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Translation and Evaluation of the Thai Version of the Diabetes Numeracy Test for Older Adults with Type 2 Diabetes

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Translation and Evaluation of the Thai Version of the Diabetes Numeracy Test for Older Adults with Type 2 Diabetes

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Dedication

In dedication to my wonderful parents for great love, unlimited support, and shining my world, to my beloved husband for his love, understanding, support, and smiling at my heart, to my dear sister for her love and making me happy, to my teachers and friends for their help and support

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Translation and Evaluation of the Thai Version of the Diabetes Numeracy Test for Older Adults with Type 2 Diabetes

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The population of older adults with type 2 diabetes mellitus (T2DM) in Thailand is increasing. As this trend continues, the nursing community and public policy makers will need increasingly effective methods to improve health outcomes within this group. This study determined the significance of non-modifiable selected personal factors (age, gender, education, and duration of disease) and modifiable factors (health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy) on diabetes self-management and glycemic control in Thai older adults with T2DM. To achieve this goal it was necessary to first create a version of the Diabetes Numeracy Test (DNT) that is conceptually equivalent to the original and is appropriate for the Thai culture and age group of the study.

The study was conducted in two phases. In Phase 1, multiple steps were conducted to assure the validity and reliability of the Thai DNT. After evaluating the results of that process the Thai-DNT was determined to be a suitable instrument for use in Phase 2. In Phase 2, the revised Thai-DNT was administered with the Three Levels of Health Literacy Scale, the General Diabetes Knowledge Test, the Thai version of the

Diabetes Management Self-Efficacy Scale, and the Revised Summary Diabetes Self-Care Activities (SDSCA). Psychometric properties of the Thai DNT were tested. Pearson correlation coefficient was used to examine the relationships among study variables. Hierarchical multiple regression was used to predict diabetes self-management and glycemic control. A convenience sample of 170 Thai older adults with T2DM participated in the study. Participants were recruited from three primary care units and a community hospital in a suburban area, Nakhon Pathom province, Thailand. The mean age of the sample was 67.82. Most were female (61%), and a large majority had low education (80% completed at most a primary school education).

Age, diabetes knowledge and self-efficacy were found to significantly predict diabetes self-management. Diabetes knowledge and duration of diabetes predicted glycemic control (A1C). Findings from this study indicate that efforts to increase diabetes knowledge and self-efficacy can help Thai older adults with their diabetes self-management behaviors and control their glycemic levels.

DNT scores were low but did not account for variance in diabetes self-management and glycemic control.

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CHAPTER 1: INTRODUCTION

This chapter introduces the study by providing the background for the study and the significance of diabetes, diabetes-related complications, diabetes self-management, older adults with diabetes, and related factors involved with glycemic control; and provides the purpose of the study, the statement of the problem, research questions, the conceptual framework, definitions of variables, assumptions, the significance for nursing, and limitations of the study.

Prevalence of Diabetes

Diabetes is a serious global problem that has become one of the most challenging health problems in the 21th century (International Diabetes Federation [IDF], 2013). In 2013, there were 382 million people with diabetes representing 130 countries across the world. That number is estimated to increase to 592 million (by 55%) by 2035 (Guariguata et al., 2014). Almost 1 in 10 of the world's adult population has diabetes (World Health Organization [WHO], 2013a). Evidence shows that the prevalence and incidence of diabetes have continued to grow worldwide since 2000. A recent report from the IDF stated that 8.3% of the world's adult population lives with diabetes. The prevalence of diabetes in North America and the Caribbean is 11%; in the Middle East and North Africa it is 9.2%; and in the Western Pacific regions it is 8.6%. The emergence of a high prevalence of people who have diabetes is found in low-and middle-income countries

include countries in the Middle East, Western Pacific, sub-Saharan Africa, and South-East Asia (IDF, 2013).

Complications due to diabetes are a major cause of disability, low quality of life, and death. Diabetes-related complications affect a variety of body systems in each person and in different ways. Consistent high blood glucose levels lead to health problems that affect heart and blood vessels, eyes, kidneys, and nerves. Overall, in 2010 almost four million people of the world population of all ages died due to diabetes, accounting for 6.8% of the global all-cause mortality (Roglic & Unwin, 2010). Recently, the IDF reported that diabetes caused 5.1 million deaths of adults aged 20 to 79 years in 2013, accounting for 8.4% of all-cause mortality among people in this age group across the globe; approximately one person died from diabetes every six seconds (IDF, 2013). Half of diabetes patients die of cardiovascular diseases such as heart disease and strokes. In addition, diabetes is a leading cause of blindness, kidney failure, and neuropathy, especially limb amputations (WHO, 2013b). One percent of global blindness is due to diabetes (WHO, 2012). By the end of 2013, diabetes around the world cost USD 548 billion in healthcare spending that included health care services, productivity loss, and disability (IDF, 2013).

Older People with Diabetes

The number of older people (defined as people aged 60 years or over) is increasing globally. In mid-2013, the world population was about 7.2 billion people, estimated to reach 8.1 billion in 2025, and 9.6 billion in 2050. Older people accounted for

11.7% of the world population in 2013. By 2050, the Department for Economic and Social Affairs expected the number of older people to rise to 21.2 % of the world population (United Nations, 2013).

Older adults face multifaceted changes that involve biological, psychological, and social aspects of their lives and the changes vary for individuals (Ferraro, 2013). However, deteriorative changes in older adults might result in physical impairment and reduced functional abilities such as reduced cardiac output, development of atherosclerosis, stiffening and decreased elasticity of blood vessels, reduced function in the gastrointestinal system, reduced muscle mass, strength, and function, reduced bone mineral and bone mass in the musculoskeletal system, less efficient sensory organs, and decreased hormones secretion (Eliopoulos, 2014). Therefore, age-related physiological changes might impact older adults' abilities for self-care and could lead to changes in their lifestyles such as decreased eating and exercise.

Older people are particularly affected by diabetes. The number of people with diabetes is increasing worldwide, especially in older populations (Wild, Roglic, Green, Sicree, & King, 2004). Prolonged life expectancy and pubic health improvements over the last decades contribute to the increasing number of older people and also the number of older adults with diabetes. The global prevalence of diabetes in people aged 60-79 is estimated at 18.6%; more than 134.6 million people account for more than 35% of all diabetes cases among adults. The number of older adults with diabetes is expected to increase to over 252.8 million by 2035 (IDF, 2013). Factors that lead to the development of diabetes in older adults include age-related changes in glucose metabolism, lifestyle

changes contributing to insufficiency of nutrition and reduced physical activities, genetic factors, abnormal hormone secretions, adiposity, medications, and comorbidities (Meneilly, 2007). Therefore, older adults have a higher prevalence of diabetes.

Older adults with diabetes have an increased rate of diabetes-related complications and they experience increased severity in illness. Diabetes was recorded as a major contributing factor of death in people aged 65 years or older, directly and indirectly via heart disease and stroke (Centers for Disease Control and Prevention [CDC], 2011). Older adults who had diabetes were 1.7 times more likely to have functional impairments (Chau et al., 2011), declining physical ability (Wray, Ofstedal, Langa, & Blaum, 2005), cognitive impairment (Chau et al., 2011; Gilmour, 2011) and have a higher risk of hypoglycemia (Greco, Pisciotta, Gambina, & Maggio, 2010). Older adults who used insulin were more likely to have hypoglycemia (Hewitt, Smeeth, Chaturvedi, Bulpitt, & Fletcher, 2011).

Older adults with diabetes tend to have fewer opportunities to receive health care services such diabetes education, diet consulting (Bruce, Davis, Cull, & Davis, 2003), and exercise counseling (Forjuoh et al., 2011). It is possible that older adults have functional impairments and declining physical ability that limit their abilities to travel by themselves to receive diabetes education and diabetes management consulting. Health care providers might determine that older adults are less able to exercise. In addition, older adults with T2DM who have extensive physical functional limitations were less likely to receive eye exams than those with only minimal and moderate physical functional limitations (OR 0.69, 95% CI 0.49 – 0.99; Lee et al., 2012).

Furthermore, older adults who had diabetes were more likely to have difficulty self-managing their diabetes, such as performing blood glucose self-monitoring (Blaum et al., 2010; Bruce et al., 2003). Cognitive impairments might affect the learning process when older adults received information and impact their diabetes self-management. Among older adults with diabetes, those who had cognitive impairment had less understanding of diabetes management (Hewitt, et al., 2011). In addition, older adults with diabetes and concurrent moderate or severe cognitive impairments are even less likely to exercise regularly and follow recommendations for meal plans (Feil, Zhu, & Sultzer, 2012).

Diabetes in Thailand

Diabetes is a growing problem and is a serious chronic illness in Thailand, located in South East Asia. The IDF reported that in 2013, there were about 49 million adults aged 20-79 years old in Thailand of whom 3,150,670 had diabetes, a prevalence of 6.42%. The number of undiagnosed diabetes cases is about 1,704,000 (IDF, 2013). Data sources in Thailand show that in 2012 Thailand had 336,265 new cases of diabetes or 523.24 per 100,000. Among new cases of diabetes in 2012, Thai women had diabetes at almost two times the rate of Thai men. The cumulative incidence of all diabetes cases from 2008-2012 in Thailand was 1,799,997 and the prevalence was 2,800.80 per 100,000 (Thonghong, Tepsittha, Jongpiriyaanan, & Gappbirom, 2012).

