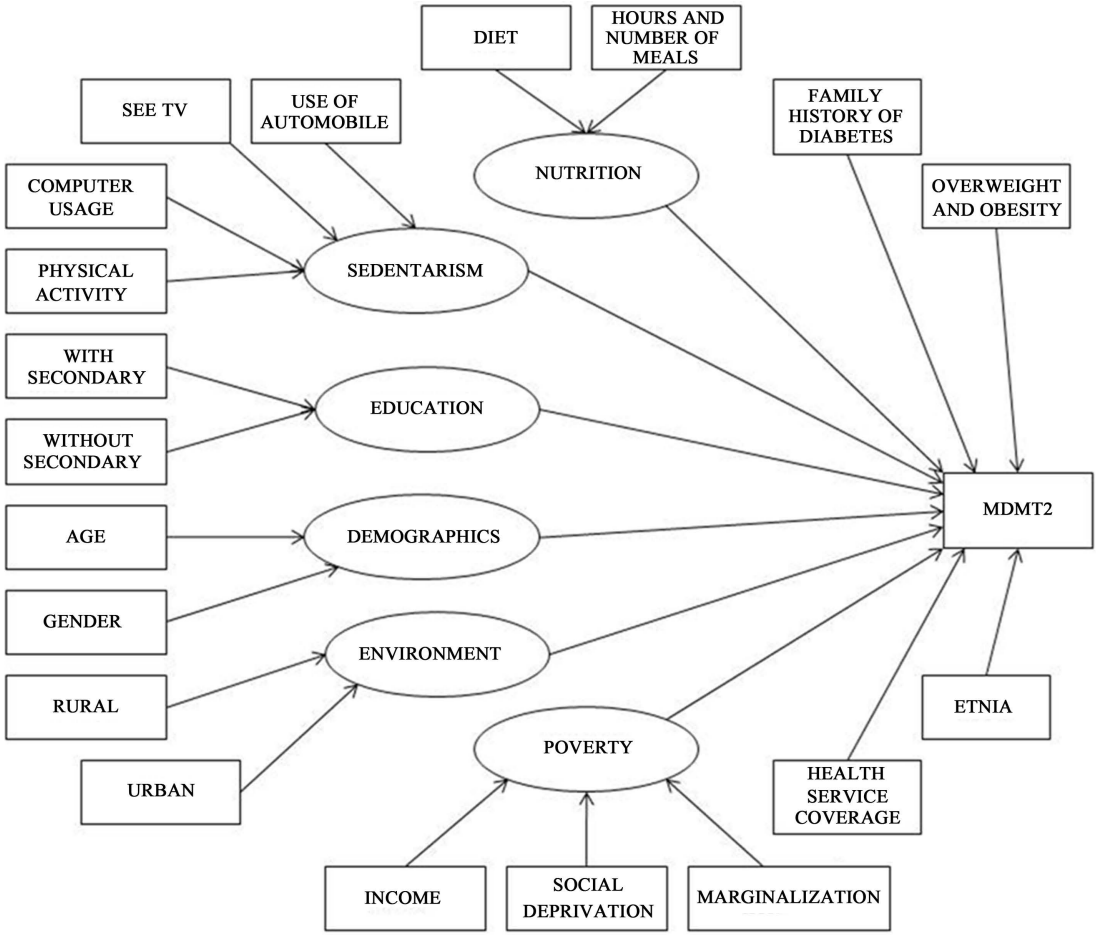

Figure 1. Theoretical model of determinants related to MDMT2.

determining factors based on the revision of the published studies that identify them as determinants of the illness (**Figure 1**), based on such scientific evidence and by availability of information, 17 indicators were selected (**Table 1**).

The population in the study was grouped in the following age ranges: 20 to 44, 45 to 49, 50 to 59, 60 to 64, 65 years and older; from the years 2005 and 2010, with data from the 58 counties that conform the State of San Luis Potosí.

Statistical Analysis

An outlook for the state was generated using the indicators signaled and the rates for MDMT2 by gender and age groups. An exploratory factorial analysis was used through the multivaried methodology for PCA in order to identify components or suppress variables (24).

