ORIGINAL ARTICLE

Enhancing Glycaemic Control: The Impact of Medical Nutrition Therapy on HbA1c Reduction in Malaysia's Primary Healthcare Clinics (2017-2022)

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ABSTRACT

Background: Diabetes Mellitus (DM) presents a major public health challenge, leading to serious complications. Medical Nutrition Therapy (MNT), provided by dietitians, is crucial for reducing HbA1c levels and improving glyceamic control. Objective: To evaluate the impact of MNT on HbA1c reduction in adults with Type 2 diabetes (T2DM) attending public health clinics in Malaysia, highlighting the importance of dietitian coverage in diabetes care. **Methods:** A retrospective cohort study was conducted among 4,680 adult T2DM patients who received MNT from 2017 to 2022. Patients with baseline HbA1c levels >8% were included, while those with chronic kidney disease, psychiatric conditions, pregnancy, or bedridden status were excluded. Pre- and post-MNT HbA1c levels were analysed using paired t-tests and regression models. **Results:** The mean HbA1c level dropped significantly from 10.83 ± 1.88% to 8.65 ± 1.92% post-intervention ($p < 0.001$), with an average reduction of 2.18%. Significant predictors of HbA1c reduction included pre-consultation HbA1c, gender, and ethnicity, with the strongest association seen in pre-consultation HbA1c. A target HbA1c ≤6.5% was achieved by 12.5% of patients. **Conclusion:** This study affirms MNT as a critical component of diabetes management, significantly improving HbA1c outcomes. Expanding dietitian services in Malaysia's primary care is essential to provide equitable access to effective diabetes care.
Malaysian Journal of Medicine and Health Sciences (2026) 22(2): 1-10.doi:10.47836/mjmhs.v22.i2.1536

Keywords: Diabetes Mellitus, HbA1c, Medical Nutrition Therapy, Dietitians, Glycaemic Control, Malaysia

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INTRODUCTION

Diabetes Mellitus (DM) is a major public health concern that is closely related to increased macrovascular and microvascular complications. It is a group of metabolic diseases characterized by hyperglycaemia resulting from defects in insulin secretion, insulin action, or both (1). Insulin is a hormone produced by the pancreas that facilitates the uptake of glucose from food into the cells for use as an energy source. If the body depletes insulin or cannot utilize insulin well, glucose will remain in the blood and will not reach the body cells. It also increases the risk of premature and preventable mortalities.

In patients with diabetes mellitus, haemoglobin A1c (HbA1c) is a crucial marker of mean glycaemia and risk for complications. Since HbA1c is a reliable indicator of both lipid profile and long-term glycaemic control, monitoring glycaemic control with HbA1c may also help identify diabetes patients who are more likely to experience cardiovascular complications. A community-based population study of 11,092 non-diabetic patients found that elevated HbA1c levels

were strongly associated with the risk of cardiovascular disease and mortality. The study also revealed that among people with diabetes, a mere 1% increase in HbA1c concentration was linked to a 30% increase in deaths from all causes and a 40% increase in mortality from cardiovascular or ischemic heart disease (2).

The trend of diabetes prevalence in Malaysia has continued to rise, as reported by the NHMS 2019; the overall prevalence of diabetes in adults was 18.3%, compared to 13.4% in 2015 compared to 13.4% in 2015[1.1](3). Medical nutrition therapy (MNT) is a key component of diabetes care (4). The term "medical nutrition therapy" was introduced by the American Dietetic Association in 1994 to provide a clear definition of the nutrition therapy process (5). MNT is defined as a "nutrition-based treatment provided by a registered dietitian nutritionist." It includes "a nutrition diagnosis as well as therapeutic and counselling services to help manage diabetes." (6). Individualized MNT should be administered to all patients with prediabetes and diabetes to ensure the achievement of treatment goals, and it is ideally provided by a registered Dietitian (7). Proper MNT implementation is crucial, and it consists of several processes that include: 1) assessment of the patient's nutrition and diabetes self-management knowledge and skills; 2) identification and negotiation of individually designed nutrition goals; 3) nutrition intervention involving careful matching of both a meal-planning approach and educational materials to the patient's needs, with flexibility in mind to have the plan be implemented by the patient; and 4) evaluation of outcomes and ongoing monitoring (8). These steps are important to assist patients in successfully acquiring the knowledge, skills, attitudes, behaviours, and commitment to face the challenges in managing diabetes.