Diabetes-related complications are a burden in Thailand. Diabetes-related complications were discovered in 26.94 % of Thais with diabetes (Thonghong, et al.,

2012), with 7-32% (depending on the sample) having diabetic retinopathy, 11.6-43.9% with diabetic nephropathy, 21-27% with diabetic neuropathy, and 0.2-1.6% with amputation (Medical Research & Technology Assessment, 2013). Diabetes, as part of the endocrine, nutritional and metabolic diseases group (ICD Mortality Tabulation List 1, 10th Revision of Thailand, E00-E88), was listed as the eighth leading cause of death in 2007-2011. Depending on age and sex, this group of diseases accounted for 12.3-13.8 deaths per 100,000 population (Health Information Unit, Bureau of Health Policy and Strategy, Thailand, 2013a). Data for 2004 (the most recent year available) showed that diabetes was the eighth (for males) and the third (for females) leading disease contributing to disability-adjusted life years of Thai people (Working Group on Burden of Disease and Risk Factors, Thailand, 2013).

Diabetes impacts the health care system and leads to burdens on patient, family, and society. The estimated cost of diabetes care in Thailand in 2008 was USD 418, 696 (1 USD = 32 THB). Of this, 23% was for direct medical cost, 40% for non-direct medical cost and 37% for indirect cost (Chatterjee et al., 2011). The annual estimated diabetes-related expenditure per person for Thai people with diabetes averages USD 256 (IDF, 2013). The hospital admission rate for diabetes continuously increased in the past decade. In 2010, diabetes was the sixth leading cause of patients' admission to the hospital at a rate of 792.61 admissions per 100,000 population (Health Information Unit, Bureau of Health Policy and Strategy, Thailand, 2013b). Therefore, it is important to control diabetes in order to prevent the complications, suffering, and costs.

Older Adults with Diabetes in Thailand

Thailand faces a demographic transitional period. Thailand has become an aging society in which more than 10% of the total population is aged ≥ 60 years. In mid-2013, the Thai population was about 67 million people, estimated to reach 67.9 million in 2025. Older people (defined as people aged 60 years or over) accounted for 14.5% of Thai population in 2013. By 2050, the number of older people in Thailand is expected to rise to 37.5 % with 10% of the Thai population expected to be 80 years or over (United Nations, 2013). Moreover, both the number and proportion of Thailand's aging population are continuously increasing. The proportion of the aging population per the total population in Thailand increased from 6.8 % in 1994 to 9.4% in 2002 and increased to 10.7% in 2007 (National Statistical Office of Thailand, 2008).

In Thailand 58.8% of older adults are in early late adulthood (age 60-69 years old), 31.7 % in middle late adulthood (age 70-79 years old), and 9.5 % in late adulthood (age ≥ 80 years old; National Statistical Office of Thailand, 2008). The increasing rate of the aging population is a result of decreasing death rates and overall health care improvements in recent decades. Furthermore, the life expectancy at birth of Thai people is longer. In 2005, the life expectancy at birth of males and females was 68 and 75 years, respectively, and the life expectancy at birth of males will increase to 75 years and females to 80 years in the next 50 years (Wapatanawong & Prasartkul, 2013). The increase of both number and longevity of aging population will likely impact many aspects of the country, especially public health care.

The population of older adults with diabetes is growing in Thailand. A national health survey that collected data about the Thai population in 2007 reported that diabetes was the second most common chronic illness in aging populations, both in males and females. Diabetes was found in 13.3% of the aging population (National Statistical Office of Thailand, 2008). Among new case of diabetes in 2012, it was found that older adults had a morbidity rate from diabetes that was greater than for other adult age groups: 2,128.04 per 100,000 population in aged ≥ 60 years compared with 1,207.35 per 100,000 population for age 50-59 years, 463.44 per 100,000 population for age 40-49 years, and 61.61 per 100,000 population in age 15-39 years (Thonghong, et al., 2012).

Among all Thai adults with diabetes, older adults with diabetes have a higher risk of diabetes-related complications than younger adults with diabetes. The Chronic Disease Surveillance Report from 2006-2010 found that adults in Thailand who were ≥ 60 years old with diabetes had more diabetes-related complications than younger adults with diabetes; rates were 2.34 times greater for diabetic retinopathy, 2.30 times greater for disability, and 2.25 times greater for heart disease (Thonghong, et al., 2012). Older adults might need different strategies for diabetes self-management compared to working age adults. For example, older adults with diabetes might need to modify eating not just for diabetes, but also if they have decreased appetite.

Thai public health policies support diabetes self-management for older adults to prevent the development or worsening of diabetes-related complications (National Economic and Social Development Board, 2012). The Thai Eleventh National Economic and Social Development Plan that has been used in 2012-2016 focuses on developing the

potential of every individual at all levels to reach health policy goals (National Economic and Social Development Board, 2012). Among the Thai development goals is to provide lifelong learning opportunities to promote better health, and decrease and prevent chronic disease-related complications. However, from a survey of experimental and quasi-experimental nursing research in patients with diabetes during 1982-2005 in Thailand, only 6.4% of these studies focused on older adults with diabetes (Playrahan, 2008). Therefore, there is a gap of knowledge in diabetes care for older adults with diabetes.

Diabetes Self-Management and Glycemic Control

To prevent diabetes complications, patients must control blood glucose levels for preprandial capillary plasma glucose between 70 and 130 mg/dL or peak postprandial capillary plasma glucose at < 180 mg/dL and glycosylated hemoglobin (A1C) levels below 7% (American Diabetes Association [ADA], 2014). Patients with diabetes achieve control by ongoing self-management for life. ADA guidelines for patients with diabetes encourage patients to take an active role in diabetes self-management. The guidelines recommend that patients with diabetes perform a set of self-management behaviors that include nutrition management, physical activity, taking medications for hyperglycemia, and insulin and glucose monitoring (ADA, 2014). A meta-analysis of research on interventions for patients with type 2 diabetes (T2DM) found that interventions that teach diabetes self-management behaviors help patients to achieve and maintain glycemic control and resulted in an A1C that was significantly decreased in the intervention groups (Klein, Jackson, Street, Whitacre, & Klein, 2013).

Health Literacy

Diabetes self-management requires adequate health literacy, defined as "the wide range of skills, and competencies that people develop to seek out, comprehend, evaluate and use health information and concepts to make informed choices, reduce health risks and increase quality of life" (Zarcadoolas, Pleasant, & Greer, 2005, p.196-197). Health literacy is further defined to comprise three levels or types of literacy including functional literacy, communicative literacy, and critical literacy (Nutbeam, 2000). For example, to successfully perform diabetes self-management behaviors, patients need to read and understand health information (functional literacy), communicate with health care providers to exchange health information (communicative literacy), and apply health information to decision making in diabetes care (critical literacy). Patients with limited health literacy were more likely to have poor knowledge about the disease (Gazmararian, Williams, Peel, & Baker, 2003; Powell, Hill, & Clancy, 2007), worse communication with healthcare providers (Schillinger, Bindman, Wang, Stewart, & Piette, 2004), poor self-management behaviors (Powell et al., 2007; Yamashita & Kart, 2011), and worse glycemic control (Ishikawa, Takeuchi, & Yano, 2008; Ishikawa & Yano, 2011; Powell et al., 2007; Schillinger, Barton, Karter, Wang, & Adler, 2006; Schillinger et al., 2002; Tang, Pang, Chan, Yeung, & Yeung, 2008; Thabit et al., 2009).

Numeracy

Similarly, the related concept of diabetes related numeracy also plays a significant role in diabetes self-management for glycemic control. Numeracy is a person's skill in using numbers and understanding how to use them in their daily life (Rothman et al., 2006). Patients with diabetes need numeracy skills for effective diabetes self-management, which requires calculations to be able to compute carbohydrate intake, use food labels, interpret blood glucose monitoring results, and determine medication doses (Bowen et al., 2013; Cavanaugh et al., 2008).

Diabetes Numeracy Test

The Diabetes Numeracy Test (DNT) was developed to measure specific diabetes-related numeracy in people with diabetes (Huizinga et al., 2008). The DNT is composed of items to assess numeracy skills needed for diabetes self-management such as traditional math operations, numerical hierarchy, fractions and percentages, and multi-step calculations covering a diabetes-specific context. Items cover interpretation of blood glucose monitoring results and testing schedule, carbohydrate intake calculation, and medication management. The DNT's items were specific to diabetes than questions on a mathematic skills test would have. Therefore, the DNT is better to evaluate numeracy skills in patients with diabetes because the questions on a regular mathematic skills test are not relevant to diabetes self-management.

The DNT was developed in English by Huizinga et al. (2008) and has two versions; the 43-item full version and a shortened, 15-item version. Both versions evaluate numeracy skills relevant to diabetes self-management behaviors including nutrition, exercise, glucose monitoring, oral and insulin medication for diabetes treatment. The original version of DNT is available at (https://www.mc.vanderbilt.edu/root/vumc.php?site=CDTR&doc=38337). The DNT was translated into the Spanish language and used to explore the relationship between several factors and diabetes outcomes (White, Osborn, Gebretsadik, Kripalani, & Rothman 2011). In White's study, the 15-item version was translated and back-translated and administered in cognitive interviews with six Latino patients with T2DM and health care providers. Eventually, the DNT-15 Latino was established. Therefore, it is possible to translated and adapt the DNT to evaluate diabetes-related numeracy skills for Thai older adults with T2DM.

