

**A WEB-BASED TAILORED DIET MANAGEMENT
TOOL (DMT) IN MANAGING DIABETES
PATIENTS**

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**A WEB-BASED TAILORED DIET MANAGEMENT
TOOL (DMT) IN MANAGING DIABETES
PATIENTS**

by

JULIANA BINTI SHAMSUDIN

**Thesis submitted in fulfilment of the requirements for
the degree of Master of Science (Nutrition) [Health]**

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DEDICATION

I would like to dedicate this thesis to my husband, Mohd Zulkifli Bin Kamarul Baha, my son, Muhammad Hayyan Zuhdi and my family (Mom, Amirah & Haikal) who have shown me unconditional love and support throughout my life. It was through their example that I learned to strive toward my goals, and I will be forever grateful.

STATEMENT OF ORIGINALITY

This work contained in this dissertation has not been previously submitted for a degree at any other tertiary education institution. To the best of my knowledge and belief, the dissertation contain no material previously published or written by another person, except where due references is made.

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LIST OF ABBREVIATIONS

ADA	American Diabetes Association
ANCOVA	Analyses of Covariance
BEE	Basal Energy Expenditure
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CHD	Cardiovascular Heart Diseases
CHO	Carbohydrate
CI	Confidence interval
cm	Centimetre
CPG	Clinical Practice Guidelines
DKA	Diabetic ketoacidosis
DMT	Diet Management Tool
DPS	Diabetes Prevention Study
eAG	Estimated average glucose
ER	Energy requirement
FAO	Food and Agriculture Organization
FBS	Fasting blood sugar
FDA	Food and Drug Administration
FFQ	Food frequency questionnaire
FPG	Fasting plasma glucose
GDM	Gestational diabetes mellitus
GI	Glycaemic index
HbA1c	Glycosylated haemoglobin
HDL	High density lipoprotein
HIV	Human immunodeficiency virus
HIS	Health Informatics Unit
HUSM	Hospital Universiti Sains Malaysia
IT	Information technology

IQR	Interquartile range
Kcal/day	Kilocalorie per day
kg	Kilogram
LCD	Low calorie diet
LDL	Low density lipoprotein
MANS	Malaysian Adult Nutrition Survey
MDA	Malaysian Dietitians' Association
mg/dL	Milligrams per decilitre
mmHg	Millimetres of mercury
mmol/L	Millimol per litre
MNT	Medical Nutrition Therapy
MOH	Ministry of Health
NHANES III	Third National Health and Nutrition Examination Survey
NHMS I	National Health Morbidity Survey I
NHMS II	National Health Morbidity Survey II
NHMS III	National Health Morbidity Survey III
NIDDM	Non-insulin dependent diabetes mellitus
OAD	Oral anti-diabetic agent
oz	Ounce
PDM	Persatuan Diabetes Malaysia
RCT	Randomised controlled trial
REE	Resting energy expenditure
RNI	Recommended nutrient intake
SD	Standard deviation
SDSCA	Summary of Diabetes Self-Care Activities
SMBG	Self-monitoring of blood glucose
TEE	Total energy expenditure
TEI	Total energy intake
Tg	Triglyceride
T1DM	Type 1 diabetes mellitus

T2DM	Type 2 diabetes mellitus
USDA	United States Department of Agriculture
USM	Universiti Sains Malaysia
VLCD	Very low calorie diet
vs	Versus
WHO	World Health Organization
%	Percentage

**APLIKASI PENGURUSAN DIET KHUSUS BERASASKAN WEB DALAM
PENGURUSAN PESAKIT DIABETES**

ABSTRAK

Diet Management Tool (DMT) merupakan sistem penilaian nutrisi yang telah dibangunkan oleh kumpulan penyelidik dari Program Dietetik, Pusat Pengajian Sains Kesihatan, Universiti Sains Malaysia (USM). Sistem tersebut telah digunakan dalam kaunseling diet ke atas pesakit diabetes yang mendapatkan rawatan di Hospital Universiti Sains Malaysia (HUSM) bagi menggantikan kaunseling diet secara tradisional (rutin). Kajian ini dijalankan untuk melihat keberkesanan kaunseling diet menggunakan DMT dalam menambahbaik nilai antropometri, biokimia dan corak pemakanan dalam pengurusan diet bagi pesakit diabetes jenis 2. Kajian secara rawak (RCT) dilakukan ke atas 50 orang pesakit diabetes jenis 2 berumur di antara 30-55 tahun yang dibahagikan kepada dua kumpulan iaitu 22 orang di dalam kumpulan kawalan (KK) dan 28 orang di dalam kumpulan intervensi (KI). Peserta dalam kumpulan intervensi diberikan kaunseling diet menggunakan DMT manakala peserta dalam kumpulan kawalan diberikan kaunseling diet secara tradisional (rutin). Sistem DMT mengandungi modul penjagaan nutrisi yang berteraskan kepada intervensi yang khusus. Data antropometri (indeks jisim tubuh, IJT), biokimia (gula darah semasa berpuasa, anggaran glukosa purata dan HbA1c) dan corak pemakanan peserta dinilai pada peringkat dasar, 3 bulan, 6 bulan dan 9 bulan. Pengumpulan data bermula pada bulan Jun 2009 dan berakhir pada Mac 2010. Penilaian status makanan ditentukan melalui pengukuran antropometri manakala pengambilan diet ditentukan berasaskan sejarah diet dan soal selidik