Studies consistently show that Medical Nutrition Therapy (MNT) provided by registered dietitians is effective in lowering HbA1c levels, a crucial marker for glycaemic control. For patients with Type 1 diabetes, MNT is associated with absolute reductions in HbA1c of 1.0–1.9%, and for those with Type 2 diabetes, reductions range from 0.3 to 2.0% (9). When combined with comprehensive diabetes care, MNT can enhance clinical outcomes and lower the risks of comorbidities and hospitalizations (10). A five-year retrospective study in Japan evaluated dietitian-led MNT for Type 2 diabetes mellitus (T2DM) patients in primary care clinics, comparing an intervention group receiving MNT with a control group. The intervention group saw a significant decrease in HbA1c levels from 8.5 ± 1.7% to 7.6 ± 1.1% ($p < 0.001$), while the control group showed no change (11). Another study involving 76 adults with impaired glucose levels compared MNT with usual care over 12 weeks. The intervention group showed improved HbA1c levels (5.79% vs. 6.01% in the usual care group) and reductions in diabetes risk markers (12). Further evidence from a systematic review of 11 trials (1,227 participants) shows that MNT leads to significant decreases in body mass index (BMI), waist circumference, cholesterol, fasting blood glucose, HbA1c, weight, and systolic blood pressure. (13). Similarly, a 12-week study involving 104 T2DM patients demonstrated improvements in fructosamine and HbA1c, along with reductions in waist circumference, HDL cholesterol, and dietary intake, emphasizing MNT's impact on metabolic parameters (14). A U.S.-based clinical trial evaluated two levels of MNT for non-insulin-dependent diabetes mellitus (NIDDM) across three states, involving 247 participants. MNT following practice guidelines (PGC) was compared to basic nutrition care (BC). Both groups showed HbA1c improvements, with the PGC group demonstrating greater benefits for patients treated for more than six months, underscoring MNT's effectiveness when integrated with guideline-based care (15). These findings highlight MNT's pivotal role in diabetes management and support expanding dietitian-led services to optimize glycaemic control and reduce diabetes-related complications.

To reduce complications and mortality among diabetic patients, Medical Nutrition Therapy (MNT) has been included in treatment protocols aimed at lowering HbA1c levels following the introduction of dietitians within primary care settings. This study aimed to assess the impact of the MNT on HbA1c reduction in patients attending public health clinics in Malaysia, highlighting the valuable role of Primary Care Dietitians in diabetes care.

MATERIALS AND METHODS

Study Design

This study was a retrospective cohort analysis that was conducted between 2017 and 2022. This study aimed to evaluate the effectiveness of Medical Nutrition Therapy (MNT) in adult outpatients with type 2 diabetes mellitus (T2DM). Data were extracted from the Key Performance Index (KPI) database, which documents MNT outcomes. The cohort consisted of patients who received MNT from a primary care dietitian at a public health clinic.

Study Population

Adults with a confirmed diagnosis of type 2 diabetes mellitus (T2DM) and had baseline glycated haemoglobin (HbA1c) values of greater than 8%; these readings were obtained at least three months prior to the participants' initial consultation with a dietitian. Each participant attended at least one MNT. Exclusion criteria included chronic kidney disease (CKD), neurological or psychiatric conditions (including psychiatric patients), pregnancy, and frail or bedridden status.

Intervention: Medical Nutrition Therapy

The An individualized MNT was administered to all eligible patients according to their appointment dates

and clinical requirements. MNT was provided in accordance with standard clinical practice guidelines for diabetes management, with a focus on individualized dietary plans intended to optimize blood glucose control[2.1](16,17). The frequency of the MNT sessions varied depending on the patient's needs, as determined by the healthcare provider. Patient data were collected retrospectively and included demographic information (age, gender, and ethnicity), as well as clinical data related to diabetes management (pre- and post-MNT HbA1c levels). Specifically, the intervention followed the Malaysian Clinical Practice Guidelines (CPG) for the Management of Type 2 Diabetes Mellitus, Sixth Edition, 2020.

Data Collection

Data were retrospectively extracted from the Key Performance Indicator (KPI) database, which compiles clinical records collected by dietitians in public health clinic settings across Malaysia[MM4.1]. These records were compiled by assigned dietitians at the clinic and state levels and submitted biannually (every six months) to the Family Health Development Division (BPKK), Ministry of Health Malaysia.

To ensure data quality, only records that met the following inclusion criteria were selected for analysis: (i) patients must have attended at least one consultation session with a dietitian for MNT, and (ii) had recorded HbA1c values before the initial MNT consultation and within six months following the intervention. Key variables included patient demographics (age, sex, ethnicity), clinical data (pre- and post-MNT HbA1c levels), and the duration between two HbA1c readings. All HbA1c measurements were obtained as port of routine clinical practice.