The DNT proved effective to assess diabetes-related numeracy skills in people with diabetes in several studies; however, the DNT was developed in English and reflects Western culture in items and skills such as counting and calculating carbohydrate quantities or servings for potatoes or pasta that are not commonly eaten foods in Thailand. The DNT does not capture Thai culture and a Thai version had not been published. Therefore, the DNT needed to be translated based on concepts and language that are consistent with Thai culture so it could be administered to Thai older adults with diabetes, and their data analyzed to explore relationships among health literacy, diabetes related numeracy, and factors related to diabetes control.

In summary, the number of patients with T2DM is increasing in Thailand, especially among older adults. Diabetes-related complications result in poor health outcomes. However, there have been limited studies of diabetes self-management and glycemic control among older adults in Thailand. Health literacy and diabetes related numeracy impact patients' abilities for successful diabetes self-management and diabetes control. Patients need health literacy and numeracy to gain and apply knowledge to perform diabetes self-management activities and achieve control of A1C but there are few studies in Thailand. Therefore, it is essential to examine health literacy and numeracy in the aging population with diabetes in Thailand because it is a relatively new concept in Thailand and it as the potential to improve older patients' diabetes self-management. The relationships between health literacy, diabetes-related numeracy, and related factors associated with diabetes control in Thai older adults with T2DM are poorly understood. However, there is no published instrument to assess diabetes-related numeracy skills in Thai older adults. Therefore, this study will help to fill gap of knowledge of the relationships among these concepts in Thailand.

Purpose of the Study

The purposes of this study were to 1) create a conceptually equivalent version of the DNT that is appropriate for Thai culture; 2) evaluate the psychometrics of the Thai version of DNT (Thai-DNT) with data from Thai older adults with T2DM; and 3) explore the relationships among non-modifiable selected personal factors (age, gender, education level and duration of diabetes), modifiable factors (health literacy, diabetes-related

numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management, and glycemic control in Thai older adults with T2DM.

Statement of Problem

Diabetes is a significant chronic illness in Thailand. The population of older adults with diabetes has increased. Diabetes related-complications affect health outcomes and burden for individual with diabetes, family, and public health. Although several studies of relationships pertaining to diabetes control and intervention studies to improve diabetes outcomes have been performed, there are few studies with older adults and fewer in Thailand.

This dissertation is consistent with the Thai Eleventh National Economic and Social Development Plan that have focused on developing the potential of every individual at all levels to reach health policy goals. This policy covers enhanced diabetes self-management for older adults to prevent development or worsening of diabetes-related complications (National Economic and Social Development Board, 2012). Therefore, providing lifelong learning opportunities for older adults with diabetes to promote better health, and decrease and prevent chronic disease-related complications is necessary to improve their abilities in their self-management behaviors.

Factors such as health literacy and diabetes-related numeracy play a significant role in diabetes control. Ongoing self-management requires that people use health literacy and diabetes-related numeracy skills. Nurses work closely with people with diabetes and provide information in their self-management. The development of a valid and reliable

version of the DNT for Thai language and culture to measure diabetes-related numeracy skills is an essential step in research that may eventually decrease diabetes-related complications and create teaching materials, diabetes education programs, and interventions for Thai older adults with diabetes to enhance their diabetes self-management behaviors.

Research Questions

This study addressed the following research questions:

1. What is the content validity of Thai-DNT?
2. What is the evidence for construct validity of the Thai-DNT?
3. What is the evidence for internal consistency and test-retest reliability of the Thai-DNT?
4. What is the level of health literacy in Thai older adults with T2DM?
5. What is the level of diabetes-related numeracy in Thai older adults with T2DM?
6. What are the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), and modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management and glycemic control in Thai older adults with T2DM?
7. Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) contributed significantly to the prediction of diabetes self-management after controlling for the effects of non-modifiable

selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?

8. Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) and diabetes self-management contribute significantly to the prediction of glycemic control after controlling for the effects of non-modifiable selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?

Conceptual Framework

The conceptual framework for this study (see Figure 1.1) combined the cultural component of health literacy (Zarcadoolas et al., 2005) and Nutbeam's (2000) three levels of health literacy. In addition, this study included concepts related to diabetes control drawn from the scientific literature including diabetes related numeracy, diabetes knowledge, and self-efficacy.

Health literacy is a complex of competencies that evolves over a person's life and that is influenced by demographic, sociopolitical, psychosocial and culture factors. People with adequate health literacy are able to apply obtained health information in a variety of situations and to participate in ongoing conversations about health, medicine, scientific knowledge and cultural beliefs (Zarcadoolas et al., 2005). Individuals' health literacy influences their ability to engage in diabetes self-management behaviors differently across cultures. People in different cultures have different ways to receive information and interventions that have been designed to be culturally appropriate

showed more improvements in diabetes self-management behaviors and glycemic control than interventions that are culturally generic (Brown, Garcia, Kouzekanani, & Hanis, 2002; Melkus et al., 2004; Rosal et al., 2011). Cultural beliefs influence perceptions of health and information seeking, life style modification for illness management, and compliance with treatment in each ethnic group. In addition, each culture differs in its communication style, and the meanings of words and gestures, related to health and illness. Therefore, culture and health literacy both impact health outcomes in diverse ethnic groups (Institute of Medicine [IOM], 2004).

Aging populations are more vulnerable because of limited health literacy may lead to worse health outcomes. Inadequate health literacy is significantly more prevalent among older adults (Zamora & Clingerman, 2011). Older people who had low health literacy were less able to open, take, and manage medications (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011) and had higher risk for all-cause mortality, especially cardiovascular death than those who had adequate health literacy (Baker et al., 2007). Older adults were faced with age-related changes of degeneration that lead to physical and cognitive impairment in multiple domains such as decline in sensory-perceptual abilities, less selective orienting of attention, learning deficits related to speed and some memory function, and changes in language abilities (Stine-Morrow & Miller, 1999). Older adults with diabetes had worse cognitive function in the areas of immediate recall, delayed recall, semantic fluency, and processing speed (Gilmour, 2011). Therefore, older adults with diabetes are at risk because of limited health literacy and might have hindered abilities for self-management, which may lead to poor diabetes outcomes.

Diabetes related numeracy has been shown to be a powerful predictor of glycemic control in patients with diabetes (Cavanaugh et al., 2008; Osborn, Cavanaugh, Wallston, White, & Rothman, 2009) and is associated with selected domains of diabetes self-management such as the ability to adjust insulin doses based on blood glucose level and to calculate carbohydrate intake among patients who use insulin (Cavanaugh et al., 2008). Furthermore, DNT scores have been associated with other factors that might impact diabetes control such as diabetes knowledge (Huizinga et al., 2008), diabetes self-efficacy (Osborn, Cavanaugh, Wallston, & Rothman, 2010b), health literacy and mathematical skills (Huizinga et al., 2008; White, et al., 2011).

Diabetes knowledge is the foundation for patients with diabetes to control their disease because patients need to know how diabetes impacts their health and how they should perform their self-management behaviors. Patients who did not understand the instructions could not apply information to their practice in daily life (Eknithiset, 2009). Patients with diabetes who had greater diabetes knowledge were more likely to have better self-management (Lerman et al., 2004; Siwina, 2003; Osborn, Bains, & Egede, 2010a) and lower A1C (better glycemic control, Bains & Egede, 2011, Nguyen et al., 2010).

Self-efficacy is an individual's belief in his or her power to produce outcomes. Self-efficacy has been tested in diabetes studies. Patients with T2DM with higher self-efficacy have better diabetes self-management (Sarkar, Fisher, & Schillinger, 2006; Wu et al., 2013). In addition, self-efficacy predicts better (lower) A1C (Nyunt, Howteerakul, Suwannapong, & Rajatanun, 2010; O'Hea et al., 2009).

The conceptual framework depicts the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy), diabetes self-management and glycemic control in Thai older adults with T2DM. Glycemic control is target goal of patients with diabetes to prevent diabetes-related complications.

Non-Modifiable Selected Personal Factors

As depicted in Figure 1.1, non-modifiable selected personal factors including age, gender, education, and duration of diabetes are antecedents to influence modifiable factors (health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy), diabetes self-management, and glycemic control. Non-modifiable selected personal factors explain some of variation in modifiable factors, diabetes self-management and glycemic control.

Modifiable factors

In Figure 1.1, health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy are modifiable factors and are proposed to contribute to individual diabetes self-management. Modifiable factors explain some of variation in diabetes self-management and glycemic control. To prevent diabetes-related complications, people with diabetes need to perform diabetes self-management and achieve glycemic control. People who have higher health literacy, higher diabetes-related numeracy, better diabetes knowledge and greater self-efficacy have better diabetes self-management behaviors, which impact better glycemic control.

Health literacy is "the wide range of skills, and competencies that people develop to seek out, comprehend, evaluate and use health information and concepts to make informed choices, reduce health risks and increase quality of life" (Zarcadoolas et al., 2005, p. 196-197). Health literacy seems to be a fundamental skill to enable patients with diabetes to engage in long life learning and gaining knowledge for their self-management. Therefore, health literacy is assumed to help patients with diabetes to understand received health information from various sources such as diabetes education, health care providers, other people and media and apply received health information for their diabetes self-management in their daily life.