The level of colineality among the indicators were evaluated through the determinant of the matrix of correlation, a value of the determinant nearing cero indicates the high existence of colineality. The Kaiser-Mayer-Olkin test was used to evaluate the adequacy of the sample, comparing the magnitudes of the observed correlation coefficients with magnitudes of partial correlation coefficients, this statistic takes values between 0 and 1, values higher than 0.70 indicate that sample is adequate for utilize PCA [24]. Barlett's sphericity test, was used to reject the hypothesis that the correlations matrix and the identity matrix are equal [25]. The explained total variation table was generated to identify the number of components with eigen-values higher than 1, as well as the percentage of the variance that they explain [24] [25]; and the sedimentation graph as a support to determine the optimum number of components to be included in the solution [24].

It was worked with a matrix of rotated components by the Varimax method in order to facilitate the interpreta-

Table 1. List of used indicators.

Code	Name	Description
MDMT2	Diabetes*	New cases in the year from diabetes mellitus type 2 [16].
IND1	Female population*	Number of people from the female gender [17] [18].
IND2	Male population*	Number of people from the male gender [17] [18].
IND3	Ages 20 to 44	Number of people from 20 to 44 years of age [17] [18].
IND4	Ages 45 to 49	Number of people from 45 to 49 years of age [17] [18].
IND5	Ages 50 to 59	Number of people from 50 to 59 years of age [17] [18].
IND6	Ages 60 to 64	Number of people from 60 to 64 years of age [17] [18].
IND7	Ages 65 and older	Number of people 65 and older [17] [18].
IND8	Urban population*	Number of people in localities ≥ 2500 habitants [17] [18].
IND9	Rural population*	Number of people in localities < 2500 habitants [17] [18].
IND10	Automobiles	Automobiles that are registered in circulation [19].
IND11	Homes with TV	Number of houses with TV [17] [18].
IND12	Without secondary*	Population without secondary school [17] [18].
IND13	Without health care*	Population without right to public health care [20].
IND14	Income**	Population % that earns up to 2 minimum wages [21] [22].
IND15	Indigineou population*	Population that speaks an indigenous tongue [17] [18].
IND16	Marginalization**	Marginalization index [21] [22].
IND17	Social deprivation**	Social deprivation index [23].

*Population ≥ 20 years of age; **Open population.

tion of the loads that the indicators have in the extracted components [24] [25]. For the processing and analysis the SPSS version 18 statistical program was used [26]. Subsequently, a confirmatory analysis with multivariate technique (SEM) was developed to evaluate the described model for the PCA results. The development of the model was carried out in the Amos software version 20.

A sequence diagram was constructed to facilitate the design of casual relations and the relation between the components and indicators, parting from this, the model was created. The three components extracted in the PCA, became non-observable latent variables and the MDMT2 became the endogenous variable, in the structural model. The measurement model was specified to indicate the indicators each component.

The sample was of 116 and the model included 23 non-observable variables (three components and 20 estimated measuring errors), therefore, it was complied with what was recommended, at least five observations per estimated parameter [25].

As entry data, the correlations matrix was used, and for the estimate of the model the maximum likelihood technique was applied and the direct estimation process. The procedure was carried out 14 times to estimate the maximum likelihood and to find the best possible adjustment.

The infringing estimates were validated, identifying three with a negative variance in the measuring error, so three constraints were added and these variances were fixed with a value of 0.005 [27] [28]. The validity of the model was done through the degrees of freedom, that according to condition and order, these must be higher of equal to zero [25].

To evaluate the overall fit of the model, the likelihood ratio chi-square statistic was examined, to measure the correspondence between the correlations matrix actual input or observed with that it is predicted by the proposed model. This indicator resulted too high in comparison with the degrees of freedom, which indicates that among the observed matrixes and those, estimated there is a significant difference, therefore this evaluation was completed with other fit measures [29].

The validation for the integral model was carried out as a whole in order to identify the degree in which the specified indicators represent the assumptions constructs, for that absolute fit measures, increasing and parsimony were used (**Table 2**) [25].