Data were screened and filtered based on the inclusion and exclusion criteria. Only patients with complete pre- and post-MNT HbA1c data were included in the final dataset. Statistical analysis were perfomed using IBM SPSS Statistics Vension 22.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics 22, with the statistical significance level set at $p<0.05$. Both descriptive and inferential statistics were applied. The sociodemographic characteristics of the study population were summarized using means, standard deviations, and frequency distributions. To evaluate the effectiveness of MNT, a paired sample t-test was performed to compare the mean HbA1c levels before and after MNT. The mean difference, 95% confidence intervals (CI), paired sample correlation coefficient, and t-statistic with degrees of freedom (df) were reported.

In[MM5.1] addition, a multiple linear regression analysis was conducted to identify predictors of post-consultation HbA1c levels. Independent variables included demographic and clinical factors such as age group, gender, ethnicity, pre-consultant HbA1c, and duration between consultations. Categorical variables (ethnicity, gender, and age group) were dummy coded, with Malays (ethnicity), females (gender), and the 60-69 age group set as the reference categories. The final model included unstandardized coefficients (B), standardized beta coefficients, standard errors, 95% CI, and associated p-values. The coefficient of determination (R2) was also reported to indicate the proportion of variance explained by the model.

RESULTS

Socio-demographic characteristics

A total of 4,680 patients were selected for this study, with a mean age of 58.2 ± 11.6 years. The age distribution showed a predominance of older adults, with the 60-69 age group comprising 33.8% (1,581 individuals) of the sample, followed by the 50-59 age group at 28.8% (1,346 individuals). Together, these two age groups accounted for 62.6% of the dataset, indicating a strong representation of older individuals. The 40-49 age group constituted 13.8% (648 individuals), while the 70-79 group represented 14.1% (659 individuals). Younger patients were underrepresented: 30–39 years (6.8%, n=320), 20–29 years (0.7%, n=36), and under 20 (0.0%, n=2).[6.1] The oldest age group, 80-94, had 1.9% (90 individuals), making it the smallest demographic group. Detailed socio-demographic characteristics are presented in Table I.

Table I: Socio-demographic characteristics

Characteristic	n	%
Year		
2017	623	13.3
2018	334	7.1
2019	922	19.7
2020	1145	24.5
2021	769	16.4
2022	887	19.0
State		
Kedah	178	3.8
Kelantan	303	6.5
Wilayah Persekutuan Kuala Lumpur & Putrajaya	191	4.1
Selangor		
Perak	845	18.1
Melaka	230	4.9
Pahang	383	8.2
Perlis	689	14.7
Pulau Pinang	48	1.0
Terengganu	117	2.5
Sabah	559	11.9
Negeri Sembilan	645	13.8
Sarawak	254	5.4
Johor	102	2.2
	136	2.9
Age Group (years)		
<20	2	0.0
20-29	36	0.7
30-39	320	6.8
40-49	648	13.8
50-59	1346	28.8
60-69	1581	33.8
70-79	659	14.1
80-89	85	1.8
90-99	5	0.1
Gender		
Male	1674	35.8
Female	3006	64.2
Ethnicity		
Malay	3435	73.4
Chinese	594	12.7
Indian	349	7.5
Others	302	6.5
Duration (days)		
0-99	697	14.9
100-199	2300	49.1
200-299	1179	25.2
300-399	329	7.0
400-499	120	2.6
≥ 500	55	1.2

Impact on HbA1c in Pre and Post-Intervention

The[MM7.1] mean HbA1c level decreased from 10.83±1.88% prior to the MNT intervention to 8.65±1.92% post-intervention (Table II). A paired-sample t-test confirmed that this reduction was statistically significant, with a mean difference of 2.18% (SD = 2.02, 95% CI: 2.12 to 2.24), $t(4679) = 73.745$, $p < 0.001$ (Table II). The distribution of HbA1c reduction among patients is shown in Table II, where the majority experienced a reduction ranging from 0.1% to 2.9%. Notably, 583 patients (12.5%) achieved the recommended HbA1c target level of ≤6.5%.

Table II: Comparison of Pre- and Post-Consultation HbA1c and Paired-Sample t-Test Results (n = 4,680)

Variable	Mean	SD	SE	95% Confidence Interval		t/r	df	p-value
				Lower	Upper			
Pre-Consultation HbA1c	10.8316	1.88274	0.02752	-	-	-	-	-
Post-Consultation HbA1c	8.6504	1.91694	0.02802	-	-	-	-	-
Mean Difference (Pre-Post)	2.18124	2.02347	0.02958	2.12325	2.23922	73.745*	4679	< 0.001
Paired Sample Correlation	-	-	-	-	-	0.433#	4679	< 0.001

* t-statistic from paired-sample t-test comparing pre- and post-consultation HbA1c.

Pearson correlation coefficient between pre- and post-consultation HbA1c values.

SD = Standard Deviation; SE = Standard Error.