kekerapan pengambilan makanan (FFQ). Selain itu, bagi profil biokimia peserta, ia ditentukan melalui pengambilan darah vena berpuasa. Pada peringkat dasar, hasil kajian mendapati bahawa 46.4% KI dan 45.5% KK dikategorikan sebagai berlebihan berat badan ($25-29.9 \text{ kgm}^{-2}$) berdasarkan pengelasan oleh World Health Organization (WHO). Manakala, nilai bacaan gula darah semasa berpuasa (FBS), anggaran glukosa purata (eAG) dan HbA1c bagi peserta KI dan KK adalah tinggi dari paras normal. Pengambilan tenaga bagi peserta KI dan KK melebihi saranan individu berdasarkan pengiraan keperluan tenaga purata. Analisis kovarians pengukuran berulang (ANCOVA) mendapati bahawa kaunseling diet oleh dietitian menggunakan DMT dalam kalangan pesakit diabetes jenis 2 dapat meningkatkan kawalan glisemik iaitu HbA1c dan eAG jika dibandingkan dengan KK ($p < 0.05$). Namun, tiada perubahan yang ketara bagi FBS, IJT dan corak pemakanan dalam peserta kajian di antara KI dan KK. Secara keseluruhannya, kajian menunjukkan bahawa intervensi kaunseling diet menggunakan DMT mempunyai kesan positif hanya dalam peningkatan kualiti kawalan glisemik iaitu HbA1c dan eAG dalam kalangan pesakit diabetes. Pendidikan diabetes secara berterusan terutama melalui kaunseling diet menggunakan intervensi khusus berasaskan web adalah penting dalam usaha untuk mengekalkan kawalan metabolik yang baik.

A WEB-BASED TAILORED DIET MANAGEMENT TOOL (DMT) IN MANAGING DIABETES PATIENTS

ABSTRACT

Diet Management Tool (DMT) is a nutrition assessment system developed by the researchers from Dietetic Programme, School of Health Sciences, Universiti Sains Malaysia (USM). The web-based system has been applied in dietary counselling for the treatment of patients with type 2 diabetes at Hospital Universiti Sains Malaysia (HUSM), replacing the standardised dietary counselling approach. This study examined the effectiveness of the dietary counselling using the DMT in the improvement of dietary management of type 2 diabetes patients in anthropometric, biochemical measurements and dietary intake pattern. A randomised controlled trial (RCT) was performed on 50 participants aged between 30-55 years old with type 2 diabetes mellitus. Participants were randomly assigned to two groups: the traditional dietary counselling (CG) (control group, n=22) and the DMT (IG) (intervention group, n=28). The IG received dietary counselling based on DMT while the CG received routine or traditional dietary counselling. The DMT consists of nutrition care modules tailored to the patients' needs. Anthropometric (body mass index, BMI), biochemical (fasting blood sugar, estimated average glucose and HbA1c) and food pattern outcomes were measured at baseline, 3 month, 6 month and 9 month. Data was collected between June 2009 and March 2010. The nutritional status was determined using anthropometric measurement while dietary intake used a combination of dietary history and food frequency questionnaire (FFQ). Biochemical profile of participants was determined using fasting

venous blood. During the baseline study, 46.4% of IG participants and 45.5% of CG participants were classified as overweight (25-29.9 kgm⁻²) based on World Health Organization (WHO) classification. Meanwhile, fasting blood sugar (FBS), estimated average glucose (eAG) and HbA1c level of both groups were higher than the normal range. Intake of energy was higher as compared to mean of individual's energy requirement. Repeated measure of ANCOVA showed that dietary counselling by the dietician for diabetic patients type 2 significantly improved glycaemic control using DMT in terms of improving HbA1c and eAG compared to control group ($p < 0.05$). However, there were no significant changes in FBS, BMI and food pattern in both groups. In conclusion, tailored intervention approach using DMT gave positive results only in the improvement of glycaemic control of HbA1c and eAG among diabetic patients. Continuing diabetes education especially dietary counselling via tailored web-based intervention can be an important tool to maintain good metabolic control.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Type 2 diabetes is the most prevalent form of diabetes and is due to the combination of insulin resistance and defective secretion of insulin by pancreatic β -cells (Diabetes UK Website, 2012). The trend of diabetic cases is increasing with the number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 (Figure 1.1). The prevalence of diabetes is higher in men than women (Wild *et al.*, 2004). There are several noteworthy Asian studies relevant to this current study. The status of diabetes in Asia showed that diabetes patients treated at diabetes centre, majority were not well controlled with HbA1c values exceeding 8% indicated of poor glycaemic control (Chuang *et al.*, 2002).

The prevalence of diabetes mellitus in Malaysia is estimated to be 2.5 million by the year 2030 (WHO, 2011a). The prevalence of diabetes in Malaysia shows an obvious increment. The Second National Health and Morbidity Survey (NHMS II, 1996) reported a prevalence rate of 8.3% type 2 diabetes compared to 6.3% in NHMS I (1986). The national prevalence of diabetes was 11.6% in the NHMS III (2006). A total of 4.5% newly diagnosed diabetes and 2.4% cases of youth (between 18-30 years) diabetes were detected in 2006 (NHMS III, 2006). The result of periodic NHMS is presented below:

Table 1.1: Result of National Health & Morbidity Survey (NHMS)

Year	Study	Prevalence
1986	HHMS I	6.3%
1996	NHMS II	8.3%
2006	NHMS III	11.6%

Malaysian population on year 2006: 26.64 million

NHMS was conducted once in 10 years period

Source: Letchuman *et al.*, 2010

Diabetes is a major health problem that affects the quality of life of the patients and is a major risk factor for morbidity and mortality due to its relatedness to cardiovascular heart diseases (CHD), cerebrovascular disease, and peripheral vascular disease. Lack of exercise, a poor diet, current smoking and alcohol intake are associated with a significant increase risk of diabetes. The majority cases of type 2 diabetes could be avoided by behaviour modification and adoption of healthier lifestyles (Hu *et al.*, 2001a).