Finally, to evaluate the fit, the values obtained from the indexes were catalogued in accordance to the scale: low grade (0.000 - 0.333), average (0.334 - 0667) and high (0.668 - 1.0); in accordance to results published by another study [33].

3. Results

As it is shown in **Table 3**, the rate for diabetes (MDMT2) showed a global decrease of 0.9 cases per 1000 habitants between 2005 and 2010, nevertheless, such decrease was higher in female population (0.6 cases/1000 hab.)

Table 2. Measures used to validate the integral model.

Fit measures	Indicator	Values that show a good fit
Absolute	likelihood ratio chi-square statistic (X^2) [24] [25]	$p > 0.05$ [24]
	Goodness of fit index (GFI) [24] [25]	>0.90 [24]
Incremental	Trucker-Lewis index (TLI) [25]	>0.90 [25]
	Normed fit index (NFI) [24] [25]	>0.90 [24]
	Relative fit index (RFI) [24] [30]	>0.90 [24]
	Incremental fit index (IFI) [24] [31]	>0.90 [24]
	Comparative fit index (CFI) [24] [32]	>0.95 [24]
Parsimony	Parsimonious normed fit index (PNFI) [24] [25]	>0.50 [24]
	Parsimony goodness of fit index (PGFI) [25]	>0.90 [25]
	Parsimonious comparative fit index (PCFI) [24]	>0.50 [24]

Table 3. State scenario of the used indicators. San Luis Potosí, México.

Code	Indicator name	Year	
		2005	2010
MDMT2*	Diabetes rate[a]	8.7	7.8
IND1*	Female Population[b]	53.0	52.5
IND2*	Male population[b]	47.0	47.5
IND3	Ages 20 - 44[b]	62.5	60.9
IND4	Ages 45 - 49[b]	8.5	8.7
IND5	Ages 50 - 59[b]	12.4	13.3
IND6	Ages 60 - 64[b]	4.9	4.8
IND7	Age 65 and older[b]	11.7	12.3
IND8*	Urban population[b]	64.8	65.6
IND9*	Rural population[b]	35.2	34.4
IND10	Automobiles[c]	12.0	17.1
IND11	Homes with TV[b]	86.2	88.0
IND12*	Without secondary school[b]	2.7	2.9
IND13*	Without health care[b]	47.5	27.2
IND14**	Income[b]	56.1	46.7
IND15*	Indigenous population[b]	11.0	10.7
IND16**	Marginalization[d]	high	high
IND17**	Social deprivation[d]	high	high

*Population ≥ 20 years; **Open population; [a]Rate per every 1000 habitants; [b]Percentage; [c]for every 100 habitants; [d]Grade.

that in the male population (0.3 cases/1000 hab.). at the same time, in the age group of 50 to 59 (IND5) there was also a decrease in the incidence rate of the illness (**Table 3**). On the other hand, some indicators, such as, urban population (IND8), percentage of homes with TV (IND11) and number of automobiles that are registered in circulation per every 100 habitants (IND10), increased in 0.8%, 1.8% and 5.1% respectably.

In **Figure 2** it is shown a State scenario for MDMT2 where it can be seen that the tendency of the global rates were higher in the year 2005 than in 2010 in all the age groups, women had a higher rates than men did in the two time lapses analyzed; and in all the analyzed series the age group from 60 to 64 years, resulted with the highest rates.

The results of the tests of viability of PCA were as follows: a) Beginning with the Barlett sphericity test and the determinant from the correlations matrix was identified a high level of colineality among the analyzed variables (determinant = 1.23E−35), presenting a significant difference in relation to the identity matrix (Chi^2 = 8722.03, df = 136, p = 0.000); b) with the Kaiser-Meyer-Olkin test (KMO = 0.82), it was determined that the correlations are adequate to apply the PCA.

The male population indicator was removed from the analysis since it was in perfect correlation (r = 1) with the female population index and it was worked with a matrix of 17 × 17. In **Table 4** shown the total variance explained by each component, achieving extract three components that explain the 96% of the accumulated variance the total data.

In **Figure 3** can be observed that as of the fourth component, the slope is almost nonexistent, therefore only the three first components should be taken into account to represent the indicators group.