Regression Analysis of Predictors for Post-Consultation HbA1c

The R-squared value[MM8.1] of 0.204 indicates that approximately 20.4%of the variance in the post-consultation HbA1c levels is explained by the predictors included in the multiple linear regression model-namely age, gender, ethnicity, pre-consultation HbA1c, and the duration between pre- and post-consultation tests. In the ANOVA table, the model's F-statistic of 85.614 with a p-value of <0.001 confirms the overall significance of the regression model. This indicates that the combined predictors—age group, gender, ethnicity, pre-consultation HbA1c, and consultation duration—are significantly associated with post-consultation HbA1c levels (Table III).[9.1]

Table III: Multiple Linear Regression Predicting Post-Consultation HbA1c

Predictor Variable	B (Unstandardized)	Std. Error	Beta (Standardized)	*p*-value	95% Confidence Interval for B
(Constant)	3.988	0.161	-	<.001	[3.672, 4.304]
Ethnicity (ref: Malay)					
Chinese	-0.157	0.078	-0.027	0.044	[-0.309, -0.005]
Indian	0.561	0.096	0.077	<0.001	[0.372,0.750]
Others	-0.044	0.103	-0.006	0.670	[-0.246, 0.158]
Gender (ref: Female)					
Male	-0.340	0.053	-0.085	<0.001	[-0.443, -0.236]
Age Group (ref: 60 – 69)					
<20	0.513	1.212	0.006	0.672	[-1.863, 2.888]
20-29	-0.409	0.297	-0.018	0.168	[-0.991, 0.173]
30-39	-0.059	0.0105	-0.008	0.575	[-0.265, 0.147]
40-49	-0.141	0.080	-0.025	0.078	[-0.297, 0.016]
50-59	-0.001	0.064	0.000	0.986	[-0.126, 0.124]
70-79	0.010	0.080	0.002	0.899	[-0.147, 0.167]
80-89	-0.297	0.191	-0.021	0.120	[-0.673, 0.078]
90-99	0.234	0.767	0.004	0.760	[-1.270, 1.738]
Pre-consultation HbA1c	0.437	0.013	0.429	<.001	[0.410, 0.463]
Duration	0.000	0.000	0.020	0.125	[0.000, 0.001]

Footnotes:

- R = 0.204
- Final regression equation:
  Post_HbA1c = 3.988 + 0.437(Pre_HbA1c) – 0.340(Male) – 0.157(Chinese) + 0.561(Indian) – 0.044(Others) + 0.000(Duration) + 0.513(age group <20)-0.409(age group 20-29)-0.059(age group 30-39)-0.141(Age group 40-49)-0.001(Age group 50-59)+0.010(Age group 70-79)-0.297(Age group 80-89)+0.234(Age group 90-99)

Final regression equation:
Post_HbA1c = 3.988 + 0.437(Pre_HbA1c) – 0.340(Male) – 0.157(Chinese) + 0.561(Indian) – 0.044(Others) + 0.000(Duration) + 0.513(age group <20)-0.409(age group 20-29)-0.059(age group 30-39)-0.141(Age group 40-49)-0.001(Age group 50-59)+0.010(Age group 70-79)-0.297(Age group 80-89)+0.234(Age group 90-99)
R = 0.204

Looking at the individual predictors, the coefficient analysis provides additional insights. Pre-consultation HbA1c showed the strongest positive association with post-consultation HbA1c levels ($p < 0.001$, Standardized Beta = 0.429), indicating that individuals with higher baseline values tended to have higher HbA1c levels after the intervention. Gender (male) was also significantly associated with post-consultation HbA1c ($p < 0.001$, Standardized Beta = -0.085), suggesting that male patients had slightly higher HbA1c levels compared to females. Among ethnic groups, being Indian was significantly associated with higher post-consultation HbA1c ($p < 0.001$, Standardized Beta = 0.077). However, age and consultation duration were not significantly associated with HbA1c outcomes ($p = 0.125$), indicating they did not meaningfully influence glycaemic control in this cohort (Table III).

DISCUSSION

This study evaluated the impact of Medical Nutrition Therapy (MNT) on glycaemic control in a diverse population of 4,680 patients. The majority of study participants were older adults, with a mean age of 58.2 years. The age distribution revealed that the largest proportion of patients were in the 60-69 age group (33.8%), followed by the 50-59 age group (28.8%), highlighting that a significant portion of the population was older, which is consistent with the age demographics of individuals typically affected by type 2 diabetes. Younger age groups (<40 years) were underrepresented, accounting for approximately 7.6% of the total sample, which reflects the lower prevalence of diabetes among younger adults. [11.1]This demographic characteristic underscores the need for accessible MNT services in public health clinics to meet the higher demand among older adults who are at greater risk of complications associated with poor glycaemic control.