Diabetes-related numeracy refers to people with diabetes's ability to perform many calculations that are required for effective diabetes self-management on a daily basis such as calculating carbohydrate intake, reading and understanding food labels, interpreting blood glucose monitoring, and appropriately take medications, and perhaps adjusting insulin dose. Therefore, diabetes related numeracy is important for patients with diabetes. Patients with diabetes who had greater diabetes related numeracy had better diabetes self-management.

Diabetes knowledge covers necessary information about diabetes such as etiology, symptomatic, diabetes-related complications, diabetes self-management and treatment. Therefore, knowledge about diabetes and its severity and how to manage the disease leads to self-management.

Self-efficacy is each individual's beliefs in his or her power to produce outcomes. These beliefs, when linked with other factors, function together to manage situations in

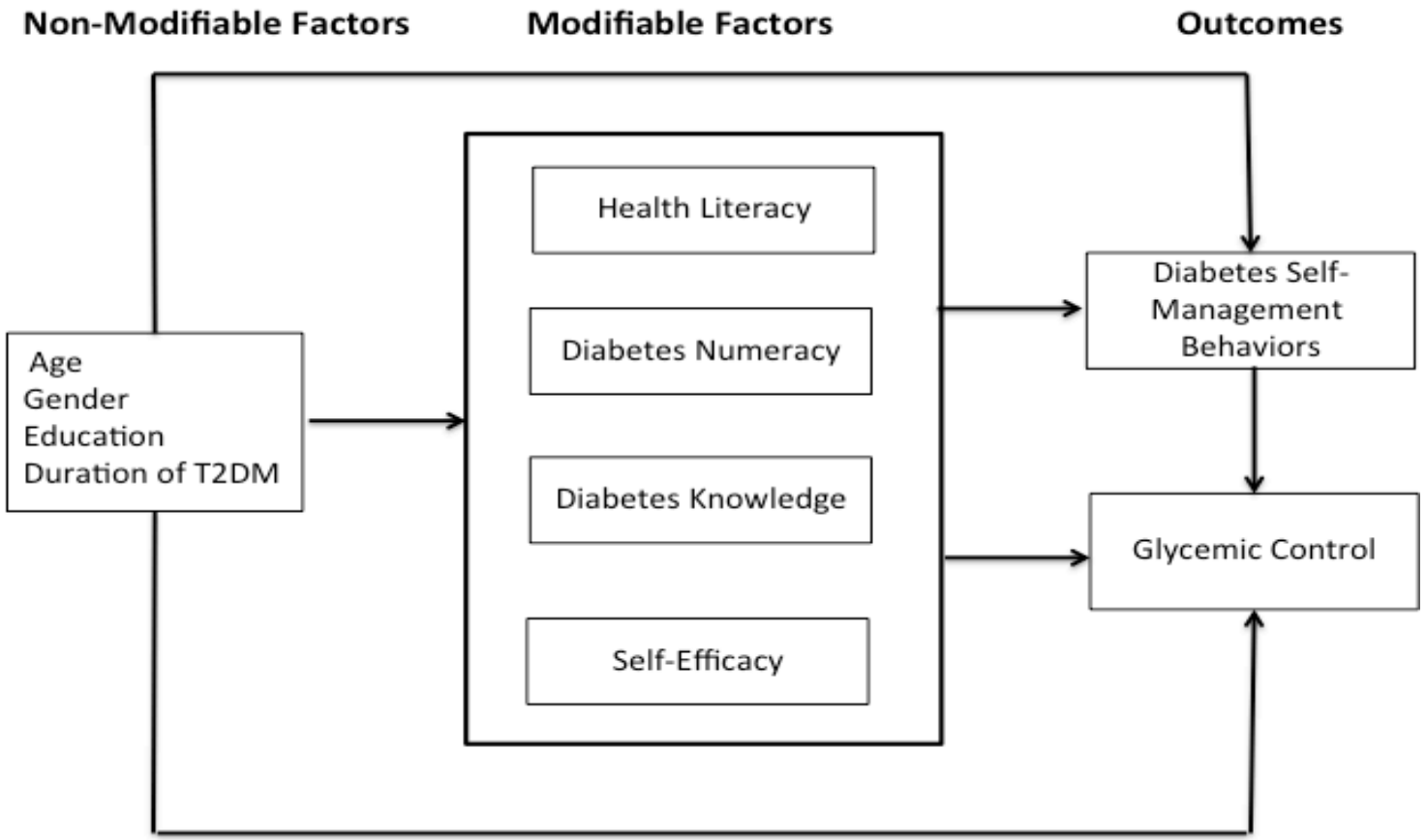
daily life (Bandura, 1997). To manage and maintain diabetes control throughout life, patients' self-efficacy plays a significant role in their performance of multiple domains of diabetes self-management. Therefore, in patients with diabetes, self-efficacy is assumed to influence how people perform and maintain their diabetes self-management behaviors such as diet behavior, exercise, taking medication, and monitoring of blood glucose, as well as glycemic control directly.

There are interrelationships among the modifiable factors. Patients with diabetes who had low numeracy were also likely to have lower health literacy (White et al., 2011), lower diabetes knowledge (Cavanaugh et al., 2008; Huizinga et al., 2008), and low self-efficacy (Cavanaugh et al., 2008; Osborn et al., 2010b). Therefore, it is possible that modifiable factors together lead to better diabetes self-management.

Diabetes self-management and glycemic control

Patients with diabetes achieve control by ongoing self-management for life. Therefore, patients with diabetes were encouraged to take an active role in diabetes self-management. To prevent diabetes-related complications, people with diabetes need to perform multiple types of diabetes self-management including diet control behaviors, physical activities, monitoring of blood glucose, and taking medication and to achieve glycemic control. The guidelines recommend that patients with diabetes perform a set of self-management behaviors that include nutrition management, physical activity, taking medications for hyperglycemia, and insulin and glucose monitoring (ADA, 2014).

Figure 1.1 The relationships among non-modifiable selected personal factors, health literacy, diabetes-related numeracy, diabetes knowledge, self-efficacy and diabetes self-management and glycemic control.



Definitions

The significant concepts in the conceptual framework are defined as follows:

Non-Modifiable Selected Factors are defined as a group of variables that cannot be changed and may affect Thai older adults' health literacy, diabetes-related numeracy, diabetes knowledge, self-efficacy, diabetes self-management, and glycemic control. Non-modifiable selected personal factors in this study included age, gender, education, and duration of diabetes.

Age is the number of years since birth, measured by asking each participant.

Gender is the sex role that represents identity as male or female as determined by the researcher or researcher assistant at the data collection interview.

Education is the highest level of studying in formal school, measured by participant self-report.

Duration of Diabetes is the number of years since diagnosis with T2DM, measured by asking each participant.

Modifiable Factors are defined as personal variables that may affect Thai older adults' diabetes self-management and glycemic control. Modifiable factors in this present study include health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy.

Health Literacy is "the wide range of skills, and competencies that people develop to seek out, comprehend, evaluate and use health information and concepts to make informed choices, reduce health risks and increase quality of life" (Zarcadoolas et

al., 2005, p. 196-197). The Three Level of Health Literacy Scale developed by Ishikawa et al. (2008) measures health literacy. It was translated and modified into the Thai-version by Chontichachalalauk (Unpublished data, 2014).

Diabetes-Related Numeracy is "the ability to use and understand numbers in daily life" (Rothman et al., 2006, p. 392). Diabetes-related numeracy refers to people with diabetes's ability to perform many calculations that are required for effective diabetes self-management on a daily basis such as calculating carbohydrate intake, reading and understanding food labels, interpreting blood glucose monitoring, and appropriately take medications, and perhaps adjusting insulin dose. Diabetes-related numeracy is evaluated by the DNT developed by Huizinga et al. (2008). The DNT-43 in English version was translated into Thai language and modified based on Thai culture and health care system in Phase 1 of this study and then was used to measure diabetes-related numeracy in Phase 2 of this study.

Diabetes Knowledge is an individual's recalled information about diabetes that involves etiology, symptomatic, diabetes-related complications, diabetes self-management and treatment. The General Diabetes Knowledge developed by Wongwiwatthananukit, Krittiyanunt, and Wannapinyo (2004) in the Thai language was used to measure diabetes knowledge.

Self-Efficacy is each individual's beliefs in his or her power to produce outcomes. These beliefs, when linked with other factors, function together to manage situations in daily life. Efficacy beliefs regulate aspiration, behavioral choices, actions and maintenance of effort, and emotional responses (Bandura, 1997). The Thai version of the

Diabetes Management Self-Efficacy Scale (T-DMSES), translated and modified by Iamsumang (2009), was used to measure self-efficacy.

Diabetes Self-Management Behaviors is the set of behaviors that people with diabetes must perform to reach their glycemic goals and prevent diabetes-related complications (ADA, 2014). In this study, diabetes self-management includes only diet control, physical activity or exercise, taking medications, and foot care. Monitoring blood glucose was removed because Thai older adults with T2DM in the study did not monitor blood glucose at home.