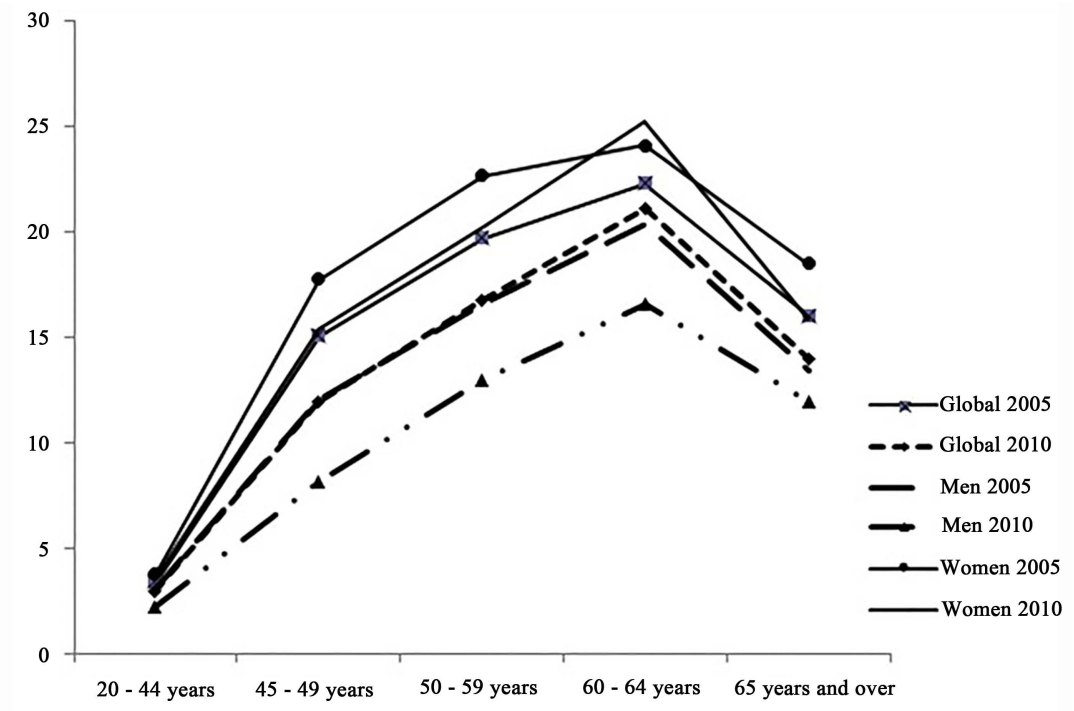

Figure 2. Rates of MDMT2 per every 1000 habitants ≥ 20 years in the State of San Luis Potosí, México.

Table 4. Total variance explained by each component, of the variance of the original indicators.

Component	Initial eigen-values		
	Total from the variance	% from the variance	% accumulated
1	12.718	74.810	74.810
2	2.539	14.933	89.743
3	1.070	6.297	96.039