Diabetes can be preventable with lifestyle interventions (Lindstrom *et al.*, 2003). Cognizant of this the Malaysian government has undertaken various campaigns on healthy lifestyles on diabetes awareness and proper nutrition practice (habits) over the years (Mustaffa, 2004). However, the expensive cost of treating diabetes imposes a heavy economic burden and poses major challenges to health care policy makers in developing countries such as Malaysia in managing this chronic disease (Wan Norlida *et al.*, 2010). Poor glycaemic control of diabetes will accelerate the occurrence of diabetes complications and thus lead to increased risk of morbidity and mortality among patients (Norma *et al.*, 2010). Several studies showed that the majority of diabetic patients in Malaysia had poor blood sugar control (Adibah, 1998; Eid *et al.*, 2003; Mafauzy, 2005; Noor Hasimah *et al.*, 2010). Lifestyle

intervention mainly dietary counselling; may benefit patients and reduce risks of diabetic complications and cardiovascular heart diseases (CHD) risk factors (Hardcastle *et al.*, 2008). In addition, Medical Nutrition Therapy (MNT) is an integral part of total diabetes care (Yusof *et al.*, 2009). One of the important objectives of MNT for type 2 diabetes is to assist clinical dieticians and healthcare providers in providing better care for individuals with diabetes. A goal of MNT in the management of type 2 diabetes is preventing and treating chronic complications of diabetes (MDA, 2005) leading to the improvement the quality of life among patients.

The improved usage of information technology worldwide especially in nutrition education indicates that an interactive web-based intervention may be beneficial for dietary change interventions, promoting healthy diet and behaviour changes (Kreuter *et al.*, 1999; Kreuter, 2000; Brug *et al.*, 2003; Kroeze *et al.*, 2006). Computer web-based systems are increasingly being used as a tool for dietary assessment (Probst *et al.*, 2008). Various researchers reported that a web-based system uses enhances glycaemic control in patients with diabetes (McMahon *et al.*, 2005; Robertson and Kattelman, 2007; Ralston *et al.*, 2009). The delivery system of diabetic control using a web-based system have also revealed great efficacy in weight loss (Tate *et al.*, 2003; Christian *et al.*, 2011). Furthermore, the establishment of a web-based technology has the potential to be developed for dietary counselling purposes which allows better communication between dieticians and patients. As such, a web-based system was implemented to facilitate dietary assessment for dietician in the diet for diabetes patients.

The approach used in this study was to develop an intervention that incorporates dietary counselling using Diet Management Tool (DMT), a web-based nutrition assessment system in managing diet of diabetic patients. This intervention would improve patient health outcomes and was evaluated in a randomised controlled trial (RCT). A nine (9) month follow up that consist of four (4) times meeting with dietician was used to evaluate the effectiveness of the intervention. This chapter will discuss the background and significance of this study, objectives, research questions and hypotheses.

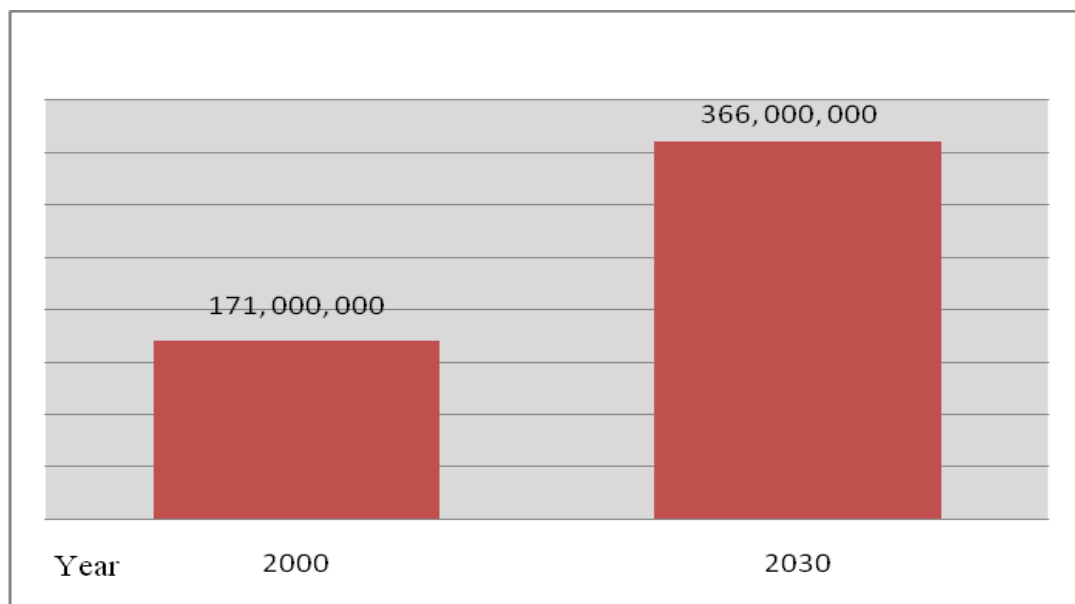


Figure 1.1: Total numbers of people with diabetes in 2000 and estimation in 2030
Source: Wild *et al.*, 2004

1.2 BACKGROUND OF THE STUDY

The prevalence of diabetes mellitus and impaired glucose tolerance in the state of Kelantan were 10.5% and 16.5% respectively (Mafauzy, 2006). In addition, the total cases for diabetic outpatient in Hospital Universiti Sains Malaysia (HUSM) showed a significant of upward trend from 2005 to 2010. The data were as follows:

Table 1.2: Total cases for diabetic outpatient in HUSM

Year	No. of patients
2005	14, 034
2006	15, 578
2007	17, 178
2008	17, 862
2009	19, 070
2010	19, 543

Source: Medical Record Department, HUSM (2011)

This research was conducted in Kelantan due to the worrying rate of new diabetic cases. There is a need to overcome this problem through lifestyle modification especially dietary management. Diabetic patients are at risk of diabetic complications and diabetic education through dietary counselling is crucial to encounter this problem. According to Nield *et al.* (2009) diet is usually the first treatment implemented after diagnosis of type 2 diabetes mellitus and is maintained throughout the addition of other intervention. Dietary interventions using dietary counselling delivered by a dietician plays an important role in conveying information regarding healthy eating habits towards diabetic patients. The roles of dieticians are to ensure that diabetic patients understand the information and practicing habituate

prescribed behaviours in their food intake management (controlling their food intake).

Dietary counselling can help in delaying the direct medical costs of diabetes, including the cost of glucose monitoring, treatment, surveillance for complications, and treatment of complications. It will also improve the quality of life and prolong life (Herman *et al.*, 2005). It has been recommended for many years that people with type 2 diabetes should be treated with dietary intervention to control their diseases as a control mechanism (Franz *et al.*, 1995; Glasgow *et al.*, 1997; Ruzita *et al.*, 1997; Ash *et al.*, 2003; Gatke *et al.*, 2006; Watanabe *et al.*, 2007; Yusof *et al.*, 2009; Al-Sinani *et al.*, 2010). It is crucial to establish the type of dietary intervention either alone or in combination with other interventions such as exercise, behavioural or therapy-based treatment. This is to maximize the effectiveness of self-management practices. Unfortunately, there are various obstacles in following a dietician's advices during and after dietary counselling. The common obstacle among diabetic patients is dietary adherence (Delamater, 2006). A dietary adherence is difficult to follow because it requires attitude and behavioural changes (Al-Hadad *et al.*, 2010). An innovative approach such as tailored intervention in dietary management is needed to overcome this problem (Kreuter, 2000; Eyles and Mhurchu, 2009; Christian *et al.*, 2011) since computer-web-based tailoring is currently one of the most promising and innovative strategies in nutrition education (Kreuter *et al.*, 1999; Brug *et al.*, 2003; Kroeze *et al.*, 2006).

1.3 RATIONALE OF THE STUDY

The study regarding the effectiveness of dietary counselling is still lacking in Malaysia. Studies have been conducted in other countries but each one of these studies has different outcomes. Currently in Malaysia, there was no study to determine the effectiveness of dietary counselling using web-based intervention or information technology approach. In this study, we would like to determine the effectiveness of dietary counselling using Diet Management Tool (DMT) in diabetic patients. DMT is a nutrition assessment system developed as an information technology initiative applied in our dietary counselling session. Only a few studies were conducted in Malaysia that determines the effectiveness of standardised dietary counselling. The studies are done by Ruzita *et al.*, 1997 and Yusof *et al.*, 2009. However, the study done by Ruzita was targeting into a group dietary counselling and Yusof were using a Low Glycemic Index diet in their dietary counselling. Meanwhile, other countries have done a web-based dietary counselling among diabetic patients (McMahon *et al.*, 2005; Robertson and Kattelman, 2007; Probst *et al.*, 2008).

Dietary counselling is essential in providing dietary guidelines to diabetic patient. Dietary counselling provides individualizing nutritional care for encouraging modification of eating habits. In addition, dietary counselling often includes meal planning (Kaczkowski, 2002). It will provide prevention of nutrition-related conditions such as the need for weight management since majority of diabetic patients is overweight or obese. This type of treatment will help patient in term of reducing calorie intake to lose body weight. Studies support this assertion, by

showing that dietary counselling improved body weight and body mass index (BMI) among diabetic patients (Ruzita *et al.*, 1997). In addition, a review conducted by Anderson *et al.* (2003) found that weight loss of 10% of initial body weight may improve glycaemic control and reduce lipid and blood pressure co-morbid risks. It was found that dietary intervention by dietary counselling gave positive effects especially in glycaemic control outcomes. These prior studies indicate that, dietary counselling reduced results of FBS or HbA1c, leading to the decrease risk of diabetic complications in upcoming life (Wing *et al.*, 1994; Franz *et al.*, 1995; Ruzita *et al.*, 1997; Watanabe *et al.*, 2007; Al-Sinani *et al.*, 2010). Furthermore, it was also found that there was a significant improvement in the quality of dietary intake in diabetic patients who received dietary counselling. Participation in dietary counselling may benefit patients by helping them to change their dietary habits (Ruzita *et al.*, 1997), decreasing in energy intake (Watanabe *et al.*, 2007; Pimentel *et al.*, 2010) and increase amount of dietary fibre consumptions (Yusof *et al.*, 2009).

On the other hand, a web-based dietary counselling also provided a valuable finding. The study reported that diabetic patients that received web-based care management had lower HbA1c ($p < 0.05$) when compared to usual care (McMahon *et al.*, 2005; Robertson and Kattelman, 2007). Study also showed that patients had significant changes in term of total fat and saturated fat in group that received web-based intervention (information technology) approached (Probst *et al.*, 2008). Therefore, the rationale of dietary counselling using Diet Management Tool (DMT) is to determine the effectiveness of dietary counselling using web-based intervention since currently there were no study conducted in Malaysia regarding this matter. The

following page was the conceptual framework of dietary counselling using Diet Management Tool (DMT) in managing diet of diabetes patients (Figure 1.2).