The Thai version of the Revised Summary Diabetes Self-Care Activities (SDSCA), translated and modified into Thai version by Wattanakul (2012), was used to measure diabetes self-management

Glycemic Control is the achievement of the physiological indicators of fasting plasma glucose (FPG) and glycosylated Hemoglobin A1C (A1C). In older adults with diabetes, the target goal in glycemic control of fasting preprandial glucose is 90-130 mg/dL. and A1C is < 7.5% (ADA, 2014). Glycemic control is influenced by following a treatment plan. Glycemic control is a goal for people with diabetes achieved by following self-management behaviors such as diet control, modifying physical activities and adjusting medication to keep optimal glycemic control. This study chose A1C to represent glycemic control of the. A1C indicates the amount of blood glucose that is attached to hemoglobin molecules in red blood cell s over the red blood cell's life span (Michel, 2011). Patients' A1C values in this study were secondary data drawn from a database of target primary care units and a community hospital. The most recent A1C

values, all measured within one month of survey completion, were recorded for this study. Glycemic control for each participant is treated as continuous variable instead of a dichotomous (achieved or not achieved). Although achievement of glycemic control in older adults refers to an A1C < 7.5 %, lower levels are recognized as more desirable than higher values.

Assumptions

The assumptions for this study are as follows:

1. Glycemic control is a target goal of older adults with diabetes.
2. Older adults with diabetes need to engage in diabetes self-management to control their blood glucose.
3. Thai older adults honestly answered the survey questions.
4. Thai older adults were able to understand the questionnaires and self-assess their health literacy, diabetes-related numeracy, diabetes self-efficacy, diabetes self-management in an interview.
5. Thai older adults could recall their personal factors and recent self-management behaviors that relate to diabetes self-management.

Significance for Nurses in Thailand

In Thailand, nurses work with patients with T2DM to help them maintain healthy self-management behaviors and achieve glycemic control. The relationships among health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy with

glycemic control are not well understood. Findings from this study will help Thai nurses better understand how to help Thai older adults with their diabetes self-management behaviors. In addition, the Diabetes Numeracy Test was not previously adapted for Thai language. The Thai-DNT might help nurse-scholars and clinicians assess and screen numeracy skills of Thai older adults with T2DM and then create diabetes education programs, interventions, and teaching material to use in teaching numeracy skills to older adults with diabetes to enhance their diabetes self-management behaviors. This study will fill a large gap in the professional knowledge in diabetes self-management in Thai older adults with T2DM.

Limitations

The limitations of this study included:

1. The findings from this study are not generalizable to all Thai older adults because this study used a convenience-sampling method.

2. Some research instruments used in this study were developed in English and based on Western data. Although the translation process used in the study aimed to make the Thai instruments culturally appropriate while retaining the English construct validity, the validity might be compromised because some English words or concepts cannot be translated to the exact meaning in Thai.

3. Self-report questionnaires rely on the abilities of the participants to answer accurately. This procedure might be biased by factors such as social desirability, participant's fatigue, and environmental distractions.

Summary

This chapter has presented background and significance, the purpose of the study, the statement of the problem, research questions, the conceptual framework, assumptions, the significance for nursing, and limitations. The purposes of this study were to 1) create a linguistically and conceptually equivalent version of the DNT that is appropriate for Thai culture; 2) evaluate the psychometrics of the Thai version of DNT (Thai-DNT) with data from Thai older adults with T2DM; and 3) explore the relationships among non-modifiable selected personal factors (age, gender, education level and duration of diabetes), health literacy, diabetes-related numeracy, diabetes knowledge, diabetes self-efficacy, diabetes self-management, and glycemic control in Thai older adults with T2DM. The findings of this study may help scholars and health care providers evaluate health literacy and diabetes related numeracy skills of Thai older adults with T2DM and then use it to guide interventions to improve diabetes self-management for patients who have low diabetes numeracy.

CHAPTER 2: REVIEW OF THE LITERATURE

This review of literature introduces the epidemiology and pathophysiology of diabetes and glycemic control, then describes and synthesizes existing relevant literature related to the relationships between variables depicted in the model. Diabetes control includes diabetes self-management behaviors and glycemic control as outcome variables. Non-modifiable selected personal factors (age, gender, education, and duration of diabetes), and modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy) were expected to relate to the diabetes outcomes.

The first part of Chapter 2 presents pathophysiology of diabetes that impacts older adults with diabetes to perform self-management. Then, the relationships between diabetes self-management behaviors and glycemic control are discussed because they are the main outcome variables of this study. Next, the relationship between each variable of health literacy, numeracy/diabetes-related numeracy, diabetes knowledge, and self-efficacy with each outcome variable including diabetes self-management behaviors and glycemic control is explained. The last part of the chapter describes the relationships between each non-modifiable selected personal factors (age, gender, education, and duration of diabetes) and modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy) and outcome variables (diabetes self-management behaviors and glycemic control). It is important to note that published studies among older adults with T2DM conducted both outside and in Thailand are limited. This review includes studies about diabetes control with adults of all ages and with either T1DM or

T2DM. In addition, because there are few existing studies on health literacy and numeracy/diabetes-related numeracy studies in Thailand, this literature review of health literacy and numeracy is mostly based on Western studies. Therefore, findings from this review and the results of the relationship among these variables in Thai population might differ. The relationships among health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy among Thai older adults with T2DM were explored.

Diabetes Pathophysiology and Glycemic Control

Diabetes is a chronic multisystem disease that involves abnormal insulin production, or inappropriate insulin utilization, or both. There are three main types of diabetes: type 1 diabetes (T1DM), an autoimmune disease; type 2 diabetes (T2DM), which is the focus of this study; other specific types of diabetes due to other causes, e.g., genetic defects in β-cells, and gestational diabetes, which occurs in pregnancy (ADA, 2014). T2DM usually affects people aged over 35 years old, and 80-90% of people with T2DM are overweight at diagnosis. T2DM accounts for over 90% of patients with diabetes. Multiple factors is believed to cause of the development of T2DM including genetic and environment factors. The main risk factor is obesity, especially abdominal and visceral adiposity. Genetic mutations lead to insulin resistance and high risk of obesity associated with T2DM (Michel, 2011).

Insulin is a hormone produced from the beta (β) cells in the islets of Langerhans of the pancreas. In general, insulin is continuously released into the bloodstream at a basal rate. When a person ingests food and the body transforms food to glucose, insulin is

released by the pancreas to lower blood glucose and maintain stable glucose levels. Insulin enhances glucose transportation from the bloodstream through the cell membrane to the cytoplasm of the cell. Increasing insulin in plasma after meals stimulates storage of glucose as glycogen in liver and muscle, inhibits gluconeogenesis, promotes fat deposition of adipose tissue, and increases protein synthesis. The normal glucose level is 70 to 120 mg/dL. The average amount of insulin released in adults is about 40-50 units per day (Michel, 2011).

People who have diabetes have secretion abnormal insulin production, or inappropriate insulin utilization. Therefore, when the body system ingests food and the body transforms food to glucose, insulin secretion from pancreases decreases, which impact to high blood glucose levels in blood circulation, indication hyperglycemia. Chronic hyperglycemia leads to chronic blood vessels dysfunction and eventually leads to angiopathy, which damages cells and tissues throughout the body. Blood vessels, cells. nerves, and tissues are damaged by the products of glucose metabolism; the formation of abnormal glucose molecules in the basement membrane of small blood vessels, for instance those found in the eyes and kidneys; and by diminished tissue oxygenation due to red blood cell dysfunction. Chronic blood vessels dysfunctions lead to macrovascular and microvascular complications. Macrovascular complications refer to diseases of large and medium-size blood vessels and includes cerebrovascular, cardiovascular, and peripheral vascular disease. Microvascular complications are diseases of the capillaries and arterioles that thicken in response to chronic hyperglycemia, in particular in the eyes

(retinopathy), kidneys (nephropathy), and the skin (Michel, 2011). Eventually, long-term diabetes-related complications reduce health status and length of life.

The primary techniques to assess glycemic control are patient self-monitoring of blood glucose (SMBG), fasting plasma interstitial glucose levels (FPG), and A1C (ADA, 2014). In Thailand, glycemic control assessments used both A1C and FPG levels. People with diabetes who have stable glycemic control or reach treatment goals should have A1C levels measured at least two times per year. However, A1C values reflect average glycemic levels over months of people with diabetes and strongly predict diabetes complications. Therefore, ADA recommends checking A1C every three months for patients who do not meet the target glycemic goal or are changing treatment until patients reach the target goal for glycemic control or maintain stable glycemic levels. Therefore, A1C checking should be conducted at least two times each year (ADA, 2014). A1C levels at or below 7% demonstrate a decreased risk for microvascular diabetes-related complications. People who achieve A1C levels at or below 7% since their diagnosis with diabetes showed a decreased long-term prevalence of macrovascular disease. A1C goals might be less stringent, such as less 8%, if patients have a history of severe hypoglycemia, limited life expectancy, advanced microvascular or macrovascular complications, extensive comorbidity, and longer duration of diabetes with difficulty meeting the target glycemic control (ADA, 2014).

Setting A1C goals for older adults with diabetes is a challenge. Older adults often experience degenerating body system functions that can lead to physical impairments. Older adults with diabetes have increased risk of multiple comorbid diseases, such as

cardiovascular and microvascular diseases, and also might have geriatric conditions such as functional impairments, cognitive dysfunction, and hearing and vision impairment that might impact self-management behaviors and reaching A1C goals. Consensus recommendations were developed by the American Diabetes Association with additional consultation from experts in the diabetes and geriatric fields (Sue Kirkman et al., 2012) to develop glycemic targets for older adults with diabetes. The consensus recommendations were developed from a review of existing evidence and consideration of issues important to treatment of older adults with diabetes. A summary of consensus recommendations for older adults with diabetes is shown in Table 2.1 and the full version is provided in Appendix A. A reasonable A1C goal for healthy older adults is < 7.5%; for older adults who have complex or intermediate health impairments a reasonable A1C goal is < 8% and for older adults who have very complex or poor health status the A1C goal is < 8.5%.