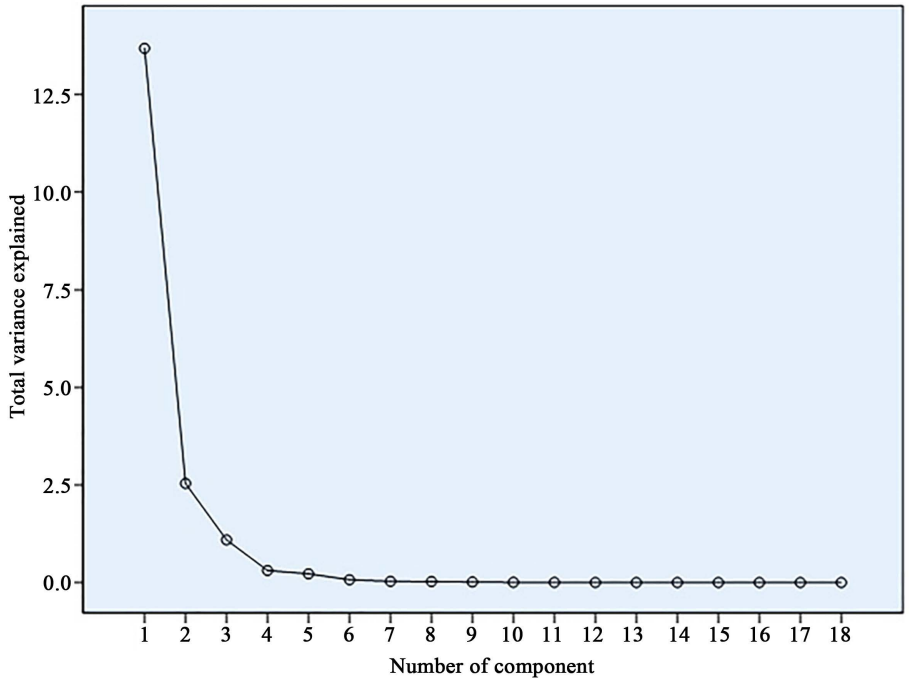

Figure 3. Sedimentation curve for the determination of the number of components extractable.

In **Table 5**, it is shown the matrix of rotated components by the varimax method which describes clearly the saturations of the indicators in each of the three components. According to this, the first component was formed by 11 indicators that on the whole explain 75% of the incidence rate evaluated in diabetes, being in order of importance in accordance to their multivariate correlations (attributed weights) the following: usage of automobiles (IND10 = 0.973), age groups 45 - 49 and 50 - 59 (IND4 = 0.968, IND5 = 0.965), urban population (IND8 = 0.965), female population (IND1 = 0.963) age group 60 - 64 (IND6 = 0.962), homes with TV (IND11 = 0.962), age groups 20 - 44 and 65 years or older (IND3=0.959, IND7 = 0.953 respectably), population without health care (IND13 = 0.929) and population without secondary school (IND12 = 0.923). In the second component, with a level of attribution to the illness of 15% the following indicators were identified: High marginalization (IND16 = 0.924), Social deprivation (IND17 = 0.918) and low income (IND14 = 0.857), whereas in the third component with a level of attribution of a barely 6%, the indicators included were: rural population (IND9 = 0.902) and indigenous population (IND15 = 0.847).

On the other hand, the confirmatory model was formed with 40 variables, 17 observable and 23 non-observable; 20 endogenous variables and 20 exogenous; and 133 degrees of freedom.

Figure 4 shows the integral model, the measuring errors (e1, … e20), the weights of the standardized regression coefficients for each indicator and the effects of the components on MDMT2.

According to the results of the structural model, the indicators of the first component represent a risk factor for MDMT2, since, for every increase of one unit in the first component; the diabetes increase rate will suffer an increase of 0.92 units, considering the synergy among the 11 indicators and their respective measuring error.

On the other hand, the indicators of the second and third component showed a very poor effect on MDMT2, showing for each unit increase in the second and third component, increased diabetes incidence rate of 0.02 and 0.01 units, respectively.

In **Table 6** it is shown the statistical values that were used to assess model fit.

4. Discussion

Being diabetes a multifactorial illness, it is of great importance to study it and analyze it through multivariate models that allow us to know the load of the factors that determine it, since the methods that have been used do not allow us to face it adequately [34]. The PCA placed the official available indicators considered in the study, in three components in accordance to the multiple correlations among them, it also identified that the indicators