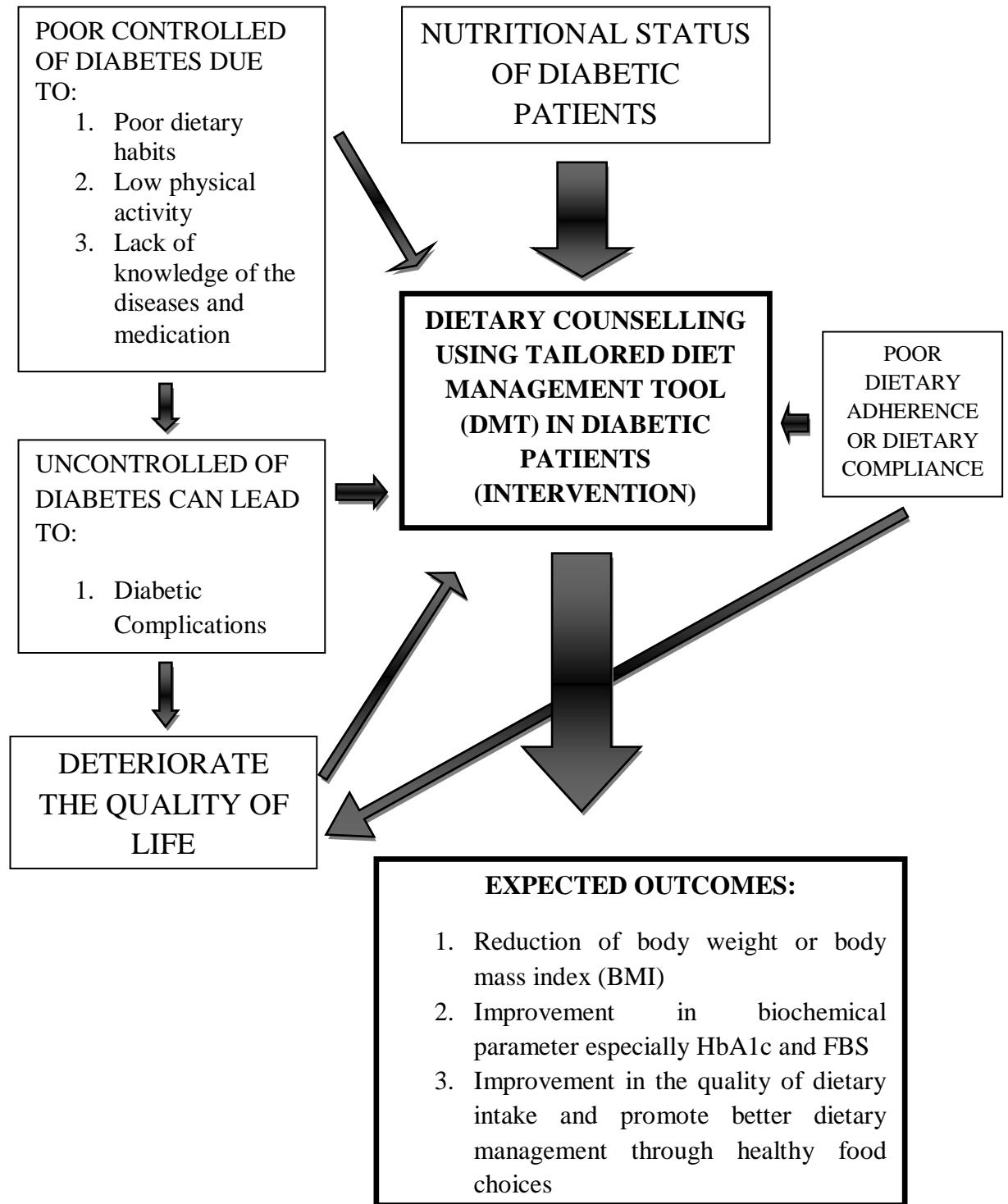


Figure 1.2: Conceptual framework of dietary counselling using a web-based tailored Diet Management Tool (DMT) in managing diet of diabetes patients

1.4 RESEARCH QUESTION

Does one-to-one dietary counselling by dieticians using DMT improve the health outcomes of type 2 diabetic patients? In order to address this research question, three (3) criterias have been determined. These are:

- a) Anthropometric measurement: Nine months weight loss (5-10%)
- b) Biochemical profile: improvement of HbA1c and FBS
- c) Dietary intake: Regular meals with appropriate choices

1.5 RESEARCH OBJECTIVE

In relation to the research question, this section outlines the objectives that guide this current research. There is one (1) general objective and three (3) specific objectives. Each objective is outlined below.

1.5.1 General Objective:

To examine whether one-to-one dietary counselling by dieticians using DMT improves the health outcomes of type 2 diabetic patients. This is in terms of evidencing weight loss (5-10%) within nine (9) months, improvement of HbA1c and FBS, and habituating regular meals with appropriate choices.

1.5.2 Specific Objectives:

- a) To examine the effectiveness of tailored intervention approach using DMT towards improvement of anthropometric measurement among diabetic patients in intervention and control group.
- b) To examine the effectiveness of tailored intervention approach using DMT towards improvement of biochemical profile among diabetic patients in intervention and control group.
- c) To examine the effectiveness of tailored intervention approach using DMT towards improvement of dietary intake pattern among diabetic patients in intervention and control group.