Effectiveness of MNT on Glycaemic Control

This study highlights the effectiveness of Medical Nutrition Therapy (MNT) in reducing HbA1c levels among Type 2 Diabetes Mellitus (T2DM) patients at Malaysian public health clinics. The mean HbA1c level was initially high (10.83 ± 1.88%), indicating poor glycaemic control in this population. However, after an average follow-up of approximately 190 days, a significant reduction in HbA1c—from 10.83% to 8.65%—demonstrated the impact of MNT in improving glycaemic outcomes. This result aligns with international studies, where dietitian-led MNT has achieved HbA1c reductions ranging from 0.3% to 2.0%.

The paired samples t-test demonstrated a highly significant reduction in HbA1c levels ($p < 0.001$), with a mean decrease of 2.18124±2.02% over an average duration of 189.97 ± 109.41 days (approximately three–six months). Such a reduction in HbA1c, achieved over a three to six-month period, is clinically meaningful, as even modest improvements in HbA1c are associated with lower risks of diabetes complications, including cardiovascular disease, neuropathy, and kidney damage. The substantial drop in HbA1c illustrates the value of MNT as a targeted intervention for achieving better glycaemic control in a relatively short timeframe. This reduction represents a substantial improvement in glycaemic control, as even small decreases in HbA1c levels are associated with a lower risk of diabetes-related complications. A 2.18% reduction is particularly notable because it reflects a major shift from poorly controlled to better-controlled diabetes in many patients, potentially leading to fewer long-term complications such as cardiovascular disease, neuropathy, and kidney damage (18).

This study's results are comparable to those in other countries, where similar interventions have produced lower HbA1c reductions. For instance, average HbA1c reductions were reported at 1.0% to 1.2% over six to 12 months in the United States and 0.9% over 12 months in the United Kingdom (19,20). A study in Egypt reported a reduction from 10.0% to 9.5% over 12 weeks (21). These findings confirm MNT's global efficacy in diabetes management, while the higher reductions observed in this study suggest the potential for robust outcomes with well-structured MNT programs in primary care settings. In summary, this study reinforces the importance of MNT in T2DM management and supports the expansion of dietitian-led services in Malaysia's primary care to improve access and glycaemic outcomes for diabetes patients.

Predictors of HbA1c Reduction

Regarding the overall model performance, the R-squared value of 0.204[MM12.1] indicates that the predictors explain a moderate portion of the variability in HbA1c outcomes. Regression analysis revealed that 20.4% of the variability in post-consultation HbA1c levels could be explained by the following predictors: age, sex, ethnicity, pre-consultation HbA1c levels, and the duration between pre- and post-consultation tests. Although this leaves a substantial portion of variability unexplained, it demonstrates that these factors significantly influence the outcomes of Medical Nutrition Therapy (MNT) in patients with type 2 diabetes. This is consistent with findings from other studies that have explored the predictors of glycaemic control post-intervention.
This study identified gender and pre-consultation HbA1c levels as significant predictors of post-consultation

HbA1c outcomes, with male patients showing higher post-consultation HbA1c levels than females (B (Standardized) = -0.085, $p < 0.001$). This finding aligns with other research indicating that women often experience greater glycaemic improvements following lifestyle or dietary interventions. Gender differences in diabetes outcomes may be partly due to variations in glucose regulation and insulin sensitivity influenced by sex hormones. Some studies have shown that women respond more favourably to certain glucose-lowering therapies, such as GLP-1 receptor agonists, while differences in drug metabolism related to body fat and hepatic clearance might explain varying responses between men and women (22). While some studies report no significant gender differences in response to lifestyle interventions, others, such as a pooled analysis of insulin glargine trials, found that women were less likely than men to achieve HbA1c targets despite higher insulin doses and more frequent hypoglycaemic events (23,24). These mixed findings highlight the importance of considering gender-specific responses in diabetes management and the need for individualized treatment approaches.

The reasons for gender-based differences in glycaemic outcomes are not fully understood, but adherence to dietary recommendations and engagement with healthcare providers may play a role. Women often adhere more closely to dietary guidelines and participate more actively in health interventions, whereas men may benefit from strategies tailored to improve dietary compliance and MNT outcomes. Social and psychological barriers, such as reluctance to seek regular medical advice or difficulty adhering to diet changes, may also hinder men's engagement with MNT. Community-based strategies could help bridge these gaps by offering gender-specific support for men, such as dietary and lifestyle education, peer support groups, and male-oriented fitness programs that include nutrition education. Addressing unique barriers, like work-related stress and cultural norms around food, through flexible, community-focused interventions may enhance MNT adherence among male patients and lead to better glycaemic outcomes.