Table 2.1 *A Framework for Considering Treatment Goals for Glycemic, Blood Pressure, and Dyslipidemia in Older Adults with Diabetes*

Patient Characteristics/ Health Status	Rationale	Reasonable A1C Goal (A Lower Goal May Be Set for an Individual if Achievable without Recurrent or Severe Hypoglycemia or Undue Treatment Burden)
Healthy (Few coexisting chronic illnesses, intact cognitive and functional status)	Longer remaining life expectancy	< 7.5%
Complex/intermediate (Multiple coexisting chronic illnesses[a] or 2+ instrumental ADL impairments or mild to moderate cognitive impairment)	Intermediate remaining life expectancy, high treatment burden, hypoglycemia vulnerability, fall risk	< 8.0%
Very complex/poor health (Long-term care or end-stage chronic illnesses[b] or moderate to severe cognitive impairment or 2+ ADL dependencies)	Limited remaining life expectancy makes benefit uncertain	< 8.5%c

Reprinted and adapted from Sue Kirkman et al. (2012) with permission from the Journal of the American Geriatrics Society

ADL = activities of daily living.

a =Coexisting chronic illnesses are conditions serious enough to require medications or lifestyle management and may include arthritis, cancer, congestive heart failure, depression, emphysema, falls, hypertension, incontinence, stage III or worse chronic kidney disease, MI, and stroke. By multiple we mean at least three, but many patients may have five or more.

b = The presence of a single end-stage chronic illness such as stage III–IV congestive heart failure or oxygen-dependent lung disease, chronic kidney disease requiring dialysis, or uncontrolled metastatic cancer may cause significant symptoms or impairment of functional status and significantly reduce life expectancy.

c = A1C of 8.5% equates to an estimated average glucose of ~200 mg/dL. Looser glycemic targets than this may expose patients to acute risks from glycosuria, dehydration, hyperglycemic hyperosmolar syndrome, and poor wound healing.

Diabetes Self-Management Behaviors and Glycemic Control

Ongoing diabetes self-management behavior is key for older adults with diabetes to control their disease to prevent diabetes-related complications and increase longevity. Diabetes self-management behaviors can consist of multiple tasks. However, in this study, diabetes self-management behaviors only included diet behaviors, exercise or physical activities, medication taking, and foot care.

Overall, diabetes self-management behaviors as a group have been found to have a significant direct negative relationship with A1C. Patients with diabetes who had better diabetes self-management had better glycemic control (lower A1C) but the relationship is small (Osborn, et al., 2010a). Two studies reported that diabetes self-management was not significantly correlated with A1C (Beckerle & Lavin, 2013; Mancuso, 2010). However, Beckerle and Lavin (2013)'s study was a retrospective cohort design with a small sample size; the data were collected from 57 medical records. The other study, Mancuso (2010) explained the possible reasons for the non-significant relationship between diabetes self-management and A1C including that other factors might relate to glycemic control more than self-management such as empowerment and participatory problem-solving skills.

In studies conducted in Thailand with adults of all ages with diabetes, the relationship between diabetes self-management and glycemic control is also ambiguous. Most Thai studies used Fasting Plasma Glucose (FPG) instead of A1C to measure glycemic control because FPG was commonly used to check glycemic level decades ago.

One study reported a non-significant relationship between overall diabetes self-management and A1C (Wattanakul, 2012). Wattanakul (2012) disscussed that the SDSCA that was used to measure diabetes self-management might not account for the intensity of specific self-care activities. In that study glycemic control was related to many factors including age and duration of diabetes. Bivarate and multiple regresson analysis used in her study could not identify the mechanism of adherence and glycemic control. Lastly, Srichana (2005) reported that overall diabetes self-management was not significant predictor of FPG.

DIET SELF-MANAGEMENT BEHAVIORS AND GLYCEMIC CONTROL

Diet behaviors were a significant predictor of A1C among patients with T2DM in Jordan (Al-Khawaldeh, Al-Hassan, & Froelicher, 2012) and in India (Venkataraman et al., 2012). Studies that revealed a significant relationship between diet behaviors and A1C demonstrated that patients with diabetes who had better diet behaviors had better A1C. Venkataraman et al. (2012) reported that in- and outpatients with T2DM in India in a tertiary hospital who did not adhere to dietary restrictions were more likely to have worse A1C (> 7% - OR = 3.23; 95% CI 1.56-6.67, $p < 0.01$). Similarly in Jordan, Al-Khawaldeh et al. (2012) found that diet self-management was a significant independent predictor of A1C. People with T2DM who had better diet self-management were more likely to have lower A1C (OR = 0.1; 95% CI 0.1-0.3). In contrast, some studies did not show a significant relationship between diet behaviors and A1C in the U.S. (Bains & Egede, 2011), in Myanmar (Nyunt et al., 2010) and in China (Tang et al., 2008).

In Thailand, studies showed that better diet behaviors were significantly related to better glycemic control for both A1C (Sapworarit, 2006; Satsaengtum, 2005) and FPG (Siriwattanapornkul, 2006). Diet behaviors were also a significant predictor of A1C (Howteerakul, Suwannapong, Rittichu, & Rawdaree, 2007; Pintong, 2005; Sowattanangoon, Kochabhakdi, & Petrie, 2008). However, the correlations between diet control behaviors and A1C (r = -0.28, Sapworarit, 2006) and FPG (Siriwattanapornkul, 2006) were small. Howteerakul et al.'s study (2007) at a tertiary hospital diabetes clinic in Bangkok (N = 243, female 65.8% mean age 60.2 SD 9.55, age ≤60 39.5%, age > 60 years 60.5%) reported that after adjusting for all other variables in a multiple regression analysis, patients who had good adherence to dietary behavior as measured by the SDSCA were more likely to have better glycemic control than those who did not (OR = 5.24; 95% CI 2.37 to 11.59).

Similarly, Pintong (2005) also found that compared with Thai patients who had good diet behavior, Thai patients who had fair diet behavior (adjust OR = 7.95, 95% CI = 2.85-22.17, p <0 .001) and those who had poor diet behavior (adjust OR = 11.23, 95% CI = 3.69-34.18, p < 0.001) were at higher risk of worse glycemic control. However, Chantrakul, Sillabutra, & Ramasoota (2007) did not find a significant relationship between diet behavior and glycemic control. Perhaps because Thai people in research settings area ate sticky rice as a regular meal. Therefore, the participants in the study might not have appropriate diet control behaviors because they could not avoid consuming sticky rice for their daily meals.

EXERICSE AND GLYCEMIC CONTROL

Most studies showed non-significant relationships between exercise and glycemic control including in the U.S. (Bains & Egede, 2011), Myanmar (Nguyen et al., 2010), and China (Tang et al., 2008). Only Al-Khawaldeh et al. (2012) reported that exercise did significantly predict glycemic control although it was not strong predictor of A1C; Jordanian people with T2DM who exercised more were more likely to have lower A1C (OR = 0.5; 95% CI 0.2-0.9).

In Thailand, Howteerakul et al. (2007) found that exercise was a significant strong predictor of A1C. In a multiple regression analysis, patients who had good adherence to exercise, as measured by the SDSCA, were more likely to have better glycemic control than those who did not (adjusted OR = 11.85; 95% CI 6.43 to 24.49) (N = 243, female 65.8% mean age 60.2 SD 9.55, age ≤60 39.5%, age > 60 years 60.5%). However, three studies in Thailand reported a non-significant relationship between exercise and glycemic control (Pintong, 2005; Sapworarit, 2006; Siriwattanapornkul, 2006).

Rogvi, Tapager, Almdal, Schiøtz, and Willaing (2012) examined the combined effect of dietary and exercise self-management in a cross-sectional study in Denmark. They reported that Danish people with T2DM who had less than one day a week of healthy diet and exercise had significantly worse glycemic control. Healthy diet, exercise, and body mass index explained 10.7% of the variance in that sample's A1C (N = 2045, mean age 64.3 years, women 35%).

MEDICATION TAKING ADHERENCE AND GLYCEMIC CONTROL

In China, Tang et al. (2008) reported a significant but weak relationship between the medication adherence subscale of the C-SDSCA with A1C (r = 0.18). In an adjusted model that included gender, duration of diabetes, having insurance, patient awareness in complication score, medication adherence subscale of the C-SDSCA and health literacy, being male, less duration of diabetes, increased patient awareness score, higher health literacy, and higher scores on the medication adherence subscale of the C-SDSCA significantly predicted lower A1C, accounting for an impressive 98.6% of the variance in A1C. However, medication-taking adherence was not significantly associated with A1C in several studies (Al-Khawaldeh et al., 2012; Bains & Egede 2011; Rogvi, et al., 2012). In Thailand, there was non-significant relationship between medication-taking adherence and A1C (Howteerakul, et al., 2007; Satsaengtum, 2005; Siriwattanapornkul, 2006).