1.6 RESEARCH HYPOTHESES

The following hypotheses were tested during the study:

- a) Participants in the intervention group who received one-to-one dietary counselling using DMT would have significant difference of anthropometric measurement compared to participants in the control group.
- b) Participants in the intervention group who received one-to-one dietary counselling using DMT would have significant difference of biochemical profile (HbA1c, FBS and eAG) compared to participants in the control group.
- c) Participants in the intervention group who received the one-to-one dietary counselling using DMT would have significant difference of dietary pattern compared to participants in the control group.

1.7 NULL HYPOTHESES

- a) There is no significant difference of anthropometric measurement between participants who received the one-to-one dietary counselling using DMT compare to control group.
- b) There is no significant difference of biochemical profile (HbA1c, FBS and eAG) between participants who received the one-to-one dietary counselling using DMT compare to control group.
- c) There is no significant difference of dietary pattern between participants who received the one-to-one dietary counselling using DMT compare to control group.

CHAPTER 2

LITERATURE REVIEW

In this chapter, several issues are discussed. The first issue delineates the key variables of this study. The second issue pertains to the effectiveness of dietary counselling. As a third component of this chapter, DMT in managing the diet of diabetic patients is discussed.

2.1 DEFINITION OF KEY TERMS

In this section, several key terms are described. They are diabetes mellitus, type 2 diabetes mellitus, nutritional status assessment and diabetes counselling.

2.1.1 Diabetes Mellitus

Diabetes mellitus is a metabolic disorder that is characterised by high blood sugar level (hyperglycaemia) resulting from defects in insulin secretion, insulin action, or both (ADA, 2011). Insulin is a type of hormone that is produced by the pancreas (Lutz and Przytulski, 2011) and it is important for the body as it transforms glucose into usable energy necessary for physio-physical actions (PDM, 2011). In a normal situation, food that we eat will be converted into a simple sugar that is called glucose. This simple sugar will then be absorbed into the blood to generate energy. When body lacks insulin or its function is exaggerated, the blood glucose level will increase. The glucose level will build up in the blood instead of going into cells of

the body. This condition is called diabetes. Diabetes is a global concern affects both developed countries and developing countries (Wild *et al.*, 2004). Diabetes mellitus is a chronic disease that requires long-term medical attention because it is associated with acute and chronic complications. In addition, diabetes complications may affect an individual's health status, quality of life (Kamarul Imran *et al.*, 2010), treatment costs (Wan Norlida *et al.*, 2010) and psychological (Rubin and Peyrot, 2001).

2.1.2 Types and Classification

Diabetes can be categorised into four (4) major types; type 1, type 2, other specific types of diabetes due to other causes and gestational diabetes mellitus (GDM) or diabetes diagnosed during pregnancy (ADA, 2012). Type 1 diabetes is also known as '*Juvenile Onset Diabetes*'. It is typically detected during childhood or adolescent. It accounts for only 5-10% of those with diabetes (ADA, 2011). This type of diabetes occurs due to the failure of pancreas to produce insulin or resulted from autoimmune destruction of the beta cell of the pancreas. Patients diagnosed with type 1 diabetes will require long-term dependent on insulin to continue their life. Besides, they need to control their dietary intake and do exercise to control the disease.

Type 2 diabetes also known as '*Adult-Onset Diabetes*', is a common type of diabetes that occur among adult people (age 45 years and above) and who has a weight problem (Magee, 2004). It accounts for 90% of cases globally (Zimmet *et al.*, 2001) and this type of diabetes includes individuals who have insulin resistance and impaired insulin secretion by the beta cells. Type 2 diabetes can be controlled by

dietary modification, medications or insulin injection and exercises. Other specific types of diabetes due to other causes that can lead to diabetes such as genetic defects in beta cells, genetic defects in insulin action, diseases of exocrine pancreas (cystic fibrosis) and drug or chemical induced (drug used in HIV or after organ transplantation) (ADA, 2012).

Another type of diabetes is known as gestational diabetes mellitus (GDM) which occurs during the second half of pregnancy. It is characterised by a high blood sugar level during pregnancy due to occurrence of hormonal changes during pregnancy. GDM has been defined as any degree of glucose intolerance with onset or first recognition during pregnancy (ADA, 2011). It is a temporary condition and typically goes off after giving birth. However, women diagnosed with gestational diabetes are at risk to getting permanent type 2 diabetes in the future.

2.2 TYPE 2 DIABETES MELLITUS

In this section, several key terms are described. They are type 2 diabetes mellitus, sign and symptoms, risk factor, complications and treatment.

2.2.1 Introduction

Type 2 diabetes is the most common form of diabetes in the world (Nield *et al.*, 2009). It can occur at any age but usually majority of type 2 diabetes patients are diagnosed with diabetes at age of 45 and above. Majority of them are obese and has a family history of diabetes (Magge, 2004). Other factors that can lead to diabetes are excess calorie intake and less physical activity. Type 2 diabetes patients are not dependent on exogenous insulin (*it comes from a sources external to a body of diabetic patients*) but many require it for control of blood sugar level if this cannot be achieved using diet alone or oral anti-diabetic agents (Zimmet *et al.*, 2001). The number of people with diabetes is expected to increase to over 366 million by year 2030. It is double of the status during year 2000 (Wild *et al.*, 2004).

2.2.2 Sign and Symptoms

There is a common sign and symptom of diabetes such as excessive thirst (polydipsia), excessive urination (polyuria) and excessive eating (polyphagia) (Lutz and Przytulski, 2011). The other sign and symptom that is common among diabetic

patients includes fatigue, unexplained weight loss (CPG Diabetes, 2009), poor wound healing, infections, altered mental status and blurred vision.