In summary, understanding gender-specific challenges and preferences in diabetes management is essential for designing more effective, personalized MNT programs that improve glycaemic control for both men and women.

Additionally, the strong association between pre-consultation HbA1c levels and post-consultation outcomes (B (Standardized) = 0.429[MM13.1], $p < 0.001$) indicated that individuals with higher initial HbA1c levels tended to have higher HbA1c levels post-intervention. Persistent high HbA1c levels may be attributed to prolonged inadequate glycaemic management, insufficient adherence to lifestyle modifications, and medical nutrition therapy guidelines. Patients exhibiting elevated initial HbA1c levels may present with concomitant comorbidities, including hypertension, obesity, or cardiovascular disease, which complicates diabetes management and hinders substantial reductions. Additionally, these patients often experience severe insulin resistance, necessitating more intensive management beyond nutritional interventions. This finding highlights the importance of early intervention and suggests that patients with poor baseline glycaemic control may require more intensive or prolonged interventions to achieve optimal outcomes. Several recommendations may enhance outcomes in individuals with higher pre-consultation HbA1c levels. Patients with higher baseline HbA1c levels may benefit from more intensive interventions, such as frequent follow-ups, personalized meal plans, or adjustments in medications. Extending the MNT program to include periodic reassessments can foster gradual improvement and sustained glycaemic control. A multidisciplinary approach combining nutrition with medication adjustments, physical activity, and psychological support can address the multiple factors that drive high HbA1c levels. Early identification of patients at risk for poor glycaemic control based on high pre-consultation HbA1c levels can prompt early intervention with personalized treatment plans. Starting MNT and lifestyle interventions in the course of disease progression could prevent HbA1c levels from reaching critical levels. Behavioural interventions, such as motivational interviewing, combined with psychosocial support to address stress, depression, and health literacy, can help patients with high HbA1c overcome adherence barriers and make sustained changes to improve MNT compliance. Creating community-based initiatives that provide people with higher HbA1c levels with continuing support, group education, and peer assistance can help address the social determinants of health that may lead to poor health control.

The finding that ethnicity is a statistically significant predictor of post-consultation HbA1c levels, suggests subtle yet meaningful differences in how ethnic groups respond to Medical Nutrition Therapy (MNT). In Malaysia, where the population is ethnically diverse, this result underscores the importance of considering the cultural and ethnic factors in the MNT. Customizing dietary recommendations to align with the dietary practices and preferences of different ethnic groups could potentially enhance the effectiveness of the MNT. For instance, dietary counselling that considers staple foods, traditional meal structures, and culturally accepted health practices may improve patient adherence and lead to better glycaemic outcomes.

The small effect size observed in this study may indicate that while ethnicity plays a role, it is not the sole or primary determinant of MNT effectiveness. This aligns with previous findings that emphasize the complexity

of diabetes management, where factors such as pre-consultation HbA1c levels, gender, and socioeconomic status often have a larger impact. Nonetheless, the significant association suggests that further research should investigate how culturally tailored MNT interventions could optimize diabetes outcomes across ethnic groups, particularly in diverse healthcare settings, such as Malaysia.

In this study, age and consultation duration were not significantly associated with post-consultation HbA1c levels. These findings suggest that neither patient age nor the length of time between consultations had a meaningful impact on the effectiveness of the (MNT) in reducing HbA1c levels in this population.
The lack of association with age implies that the MNT provides similar glycaemic benefits across different age groups, highlighting its universal applicability and potential effectiveness regardless of the patient's age. This aligns with other studies indicating that tailored dietary interventions can benefit patients across a wide age spectrum, suggesting that the MNT could serve as a foundational component of diabetes management for patients at various life stages.

Additionally, the non-significance of consultation duration suggests that the time intervals between MNT sessions or HbA1c tests do not independently influence the outcomes. This finding may indicate that the quality and content of MNT interventions are more crucial for achieving glycaemic control than the frequency of follow-ups. It reinforces the importance of providing personalized and high-quality nutrition counselling during each session, rather than relying solely on the timing or number of consultations, to maximize the therapeutic impact of MNT on diabetes management.

Clinical Implications
The results of this study provide strong evidence for the effectiveness of MNT in reducing HbA1c levels in a real-world setting, particularly for older adults with poorly controlled diabetes. The increase in the proportion of patients achieving target HbA1c levels underscores the clinical importance of incorporating MNT into diabetes care, particularly for patients struggling with high baseline HbA1c levels. However, the significant gender differences observed suggest that additional support or tailored interventions may be necessary to ensure equitable outcomes across genders.

