

STATISTICAL ANALYSIS OF THE NEXUS  
BETWEEN DIETARY HABITS AND  
PRACTICES WITH CLINICAL OUTCOME IN  
SAUDI PATIENTS WITH TYPE 2 DIABETES

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## **SUPERVISOR'S DECLARATION**

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy in Statistics.

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## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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WAQAS SAMI

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To my beloved parents  
Sami Ullah Mahmood and Anjum Sami  
Without whom none of my success would be possible

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My wife and kids  
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Who were the motivation behind to pursue Ph.D.

## ABSTRAK

Tabiat pemakanan dan gaya hidup tidak aktif merupakan faktor utama peningkatan mendadak kes kencing manis atau Diabetes Mellitus (DM) di Arab Saudi (KSA). Dengan kadar peningkatan pesat jumlah pesakit kencing manis di Arab Saudi, dianggarkan pada tahun 2022 kelaziman T2DM akan menjadi 44.1%. Komplikasi kencing manis, terutamanya kencing manis retinopati (DR) juga sedang meningkat pada kadar yang membimbangkan di KSA. Pada 2007, kelaziman DR adalah 31% dan ianya meningkat kepada 36.4% pada 2015. Hampir setiap suku tahun, sekitar 30 - 40% pesakit kencing manis telah datang ke klinik dengan masalah *dyslipidaemia*, komplikasi awal organ dan tahap HbA1c yang semakin tinggi. Kajian kepustakaan yang diterbitkan menunjukkan bahawa hubungan antara tabiat pemakanan dan amalan pesakit kencing manis jenis 2 tidak dikaji dengan sebaiknya di KSA. Tambahan itu, hanya sedikit kajian telah dijalankan bagi menangani isu kencing manis *dyslipidaemia* dan HbA1c yang tidak terkawal juga semakin meningkat di KSA. Di samping itu, terdapat bukti yang jelas dalam kesusasteraan tentang adanya model konsultasi pemakanan yang boleh digunakan untuk menjalankan penilaian diet kencing manis jenis 2. Oleh itu, objektif kajian ini adalah; untuk menilai tahap dasar pesakit kencing manis tentang Pengetahuan Diabetes Mellitus (DMK), Pengetahuan Pemakanan (DK), Tingkahlaku Pemakanan (DA), Amalan Pemakanan (DP), profil lipid dan HbA1c; untuk menguji secara empirik model konsultasi pemakanan dan, untuk mencari kelaziman DR dan perkaitannya dengan HbA1c. Pra-ujian dijalankan untuk menilai kesahan muka dan kesahan kandungan, manakala tujuan kajian rintis adalah untuk menilai kebolehpercayaan dan kesahihan soal selidik. Data untuk kajian utama telah dikutip dari 5 Februari hingga 24 April 2017 daripada 350 pesakit dengan menggunakan teknik pensampelan rawak sistematik melalui kaedah penyiasatan langsung. Ujian satu-sampel *Wilcoxon signed ranked*, ujian satu-sampel *chi-square*, ujian *Mann-Whitney U*, *Pearson chi-square*, *logistic regression* dan Pemodelan Kuasa Dua Terkecil Model Persamaan Struktur (SEM) telah digunakan untuk menguji hubungan-hubungan yang hipotesiskan. Analisis asas menunjukkan bahawa pesakit diabetes jenis 2 mempunyai DMK dan DK yang lemah, DA yang tidak sesuai, DP yang tidak sihat serta profil lipid dan HbA1c yang tidak terkawal. Skor-skor yang dihasilkan dari analisis asas telah digunakan dalam SEM. Model formatif telah digunakan dalam kajian ini. Keputusan penilaian terhadap model luaran menunjukkan bukti kesahan konvergen, tiada masalah multikolinearan, dan berat luaran bagi semua penunjuk adalah signifikan seperti yang ditunjukkan oleh nilai-*t* dan nilai-*p*. Penemuan terhadap model struktur menunjukkan wujud hubungan yang kuat di antara DMK, DK, DA, DP dan HbA1c. Selain itu, DMK (faktor berpengaruh) dengan ketaranya secara langsung mempengaruhi DK dan DP, manakala, ia juga mempunyai kesan tidak langsung yang signifikan terhadap HbA1c (pemboleh ubah hasil). Kelaziman DR didapati 28.3% dan mempunyai perkaitan yang signifikan terhadap HbA1c. Terdapat ketiadaan kesedaran terhadap pemakanan yang sihat, tabiat makan yang tidak baik dan kurangnya budaya senaman dalam masyarakat Arab. Ini telah menyebabkan diabetes terutamanya jenis 2 dan obesiti. Ianya memerlukan program tiga dimensi yang mempromosi senama pada usia muda dan pendidikan nutrisi tanpa mengira kawasan, jantina dan lapisan masyarakat. Kajian ini telah mencadangkan satu model konsultasi pemakanan yang telah terbukti, yang mana ianya boleh digunakan secara bersendirian atau disepadukan dengan model perundingan kencing manis yang ada untuk penjagaan kencing manis yang lebih berkesan. Penyedia kesihatan perlu memberi penekanan khusus kepada pesakit kencing manis melalui pemboleh ubah yang dikaji iaitu DMK, DK dan DA kerana faktor-faktor ini mempunyai pengaruh langsung dan tidak