2.2.3 Diabetes Risk Factor

There are many risk factors that can lead to diabetes. Some of the risk factors are based on family history and genetics. However, family history and genetics factor alone are not reason for being diagnosed with diabetes. The other risk factors that can lead to diabetes are obesity, sedentary lifestyle (Costacou and Mayer-Davis, 2003), unhealthy eating habits and ageing. Obesity is known to be a strong risk factor for type 2 diabetes mellitus (Van Dam *et al.*, 2002).

2.2.4 Diabetic Complications

Uncontrolled diabetes can lead to complications that will burden and affect patient's life. Diabetic's complication can be classified as acute or chronic (long term complication). Acute complications require immediate care (Lutz and Przytulski, 2011). Three (3) acute complications seen in patients with diabetes are hypoglycaemia, hyperglycaemia (CPG Diabetes, 2009) and diabetic ketoacidosis (DKA) (Lutz and Przytulski, 2011). Hypoglycaemia can be defined as a blood sugar level of less than 4.4 mmol/L. Hypoglycaemia may be caused of certain condition such as having too much insulin, too little food intake or delayed meal, excessive exercise, alcohol or medication such as oral hypoglycaemia agents (Lutz and Przytulski, 2011). While hyperglycaemia occurs when blood glucose levels are

above or higher than the normal value (fasting blood sugar: more than 6.1 mmol/L, random blood sugar: more than 8.0 mmol/L). Meanwhile, chronic (long term) diabetic's complication is divided into two (2) categories. It includes macrovascular (cardiovascular, cerebrovascular, peripheral vascular systems) and microvascular complications (nephropathy, neuropathy, and retinopathy).

In a study conducted by National Health Morbidity Survey III (NHMS III, 2006), the prevalence of diabetes cases based on complications include lower limb amputation (4.3%), followed by stroke (3.4%) while dialysis or kidney transplant contribute about 1.6% among diabetic patients in Malaysia (Letchuman *et al.*, 2010). Based on research done by Mafauzy (2005), the highest prevalence of diabetic complication among diabetic patients who had received treatment at primary healthcare in Malaysia was neuropathy (30.1%), retinopathy (23.5%), albuminuria (22.9%) and micro albuminuria (20.4%). The results showed that majority of diabetes patients did not have good metabolic control since most of the patients (80%) had HbA1c results of more than 7.0% and 89.0% had fasting plasma glucose (FPG) of more than 6.7 mmol/L. Surprisingly, the result also revealed that only a few of the patients (6.9%) practiced self-monitoring of blood glucose (SMBG) and 6.2% did home urine glucose test.

Noor Hasimah *et al.* (2010) also conducted a research regarding the complications among type 2 diabetic patients at a general hospital in East Coast of Malaysia. The research was a retrospective study based on patient's medical record, which involved 215 patients who were admitted with diabetic complications in medical ward for six (6) months. The results showed that 89.2% of participants had

one (1) or more diabetic complications and mostly nephropathy (34.9%). On the other hand, comparison between genders showed that the diabetic foot ulcer was the most common diabetic complications among males (43.8%) while diabetic nephropathy was commonly among females (40.9%). In addition, the study revealed that 92.6% participants had poor blood sugar control during hospitalization. For this reason, diabetes requires medical care and self-management education to reduce and prevent its complication. Furthermore, better glycaemic control is associated with better clinical outcomes among diabetic patients (Al-Qazaz *et al.*, 2011).

2.2.5 Diabetes Treatment

Diabetes is a difficult disease to live with and also difficult to manage (Rubin and Peyrot, 2001). Diabetes needs to be controlled and it needs cooperation with all healthcare professionals such as doctor, diabetes educator, dietician and also patients to ensure the success of the treatment (Schiller *et al.*, 1998). In healthcare settings, education and training are required to develop the communication skills of health professionals in all aspects of preventive medicine (Poskiparta *et al.*, 2006). The collaboration between the healthcare professionals in the treatment mission needs a continuous communication to achieve the desired target. The patients need to know about their disease, symptoms, risk of diabetic complications especially the foot care and the type of treatment they received. Other than that, the patients need to control their food intake, actively involved in physical activities, practice self-monitoring of blood glucose, extra care during sickness, hypoglycaemia and stress (Asian Pacific Type 2 Diabetes Policy Group, 2005).

The primary treatment goal for people with diabetes is blood glucose control since it helps to delay or prevent diabetic complications (Renosky *et al.*, 2008). The metabolic control targets for diabetes are good metabolic control, minimize the complication of diabetes, control of co-occurring disease and improve quality of life. In order to achieve the target, the results should be of HbA1c < 6.5%, fasting blood sugar (FBS) between 4.4 – 6.1 mmol/L and 2-hour post-prandial blood glucose between 4.4 – 8.0 mmol/L (CPG Diabetes, 2009). Diabetes is not significantly associated with gender, age, duration of diabetes, BMI or HbA1c prior to baseline. The most important is improved control which depends largely on patient’s self-care behaviours (Hartz *et al.*, 2006). Moreover, eating a variety of foods, maintaining a healthy weight, choose diet that is low in fat and cholesterol, increase fibre intake, controlling sugar intake, use salt in moderation are certain precautions for diabetes control (Jeevani, 2011).