BLOOD GLUCOSE MONITORING AND GLYCEMIC CONTROL

Self-monitoring of blood glucose (SMBG) helps patients with diabetes to assess their glycemic status and make decisions about adjusting food proportion, exercise or physical activity, and medication because SMBG provides immediate data of blood glucose level. In addition, SMBG detects hypoglycemic or hyperglycemia that warns patients to manage those situations.

More frequent SMBG was significantly related to better A1C in Lebanese patients with diabetes who received only oral glucose lowering medication (Azar et al., 2013). Karter et al. (2001) compared glycemic control among patients with diabetes who were

adherent and non-adherent to recommended self-monitoring recommendations to perform SMBG at least daily. They found that patients who performed SMBG daily as recommended were more likely to improve A1C levels; people who received insulin therapy and people who received oral medication for T2DM improved A1C by 0.6%, and people who took no medication but managed diabetes only with dietary control improved by 0.4% compared with patients did not perform SMBG as recommended. In path analysis, Brega et al. (2012) found that SMBG had a weak negative direct relationship with A1C (standardized parameter estimate = -0.120, $p < 0.05$). People with diabetes who performed SMBG had lower A1C levels. However, some studies reported a non-significant relationship between blood glucose monitoring and glycemic control (Al-Khawaldeh et al., 2012; Bains & Egede, 2011; Nguyen et al., 2010; Tang et al., 2008).

In Thailand, SMBG supplies and equipment are available. However, many Thai people with diabetes do not access or cannot afford to perform self-monitoring blood glucose because the cost is expensive and is not covered by health insurance or reimbursed by the government. Therefore, this present study did not evaluate SMBG.

Health Literacy

A literature review of 85 studies encompassing 31,129 subjects in the U.S reported that almost half of adult samples from these studies had inadequate health literacy (Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005). In addition, older adults had higher risk of limited health literacy. A systematic review by Zamora and Clingerman (2011) reported that advancing age was associated with a

significant increased prevalence of inadequate health literacy among older adults. Adams et al. (2009) reported that 24% of a sample of Australian adults (N = 2824) had limited health literacy and 21% had inadequate health literacy. The prevalence of poor health literacy increased with age; 50% of people aged ≥ 65 years had inadequate health literacy compared with 11% of those aged 25-44 years.

Low health literacy has been associated with poor health outcomes. A systematic review of 111 articles (98 articles on health literacy, 22 on numeracy, and 9 on both) found that people who had low health literacy had increased rates of hospitalization and emergency care use, less use of mammography screenings and influenza vaccines, poorer abilities to take and manage medications, such as being less able to interpret or understand medication labels and food labels (Berkman et al., 2011). Rothman et al. (2006) reported that health literacy had a significant relationship with primary care patients' ability to comprehend food labels. Participants in the Rothman et al. study commonly answered incorrectly items about food labels including items about serving size and calculations of food label information. When people are not able to use food labels correctly, they might have difficulty calculating the size of food portions they should eat to control their disease.

Older adults are especially vulnerable to limited or inadequate health literacy. Baker et al. (2007) found that older people who had low health literacy had higher risk for all-cause mortality rate and especially cardiovascular death than those who had adequate health literacy. The crude mortality rates of the participants in the cohort study

(N = 3260) were 18.9% for those with adequate health literacy, 28.7% for those with marginal health literacy, and 39.4 % for those with inadequate health literacy.

People with diabetes who had poorer health literacy also had lower computer use and internet access to health care information (Mayberry, Kripalani, Rothman, & Osborn, 2011; Sarkar et al., 2010a). In addition, there are significant relationships between lower health literacy and poor diabetes outcomes including higher frequency of self-reported hypoglycemia (Sarkar et al., 2010b) and diabetes-related complications (Kim, Love, Quistberg, & Shea, 2004; Schillinger et al., 2002).

Health literacy seems to be a fundamental skill to enable patients with diabetes to engage in long life learning and gain knowledge for their self-management. In several studies, health literacy was significantly correlated with diabetes knowledge (Al Sayah, Williams, & Johnson, 2013; Bains & Egede, 2011; DeWalt, Boone, & Pignone, 2007; Gazmararian et al., 2003; Inoue, Takahashi, & Kai, 2013; Ishikawa et al., 2008; Leung, Lou, Cheung, Chan, & Chi, 2013; Mancuso, 2010; McCleary-Jones, 2011; Powell et al., 2007). People with diabetes who had higher health literacy had higher diabetes knowledge.

Lower health literacy is also significantly related to lower self-efficacy (Bohanny et al., 2013; DeWalt et al., 2007; Inoue et al., 2013; Ishikawa et al., 2008; Leung et al., 2013; Osborn et al., 2010b). Communicative and critical health literacy domains were significantly related to understanding diabetes care and self-efficacy for diabetes self-management. Patients with diabetes who had higher communicative and critical health literacy had higher understanding of diabetes care and greater self-efficacy (Inoue et al.,

2013). Health literacy is believed to affect patients' learning process for receiving health information. People with diabetes who had low health literacy had worse communication with health care providers (Ishikawa et al., 2009; Schillinger et al., 2004), which may influence diabetes knowledge and care.

CONCEPTUALIZATION OF HEALTH LITERACY

Health literacy emerged as a term at a health education conference in 1974 but it was not published in health care journals until two decades later (Mancuso, 2009). There are several definitions of health literacy that originated from different sources. The World Health Organization (WHO) presented their definition of health literacy in 1998 as "the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health" (1998), p.10. The WHO campaigned its member countries to promote health literacy for health promotion.

Since then, the heath literacy concept appeared in studies of diabetes control a decade ago and became recognized as important to diabetes outcomes. Most studies in diabetes used the American Medical Association—AMA (Parker et al., 1999) definition of health literacy as, "a constellation of skills, including the ability to perform basic reading and numerical tasks required to function in the health care environment. Patients with adequate health literacy can read, understand, and act on health care information" (Parker et al., 1999, p.553). The Institute of Medicine (IOM) defines health literacy as "the degree to which individuals have the capacity to obtain, process, and understand

basic health information and services needed to make appropriate health decisions" (2004, p. 32). Nutbeam's definition of health literacy identifies three types including function literacy, communicative literacy, and critical literacy. Functional literacy is principle skills that are people's ability to effectively read and write in daily life. The communicative literacy is people 's abilities to combine skills such as advanced cognitive, literacy, and social skills to participation in daily activities for extract information, derive meaning from vary communication styles, and apply received information to change circumstances. Critical literacy is more advanced cognitive skills to help people for analyses and use information to exert greater control over life circumstance (Nutbeam, 2000).

These health literacy definitions from the AMA, IOM, and Nutbeam all conceptualize health literacy as the ability to integrate basic to advanced skills to effectively function in making important health-related decisions. Health literacy skills include cognitive, reading, numeracy, critical thinking, decision-making, communication, and social skills. However, Nutbeam's definition defines more specific skills in term of function, communication, and critical health literacy.

This study used a combination of health literacy definitions from Nutbeam and the health literacy framework of Zarcadoolas et al. (2005). Nutbeam's description of the three levels of health literacy does not address cross-cultural issues. However, Zarcadoolas, et al.'s (2005) definition of health literacy includes the concepts of culture, civics, and science. Zarcadoolas et al. define health literacy as "the wide range of skills, and competencies that people develop to seek out, comprehend, evaluate and use health

information and concepts to make informed choices, reduce health risks and increase quality of life" (p. 196-197). Zarcadoolas et al. (2005) proposed four central domains of health literary. Fundamental literacy is the ability to read, speak, write, and interpret numbers. Science literacy is the ability to understand and comprehend information related to science and technology. Civic literacy is the awareness of public activities and involvement in community decision-making. Cultural literacy is "the ability to recognize and use collective beliefs, customs, world-view and social identify to interpret and act on health information" (p. 197).

Therefore, a combination of health literacy concepts from Nutbeam's three levels and the cultural component of Zarcadoolas et al. (2005) was an appropriate conceptualization of health literacy for this study. In the context of diabetes care, health literacy pertains to the skills needed for diabetes self-management including calculating carbohydrate intake, using food label, interpreting their blood glucose and adjust insulin, communicating with health care providers to exchange information, accessing health information, and applying knowledge to health decision-making.

The relationship of health literacy with diabetes outcomes as been examined in several studies. Most studies were conducted in the United States (in African Americans, McCleary-Jones, 2011; in American Indians and Alaska Natives, Brega et al., 2012). Studies were also conducted in Japan (Ishikawa et al., 2008, 2009; Ishikawa & Yano, 2011), China (Tang et al., 2008) and Ireland (Thabit et al., 2009). The studies collected data from many places such as primary care units and hospitals, and in community areas and urban area but did not focus on age group. Many health literacy measurements used

among patients with diabetes have been used in research such as the Rapid Estimate of Adult Literacy in Medicine (original REALM and the revised form REALM-R), the Test of Functional Health Literacy in Adults (TOFHLA and the shorter form s-TOFHLA), the Newest Vital Sign (NVS), the 3-level health literacy scale (3LHLS), the Diabetes-Specific Health Literacy Measure (DSHLM), and Three Print Literacy Items, and the four numeracy items.