langsung kepada DP dan HbA1c. Penemuan keseluruhan model konsultasi diet yang dicadangkan memudahkan paradigma penjagaan kesihatan baharu. Ringkasnya, penilaian pemakanan pesakit kencing manis pada peringkat awal dan secara berkala dapat membantu pengurangan komplikasi penyakit kencing manis, yang seterusnya meningkatkan kualiti kehidupan pesakit.



## ABSTRACT

Dietary habits and sedentary lifestyle are the major factors for rapidly-rising incidence of Diabetes Mellitus (DM) in the Kingdom of Saudi Arabia (KSA). At this rapid rate of increase in the number of Saudi diabetics, it is expected that by the year 2022 the prevalence of T2DM would be 44.1%. Diabetes complications, especially Diabetic Retinopathy (DR) is also increasing at an alarming pace in KSA. In 2007, the prevalence of DR was 31% which in 2015 increased to 36.4%. It was observed that almost in every quarter-yearly around 30% - 40% of the diabetic patients were presenting in the clinics with dyslipidaemia, early end-organ complications and elevated HbA1c levels. It has been pointed out in the published literature that the relation between dietary habits and practices of type 2 diabetics have not been studied well in KSA. Moreover, diabetic dyslipidaemia and uncontrolled HbA1c is also on the rise in KSA with very few studies addressing this issue. In addition, there is a bleak evidence in the literature about the availability of dietary consultation model that can be used to carry out the dietary assessment of type 2 diabetics. Therefore, the objectives of this research were; to assess diabetic patient's baseline Diabetes Mellitus Knowledge (DMK), Dietary Knowledge (DK), Dietary Attitude (DA), Dietary Practices (DP), lipid profile and HbA1c; to empirically test the hypothesised dietary consultation model and, to find the prevalence of DR and its association with HbA1c. Pre-test was conducted to evaluate the face validity and content validity, whereas, the purpose of pilot study was to evaluate the questionnaires' reliability and validity. The data for main study was collected from 5<sup>th</sup> February to 24<sup>th</sup> April 2017 from 350 patients using systematic random sampling technique by direct investigation method. One-sample Wilcoxon signed ranked test, one-sample chi-square test, Mann-Whitney U test, Pearson chi-square, logistic regression and Partial Least Squares Structural Equation Modelling (SEM) was used to test the hypothesised relationships. Baseline analysis showed that type 2 diabetics had poor DMK and DK, inappropriate DA, unhealthy DP and uncontrolled lipid profile and HbA1c. Scores generated from baseline analysis were used in SEM. A formative model was used in this research. Results of outer model evaluation showed the evidence of convergent validity, no problem of multicollinearity, and outer weights of all indicators were significant as evident by t-values and p-values. Findings of structural model showed that there is a strength interrelationship between DMK, DK, DA, DP and HbA1c. Moreover, DMK (influential factor) was directly significantly predicting DK and DP, whereas, it had the highest significant indirect effect on HbA1c (outcome variable). The prevalence of DR was found to be 28.3% and had a significant association with HbA1c. There is great unawareness of healthy diet, poor eating habits and void of exercise-culture in Arab society. It breeds diabetes especially of type 2 and obesity. It demands a three-dimensional programme of promoting early age exercise and nutrition education irrespective of region, gender and stratum of society. The study proposed a validated dietary consultation model, this model can be used alone or integrated with any available diabetes consultation model for more effective diabetes care. Healthcare providers should pay special emphasis on diabetics DMK, DK and DA as these factors have a direct and indirect influence on DP and HbA1c. Findings of the overall proposed dietary consultation model facilitates a new healthcare paradigm. Conducting dietary assessment of diabetics at initial stage and periodically can help in overall reduction in diabetes complications, thus improving the quality of life of patients.