Table 2.1: Target for type 2 diabetes mellitus

Glycaemic control	Levels
Fasting blood sugar	4.4-6.1 mmol/L
Non fasting blood sugar	4.4-8.0 mmol/L
HbA1c	< 6.5%
Lipids	
Triglycerides	≤ 1.7 mmol/L
HDL Cholesterol	≥ 1.1 mmol/L
LDL Cholesterol	≤ 2.6 mmol/L
Exercise	150 mins/week
Blood pressure	
Normal renal function	≤130/80 mmHg
Renal impairment/Gross proteinuria	≤125/75 mmHg

Source: CPG Diabetes, 2009

a) Medical Nutrition Therapy (MNT) for Diabetes

Dietary control is considered as a cornerstone of diabetes management. Effective diabetes management cannot be achieved if no special attention given to dietary intervention. Dietary management not solely focused on blood sugar control but also in term of controlling obesity, hypertension and dyslipidaemia. The dietary management goals for diabetes are to achieve and maintain optimal blood glucose level, reduce risk of complication of diabetes and follow balanced diet (MDA, 2005). The education concerning diet management can help to control diabetes and reduced diabetic complications in future. Dietician plays an important role to ensure the information of nutrition and diet given properly to diabetic patients. The information can be used by diabetic patients in term of selection and quantity of food taken. Dietary advice provided by dietician should take into account the aspect of personal and cultural, preferences, belief and lifestyle (MDA, 2005). The dietary advice should fulfil the needs of patients and they are really prepared or motivated to do changes in dietary management.

Medical Nutrition Therapy (MNT) is a nutrition practice guidelines which was developed by dieticians in order to provide a solid framework to assist dietician in the management of diet and disease. The framework consists of assessment, intervention (nutrition prescription, education, goal setting) and evaluation of outcomes of MNT (Franz *et al.*, 1995). As evidence by cased-based review, MNT is an effective adjunct therapy for individuals with diabetes and is associated with a 1% - 2% reduction in HbA1c (Vetter and Volger, 2010). Based on ADA (2005), clinical trials or outcome studies of MNT have reported decreases in HbA1c at three (3) to

six (6) months ranging from 0.25% to 2.9% with higher reductions seen in type 2 diabetes of shorter duration.

Table 2.2: Medical Nutrition Therapy (MNT) Guidelines for the management of type 2 diabetes

Nutrient	Recommendation
Carbohydrate	<ul style="list-style-type: none"> - Carbohydrate from whole grains, fruits, vegetables and low fat dairy products should be included in a healthy diet. - Total amount of carbohydrate is more important than the source (starch or sugar) or type (high or low GI). - Sucrose and sucrose containing foods may be incorporated into a healthy meal planning. - Sucrose and sucrose containing foods can be substituted for other CHOs as part of mixed meals up to maximum of 10% of energy, provided adequate control of blood lipids. - Choosing low GI foods in place of conventional or high GI foods has a small but clinically useful effect on medium-term glycaemic control. - There is however insufficient evidence of its long-term benefit to recommend use of low GI diets as a primary strategy in meal planning. - Non-nutritive sweeteners are safe when consumed within the acceptable daily intake levels established by FDA. - Consumption of dietary fibre is encouraged as for the general public (20-30 gm/day).
Fat	<ul style="list-style-type: none"> - 25-30% of total calories. - Less than 10% of energy intake should be derived from saturated fats. - To lower LDL cholesterol, energy derived from saturated fat can be reduced if weight loss is desirable or replaced with either carbohydrate or monounsaturated fat if weight loss is not a goal. - 4-7% of polyunsaturated fat of energy intake. - Maximize monounsaturated fat intake. - Minimize trans fatty acids intake. - Dietary cholesterol intake should be less than 300 mg/day. Individuals with LDL cholesterol more than 2.6 mmol/L may benefit from lowering dietary cholesterol to < 200mg/day.
Protein	<ul style="list-style-type: none"> - About 15-20% of total calories. - Moderate protein restriction of 0.6-0.8 g/kg/d may be considered in patients with overt nephropathy with/or renal impairment.
Micronutrients	<ul style="list-style-type: none"> - There is no clear evidence of benefit from vitamin or mineral supplementation in people with diabetes, who do not have underlying deficiencies. Exceptions include folate for prevention of birth defects and calcium for prevention of bone diseases.
Alcohol	<ul style="list-style-type: none"> - In individuals who choose to drink alcohol, daily intake should be limited to one drink for adult women and two drinks for adult men. One drink is defined as 12 oz beer, 5 oz of wine or 1.5 oz of distilled spirits. - Alcohol should be consumed with food to reduce the risk of hypoglycaemia.

Source: MDA, 2005

b) Weight Management in Type 2 Diabetes

Most type 2 diabetic patients are overweight or obese (Hensrud, 2001) and therefore there is a need to reduce weight in order to control diabetes (Huisman *et al.*, 2009). Obesity is an important and well established risk factor for diabetes (Wannamethee and Shaper, 1999). Obesity and weight gain can increase risk for diabetes by greater than 90-fold (Anderson *et al.*, 2003). Achieving weight loss is very important in the treatment of diabetes since it helps to improve insulin absorption and decrease high blood glucose levels. Uncontrolled of these conditions can lead to serious diabetes complications such as cardiovascular disease, retinopathy, neuropathy or nephropathy. Type 2 diabetes is associated with obesity because the weight management is one of the important management for diabetes treatment. Patients with obesity problem need to be offered with individual intervention in order to encourage weight reduction. This is important because energy restriction will improve glycaemic control (Hensrud, 2001).

Weight management is one of the important components in the management of diabetes. There is also a strong relationship between weight and incidence of type 2 diabetes mellitus. In a study done by Wannamethee and Shaper (1999), substantial weight gain (more than 10%) was associated with a significant increases in risk of type 2 diabetes compared to participant with stable weight after adjustment of age, initial BMI and other risk factors . The target of weight reducing is between 5-10% in 3-6 months as recommended for those who are overweight or obese (Asian Pacific Type 2 Diabetes Policy Group, 2005). This was supported by Ash *et al.* (2003) which demonstrated that a dietary prescription of 1400-1700 kcal/day was effective in