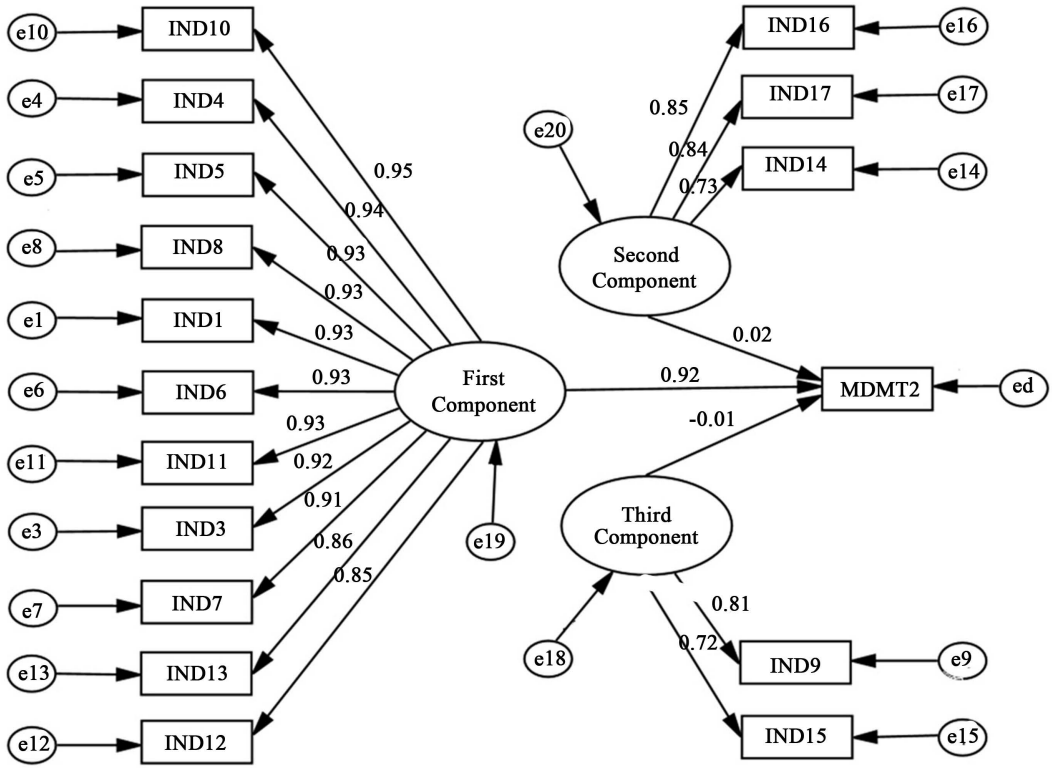

Figure 4. Structural model of the multivariate relations between MDMT2 and its social and environmental determinants obtained from SEM.

Table 5. Rotated component matrix by the Varimax method from PCA that shows the saturations (correlations) for each evaluated indicator in the different components extracted.

Code	Name of the indicator	Component		
		1	2	3
IND10	Automobiles	0.973		
IND4	Age 45 - 49	0.968		
IND5	Age 50 - 59	0.965		
IND8	Urban population	0.965		
IND1	Female population	0.963		
IND6	Age 60 - 64	0.962		
IND11	Homes with TV	0.962	−0.258	
IND3	Age 20 - 44	0.959		
IND7	Age 65 and older	0.953		
IND13	Without health care	0.929		0.280
IND12	Without secondary school	0.923	−0.259	
IND16	Marginalization	−0.298	0.924	
IND17	Social deprivation		0.918	
IND14	Income	−0.338	0.857	
IND9	Rural population	0.257		0.902
IND15	Indigenous population		0.327	0.847

Table 6. Validation indicators of integral model fit.

Fit measures	Indicator	Value	Grade		
			Low	Average	High
absolute	Chi-square authenticity ratio	3367.6 (133 df)	X		
	GFI	0.298	X		
incremental	TLI	0.637		X	
	NFI	0.636		X	
	RFI	0.628		X	
	IFI	0.645		X	
	CFI	0.645		X	
parsimony	PNFI	0.622		X	
	PGFI	0.259	X		
	PCFI	0.631		X	

GFI: Goodness of fit index; TLI: Trucker-Lewis index; NFI: Normed fit index; RFI: Relative fit index; IFI: Incremental fit index; CFI: Comparative fit index; PNFI: Parsimonious normed fit index; PGFI: Parsimony goodness of fit index; PCFI: Parsimonious comparative fit index.

of the first component have a high correlation with diabetes, whereas the second and third have little.

The first component explains almost 75% of the total variance, the order of the indicators that make it up in accordance to the correlations coefficient multivariate is: automobiles in circulation, the different age groups, urban population, female population, homes with TV, population without health care and without secondary school studies; these indicators can be attributed them the greatest percentage of weight in the incidence rates for diabetes mellitus type 2, while the ones in the second component (marginalization, social depravation, income) and third component (rural population and indigenous population) can be attributed little weight.