This study has notable strengths and limitations. With a sample size of 4,680 patients, the findings are robust and generalizable, reducing the risk of random error. The significant reduction in HbA1c levels post-intervention provides strong evidence for the effectiveness of Medical Nutrition Therapy (MNT) in diabetes management. The inclusion of diverse age, gender, and ethnic groups offers valuable insights into how sociodemographic factors impact MNT outcomes. Regression analysis further strengthens the study by identifying key predictors influencing post-intervention HbA1c levels. Conducted in a real-world primary care setting, the findings are highly applicable to routine clinical practice.

However, the study has some limitations. This study is subject to several limitations. First, the retrospective design limits the ability to establish causality and control for potential confounding factors. Additionally, the study population was drawn from primary care clinics, which may not be representative of the broader Malaysian population with type 2 diabetes.

Future research should explore the long-term sustainability of MNT-induced HbA1c improvements and investigate the impact of MNT on other clinically relevant outcomes, such as the incidence of diabetes-related complications and quality of life.

The lack of long-term follow-up limits the ability to assess the sustained effects of HbA1c reduction. Medication changes during the study were not accounted for, potentially confounding results. While gender significantly impacted outcomes, the reasons for this disparity were not explored, leaving room for further investigation.

CONCLUSION

In conclusion, Medical Nutrition Therapy (MNT) demonstrates a significant positive impact on glycaemic control in diabetes patients, as shown by a substantial reduction in HbA1c levels following intervention. Key predictors of post-intervention outcomes include gender, pre-consultation HbA1c levels, and ethnicity, underscoring the value of personalized approaches in diabetes care. These findings highlight the crucial role of MNT as a standard component of diabetes management, and emphasize the need to expand dietitian services within primary care to ensure that every patient has access to quality, tailored nutritional support. Broadening the reach of dietitian-led interventions could enhance patient outcomes, reduce complications, and contribute to better long-term health in Malaysia's diabetic population.

ACKNOWLEDGEMENT

We would like to thank the Director General of Health Malaysia for his permission to publish this article. Special thanks to the Institute of Public Health and Family Health Development Division for the support and encouragement of expert contribution to conduct this study. We also gratefully acknowledge the data collectors and staff involved in this study.

REFERENCES

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2010 Jan;33 Suppl 1(Suppl 1). doi: 10.2337/dc10-S062. Erratum in: Diabetes Care. 2010 Apr;33(4). PMID: 20042775; PMCID: PMC2797383.
2. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients. Biomark Insights. 2016 Jul 3;11:95-104. doi: 10.4137/BMI.S38440. PMID: 27398023; PMCID: PMC4933534.
3. Institute for Public Health (IPH), National Institutes of Health, Ministry of Health Malaysia. National Health and Morbidity Survey (NHMS) 2019: Vol. I: NCDs – Non-Communicable Diseases: Risk Factors and other Health Problems. Ministry of Health Malaysia; 2020.
4. Morris SF, Wylie-Rosett J. Medical Nutrition therapy: a key to diabetes management and prevention. Clin Diabetes. 2010 Jan;28(1):12-18. doi: 10.2337/diaclin.28.1.12.
5. Pastors JG, Warshaw H, Daly A, Franz M, Kulkarni K. The evidence for the effectiveness of medical nutrition therapy in diabetes management. Diabetes Care. 2002 Mar;25(3):608-13. doi: 10.2337/diacare.25.3.608. PMID: 11874956.
6. Centers for Disease Control and Prevention. About Diabetes. Centers for Disease Control and Prevention, U.S. Department of Health & Human Services. https://www.cdc.gov/diabetes/basics/diabetes.html. Accessed October 2023.
7. American Diabetes Association. Executive summary: standards of medical care in diabetes—2009. Diabetes Care. 2009;32 Suppl 1. doi: 10.2337/dc09-S006.
8. Pastors JG, Warshaw H, Daly A, Franz M, Kulkarni K. The evidence for the effectiveness of medical nutrition therapy in diabetes management. Diabetes Care. 2002 Mar;25(3):608-13. doi: 10.2337/diacare.25.3.608. PMID: 11874956.
9. American Diabetes Association. Standards of Medical Care in Diabetes-2021 Abridged for Primary Care Providers. Clin Diabetes. 2021 Jan;39(1):14-43. doi: 10.2337/cd21-as01. PMID: 33551551; PMCID: PMC7839613.
10. Agee MD, Gates Z, Irwin PM Jr. Effect of Medical Nutrition Therapy for Patients With Type 2 Diabetes in a Low-/No-Cost Clinic: A Propensity Score-Matched Cohort Study. Diabetes Spectr. 2018 Feb;31(1):83-89. doi: 10.2337/ds16-0077. PMID: 29456430; PMCID: PMC5813315.
11. Nitta A, Imai S, Kajiayama S, Matsuda M, Miyawaki T, Matsumoto S, et al. Impact of Dietitian-Led Nutrition Therapy of Food Order on 5-Year Glycemic Control in Outpatients with Type 2 Diabetes at Primary Care Clinic: Retrospective Cohort Study. Nutrients. 2022 Jul 13;14(14):2865. doi: 10.3390/nu14142865. PMID: 35889820; PMCID: PMC9322906.
12. Parker AR, Byham-Gray L, Denmark R, Winkle PJ. The effect of medical nutrition therapy by a registered dietitian nutritionist in patients with prediabetes participating in a randomized controlled clinical research trial. J Acad Nutr Diet. 2014 Nov;114(11):1739-48. doi: 10.1016/j.jand.2014.07.020. PMID: 25218597.
13. Razaz JM, Rahmani J, Varkaneh HK, Thompson J, Clark C, Abdulazeem HM. The health effects of medical nutrition therapy by dietitians in patients with diabetes: A systematic review and meta-analysis. Prim Care Diabetes. 2019 Oct;13(5):399-408. doi: 10.1016/j.pcd.2019.05.001. Epub 2019 Jun 9. PMID: 31186171.
14. Barakatun Nisak MY, Ruzita AT, Norimah AK, Kamaruddin NA. Medical nutrition therapy administered by a dietitian yields favourable diabetes outcomes in individuals with type 2 diabetes mellitus. Med J Malaysia. 2013 Feb;68(1):18-23. PMID: 23466761.
15. Franz MJ, Monk A, Barry B, McClain K, Weaver T, Cooper N, et al. Effectiveness of medical nutrition therapy provided by dietitians in the management of non-insulin-dependent diabetes mellitus: a randomized, controlled clinical trial. J Am Diet Assoc. 1995 Sep;95(9):1009-17. doi: 10.1016/S0002-8223(95)00276-6. PMID: 7657902.
16. Ministry of Health Malaysia. Clinical Practice Guidelines: Management of Type 2 Diabetes Mellitus, Sixth Edition. Putrajaya: Ministry of Health, Malaysia; 2020.