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## LIST OF SYMBOLS

$\beta$	Path Coefficient
$\beta$	Regression Coefficient
$1 - \beta$	Power of Study
$R^2$	Coefficient of Determination
$f^2$	Effect Size
$t$	Statistical Result of t-test
$<$	Less than
$>$	Greater than
$d^2$	Desired Precision
$Z^2$	Value from Standard Normal Distribution Corresponding to desired Confidence Interval
$p$	Expected True Proportion
$1 - p$	1-Expected True Proportion
$\chi^2$	Chi-Square
SD	Standard Deviation
$k$	Size of Interval for Selection
$N$	Population Size
$n$	Sample Size

## LIST OF ABBREVIATIONS

AACE	American Association of Clinical Endocrinologists
ADA	American Diabetes Association
AVE	Average Variance Extracted
BCCM	Behavioural Change Communication Material
BCa	Bias-Corrected and Accelerated
BED	Binge Eating Disorder
BMI	Body Mass Index
CB-SEM	Covariance-Based Structural Equation Modelling
CBIA-DM	Community Based Interactive Approach to Diabetes Mellitus
CDC	Centre for Disease Control and Prevention
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CHD	Coronary Heart Disease
CI	Confidence Interval
CITC	Corrected Item Total Correlation
CME	Continuous Medical Education
CVA	Cerebrovascular Accident
CVD	Cardiovascular Diseases
CVI	Content Validity Index
DA	Dietary Attitude
DAQ	Dietary Attitude Questionnaire
DCCT	Diabetes Control and Complications Trial
DK	Dietary Knowledge
DKQ	Dietary Knowledge Questionnaire
DM	Diabetes Mellitus
DMK	Diabetes Mellitus Knowledge
DMKQ	Diabetes Mellitus Knowledge Questionnaire
DME	Diabetes Mellitus Education
DN	Diabetic Nephropathy
DNP	Diabetic Neuropathy
DP	Dietary Practices

DPQ	Dietary Practices Questionnaire
DR	Diabetic Retinopathy
DRS	Diabetic Retinopathy Study
DZ	Dizygous
EFA	Exploratory Factor Analysis
ELISA	Enzyme-Linked Immunosorbent Assay
ESRD	End Stage Renal Disease
ETDRS	Early Treatment of Diabetic Retinopathy Study
FBS	Fasting Blood Sugar
FFQ	Food Frequency Questionnaire
GCC	Gulf Cooperation Council
GDM	Gestational Diabetes Mellitus
GFR	Glomerular Filtration Rate
GoF	Goodness of Fit
GSCA	Generalized Structured Component Analysis
HbA1c	Haemoglobin A1c
HBM	Health Belief Model
HDL-C	High Density Lipoprotein-Cholesterol
HGI	High Glycaemic Index
HGI	High Glycaemic Index
HRQoL	Health-Related Quality of Life
ICR	Internal Consistency Reliability
I-CVI	Item-Content Validity Index
IDF	International Diabetes Federation
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
INO	International Nutritional Organization
KAP	Knowledge, Attitude, Practice
KAP-O	Knowledge, Attitude, Practice-Outcome
KMO	Kaiser Meyer Olkin
KSA	Kingdom of Saudi Arabia
K-S Test	Kolmogorov Smirnov Test
LDL-C	Low Density Lipoprotein-Cholesterol



LGI	Low Glycaemic Index
MCQ	Multiple Choice Question
MENA	Middle East and North America
MI	Myocardial Infarction
MODY	Maturity Onset Diabetes of the Young
MUFA	Monounsaturated Fatty Acids
MZ	Monozygous
NCHS	National Centre for Health Statistics
NEUSREL	Nonlinear Universal Structural Relational Modelling
NFI	Normed Fit Index
NHLBI	National Heart, Lung, and Blood Institute
NICE	National Institute for Health and Care Excellence
NPDR	Non-Proliferative Diabetic Retinopathy
OGTT	Oral Glucose Tolerance Test
OLS	Ordinary Least Square
PCA	Principal Component Analysis
PDR	Proliferative Diabetic Retinopathy
PLS-SEM	Partial Least Square Structural Equation Modelling
p-value	Probability Value
Q-CVI	Questionnaire-Content Validity Index
RMSEA	Root Mean Square Error of Approximation
RMSTheta	Root Mean Square Residual Covariance
RR	Relative Risk
SAED	Intelligent Mobile Diabetes Management and Education System
SAR	Saudi Riyal
SCT	Social Cognitive Theory
SEM	Structural Equation Modelling
SPSS	Statistical Package for Social Sciences
SRMR	Standardized Root Mean Square Residual
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
TC	Total Cholesterol

TG	Triglycerides
TPB	Theory of Planned Behaviour
UAE	United Arab Emirates
UK	United Kingdom
UKPDS	United Kingdom Prospective Diabetes Study
USA	United States of America
VIF	Variance Inflation Factor
VOO	Virgin Olive Oil
VTDR	Vision Threatening Diabetic Retinopathy
WESDR	Wisconsin Epidemiology Study of Diabetic Retinopathy
WHO	World Health Organization

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