This is confirmed by the structural model, that shows the hierarchy of the components in accordance to the effect that they have on MDMT2 and on that of the indicators, based on the weight that it represents over their respective component, thus, the ones in the first component (effect = 0.92) are the most important ones. The second and third components have an effect of 0.02 and −0.01 respectably over MDMT2 which it is not significant, therefore the indicators that conform it are not very relevant for the illness, nevertheless, Kuhmbou [6] and Dinca-Panaitescu and col [7] reported that a low income was in relation with high levels of diabetes, non the less this authors used lineal regression methods and logistics that may only evaluate casual lineal relations, whereas in the present study multivariate relations were analyzed of the different factors simultaneously, considering the measuring error.

Different studies confirm the associations that the model identified, but on a lineal manner, the results of this study are in accordance in an indirect way with those of Bener and Col [8] and Escolar [11], who reported that obesity is a risk factor for the development of the illness; on the other hand, the time that the population spends in the car is an indicator of obesity [35], in this study it was estimated in an indirect way, through the number of automobiles that are registered in circulation, this indicator resulted as a risk factor as well. Also, a relation was found between diabetes and the age; in other studies this relation was also identified [6] [8]-[10]. Another finding was that living in an urban area is also a risk factor, which also coincides with other reported results [6] [9].

Also, it was identified that being a female is a risk factor to suffer diabetes, which also coincides with other studies [7] [10]. It was also identified as a risk factor the time that the population watches television; this was estimated through the number of habited houses that have a TV, this coincides indirectly with other studies [12].

Bener and Col [8] published that a low educational level is a risk factor, in this study a similar result was obtained, and it was also found that not having health care in public institutions is a risk factor, this coincides with what was published by the PAHO [4].

In the analysis, some indicators were not considered which are relevant, as determinants of MDMT2, since official sources do not have a register on these. According to the theoretical model taken as a base for this study (**Figure 1**), the following risk factors were not included: overweight and obesity [4] [5] [11] [35] family diabetes

background [5] [8], nutritional aspects such as diet type, number of meal per day and their schedules [4] [5], time spent in: physical activities [4] [5] [8], watching television [12] and the use of computers [4] [5] [36].

In future investigations it would be important to consider all of these indicators in order to achieve a more complete analysis and improve decision making, it is possible that when included in the analysis, some of the ones placed in the first component would be moved to another component of lesser importance.

According to the 2012 ENSANUT, in the State of San Luis Potosi, from 2006 to 2012 there was an increase of 3.8% in diabetes mellitus prevalence in adults ≥ 20 years [37], which demonstrates that the prevention and control strategies for the illness must improve. At the same time, the program for prevention and control for diabetes that is currently at work in the state [38], focuses its actions in adults ≥ 20 in general, therefore the integral results obtained in the study may be used to sustain strategies that would improve the different national programs for the prevention and control of DMT2 [38] [39].

5. Conclusions

The structural model shows its utility for the evaluation and hierarchy of the social and environmental determinants for MDMT2; this information may sustain the design of strategies and public policies for the prevention and control of the illness, which have to be directed mainly to the factors which integrate the first component, considering as well the order of importance of such factors to the interior of the same component according to their level of attribution with such illness, besides being planned and carried out taking into account in a holistic way all of these factors. On the other hand, the health system should have a database of all the indicators related to diabetes in order to carry out complete integrals analysis and improve decision making.

Finally, we consider it important to emphasize in the necessity of to work, in the design of indicators that allow us to incorporate aspects related to nutritional habits of the population at risk, to achieve assess their levels of attribution in the high rates of diabetes. Currently it does not have this information.

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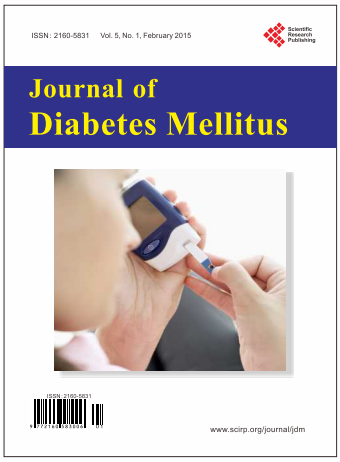

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