17. Ministry of Health Malaysia. 2023. National Diabetes Registry Report 2023.
18. Sami, W., Ansari, T., Butt, N. S., & Ab Hamid, M. R. B. (2018). Assessment of a Dietary Consultation Model for Effective Diabetes Care in Saudi Population using Partial Least Squares Estimation. Pakistan Journal of Statistics and Operation Research, 14(2), 435-450. https://doi.org/10.18187/pjsor.v14i2.2249
19. Franz MJ, Powers MA, Leontos C, Holzmeister LA, Kulkarni K, Monk A, et al. The evidence for medical nutrition therapy for type 1 and type 2 diabetes in adults. J Am Diet Assoc. 2010 Dec;110(12):1852-89. doi: 10.1016/j.jada.2010.09.014. PMID: 21111095.
20. Dyson PA, Twenefour D, Breen C, Duncan A, Elvin E, Goff L, Hill A, Kalsi P, Marsland N, McArdle P, Mellor D, Oliver L, Watson K. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. Diabet Med. 2018 May;35(5):541-547. doi: 10.1111/dme.13603. PMID: 29443421.
21. Abdelsalam SE, Ismaail MAR, Sultan EA, Elsherif OE, Salama HM, Hassan SI. The outcome of medical nutrition therapy on glycemic control among type 2 diabetic patients. Pan Afr Med J. 2023 Jun 15;45:85. doi: 10.11604/pamj.2023.45.85.35520. PMID: 37663634; PMCID: PMC10474809.
22. Ciarambino T, Crispino P, Leto G, Mastrolorenzo E, Para O, Giordano M. Influence of Gender in Diabetes Mellitus and Its Complication. Int J Mol Sci. 2022 Aug 9;23(16):8850. doi: 10.3390/ijms23168850. PMID: 36012115; PMCID: PMC9408508.
23. Glechner A, Harreiter J, Gartlehner G, Rohleder S, Kautzky A, Tuomilehto J, Van Noord M, Kaminski-Hartenthaler A, Kautzky-Willer A. Sex-specific differences in diabetes prevention: a systematic review and meta-analysis. Diabetologia. 2015 Feb;58(2):242-54. doi: 10.1007/s00125-014-3439-x. Epub 2014 Dec 3. PMID: 25465437.
24. McGill J, Vlajnic A, Knutsen P, Recklein C, Rimler M, Fisher S. Effect of gender on treatment outcomes in type 2 diabetes mellitus. Diabetes Res Clin Pract. 2013 Dec;102(3):167-74. doi: 10.1016/j.diabres.2013.10.001. PMID: 24231564.