In Thailand, health literacy is a fairly new concept. Two studies were found that address health literacy and health outcomes. Saeko (2009) found that health literacy was significantly associated with good eye care practices among eye-surgery patients. The eye-surgery patients who had adequate health literacy were more likely to correctly practice eye care than those who had limited health literacy (Saeko, 2009). An intervention study by Kaewsomboon (2008) tested a participatory learning program that was designed to promote health literacy in patients with pre-invasive cervical carcinoma who were undergoing Colposcopy at a hospital. The results showed that after finishing the intervention, patients in the intervention group had significantly higher mean scores of knowledge on cervical cancer and Colposcopy, fewer perceived complications after Colposcopy, lower anxiety level, and better adherence during the Colposcopy procedure than those in the control group. However, no published studies of health literacy in patients with diabetes in Thailand have been identified.

HEALTH LITERACY AND DIABETES SELF-MANAGEMENT

Health literacy was significantly and indirectly related to overall diabetes self-management in Osborn et al.'s (2010a) test of the mechanisms linking health literacy and diabetes self-management in adults with T2DM (N = 130, aged 65+ years 49%, female 72.5%). Using structural equation modeling (SEM) analysis, the results showed that health literacy measured by the REALM-R had a direct relationship with social support ($r = -0.20$, $p < 0.05$) and through social support had an indirect relationship with diabetes self-management ($r = -0.07$). However, health literacy did not demonstrate a significant relationship with overall diabetes self-management in five studies including two studies that used any form of TOFHLA (Kim et al., 2004; Mancuso, 2010), two studies that used any form of REALM (Bains & Egede, 2011; McCleary-Jones, 2011), and one study that used the Diabetes-Specific Health Literacy scale (Yamashita & Kart, 2011).

The relationship between health literacy and diet self-management is not conclusive due to few studies on the topic. Brega et al. (2012) reported a significant relationship between health literacy and diet self-management in their study of American Indians and Alaska Natives with diabetes (N = 2594). Using SEM to examine the relationship between health literacy and glycemic control, Brega et al. (2012) showed that health literacy had a positive significant relationship with healthy food consumption and had a negative significant relationship with unhealthy food consumption. People with diabetes who had higher health literacy were more likely to have more healthy food consumption and less unhealthy food consumption.

In contrast, Shigaki et al. (2010) reported that health literacy was not significantly related to diet self-management in in their study of Americans with T2DM from two university family medicine clinics (N = 77) that used multivariate analysis. Shigaki et al. claimed that the relationship between health literacy and frequency of maintaining diet was negative. It is possible that participants in the study had self-report bias of health diet or higher health literacy levels. Shikagi et al. speculated that participants who reported high levels of health literacy might be less optimistic in recall measures asking them to estimate frequency of maintain a truly healthy diet. However, the two studies used different measurements of health literacy (one used the-Three Print Literacy Items and the four numeracy items, Brega et al., 2012 and the other used NVS, Shigaki et al., 2010). In addition, Shigaki et al.'s sample size was smaller for multiple analysis and the authors reported a small ($r = 0.02$) relationship between health literacy and diet behaviors at significant level 0.10.

Health literacy was related to medication adherence among people with diabetes in two studies. Osborn et al. (2011) found that health literacy measured by REALM had a direct but small effect on the diabetes medication adherence subscale of the SDSCA ($r = 0.12$, $p < .02$) in a path model (N= 398). Moreover, limited health literacy might be a barrier for patients with diabetes to administer their medications. Karter et al. (2010) found that in-patients with poorly controlled T2DM (n = 169) who adhered to insulin treatment following a new prescription more often reported higher health literacy than those who did not adhere to insulin treatment ($p < 0.05$).

Health literacy had a direct positive relationship to SMBG in one study (Brega et al., 2012) but it was not significantly associated in two studies (Mbaezue et al., 2010; Shigaki et al., 2010). Mbaezue et al. (2010) tested the relationship between health literacy and SMBG in a large hospital-based clinic that served a racially and ethnically diverse uninsured and underinsured population in Atlanta, in the U.S. Participants who kept a record of their blood glucose tests were more likely to have adequate health literacy ($p < 0.05$). However, health literacy was not significantly related with the frequency of SMBG.

In summary, the relationships between health literacy and each domain of diabetes self-management are ambiguous due to a lack of consistent evidence. Health literacy was significantly related to diet self-management (Brega et al., 2012), medication adherence in two studies (Karter et al., 2010; Osborn et al., 2011) and SMBG (Brega et al., 2012). However, health literacy was not related to diet (Shigaki et al., 2010), physical activities or exercise (Brega et al., 2012; Shigaki et al., 2010), and SMBG in two studies (Mbaezue et al., 2010; Shigaki et al., 2010). Findings from this literature review are consistent with Fransen, von Wagner, and Essink-Bot (2012) who reported that there were few studies of the relationship between health literacy and diabetes self-management behaviors. Moreover, studies they reviewed used various health literacy measurements that made it difficult to compare the results across studies. In addition, the mechanism of the relationship between health literacy and diabetes self-management is not clear. There are other factors that might impact diabetes self-management and health literacy alone might not be strong enough to improve diabetes self-management.

HEALTH LITERACY AND GLYCEMIC CONTROL

A number of studies have found inconsistent relationships between health literacy and glycemic control. In Europe, Thabit et al. (2009) found that health literacy measured by REALM was negatively and moderately associated with glycemic control ($r = -0.35$, $p < 0.05$) in a sample of Irish people with T2DM. In Japan, Ishikawa et al. (2008) tested the 3-level of health literacy (3LHL) measurement with 138 Japanese patients with T2DM (mean age 65±10). Most participants in the study had higher scores of functional health literacy than other subscales and 25% of sample was in poor glycemic control (A1C ≥8%). However, only the communicative health literacy subscale showed a significant negative relationship with A1C ($r = -0.20$, $p < 0.05$), meaning that patients who had better communication about diabetes-related information since they received the diagnosis of diabetes had better A1C levels. Functional and critical health literacy subscales and overall health literacy did not show significant relationships with A1C.

Four studies reported that health literacy had a significant relationship with glycemic control after adjusting for characteristics, clinical outcomes and other variables (Powell et al., 2007; Schillinger et al., 2002; Schillinger et al., 2006; Tang et al., 2008). Powell et al. (2007) found that people with T2DM who had lower health literacy levels (measured by REALM) had A1C levels 1.21% to 1.36% higher than those with health literacy level ≥ 9th grade. Health literacy, age, and gender had a significant relationship with glycemic control after adjusting for education level, age, gender, race, and diabetes treatment ($R^2 = 0.27$, $p < 0.05$).

Similarly in China, Tang et al. (2008) developed the Chinese version of the short-form test of functional health literacy (s-TOFHLA) and examined the relationship between health literacy and glycemic control in 149 Chinese patients with T2DM. Health literacy was significantly, moderately, and inversely related to A1C ($r = -0.32$, $p < 0.001$). Chinese patients with T2DM who had higher health literacy were more likely to have better A1C. In multiple regression analysis, higher health literacy, being male, less duration of DM, higher awareness of disease, and better overall management of diabetes in self-management significantly predicted reduced A1C levels, accounting for 98.6% of the variance ($F = 180.86$, $p < 0.001$). The beta value of health literacy in the model was -0.12, which could be interpreted that if a patient increased by one unit of health literacy score, A1C level would decrease a 0.12%-age point.

Health literacy also independently predicted glycemic control. In 408 English- and Spanish-speaking patients with T2DM from two primary care units of a university hospital, Schillinger et al. (2002) found that half of patients in the study had inadequate or marginal health literacy (s-TOFHLA < 23) and the mean A1C of participants was 8.5%. After adjusting for age, race, sex, education, language, insurance, and other variables, health literacy was independently associated with A1C (coefficient -0.02, $p < 0.05$), interpreting that for each one point decrease in health literacy, A1C increased by 0.02. Moreover, in further analysis, patients who had inadequate health literacy were 0.57 less likely to achieve tight glycemic control (A1C < 7.2%, adjusted OR, 0.57, 95% CI, 0.32-1.00, $P = 0.05$) and were two times more likely to have poor glycemic control (A1C > 9.5%, adjusted OR, 2.02, 95% CI, 1.11-3.73, $P < 0.05$). Schillinger et al. (2006)

reported that path analysis showed that patients who had higher health literacy had better glycemic control (standardized path estimates = -0.16, $p < 0.05$).

In contrast, three studies reported that health literacy did not have a direct effect but an indirect effect on glycemic control (Brega et al., 2012; Osborn et al., 2010a; Osborn et al., 2010b). Brega et al.'s (2012) study of American Indians and Alaska Natives people with diabetes found that health literacy had an indirect effect on glycemic control (A1C) through its relationship with SMBG behavior with a significant indirect effect (standardized parameter estimate = -0.028, $p < 0.05$). Meanwhile, Osborn et al. (2010b) reported that from path analysis health literacy was related to higher diabetes self-efficacy ($r = 0.14$, $p < .01$) and higher diabetes self-efficacy was related to lower A1C ($r = -0.25$, $p < 0.001$). Osborn et al. (2010a) studied outpatients with T2DM and found that health literacy had a direct effect on social support ($r = -0.20$, $p < 0.05$) and through social support had an indirect effect on diabetes self-management ($r = -0.07$) and on glycemic control ($r = -0.01$).

Five studies reported a non-significant relationship between health literacy and glycemic control after adjusting for patient characteristics, clinical outcomes, and related factors (Bains & Egede, 2011; Kim et al., 2004; Mancuso, 2010; Morris, MacLean, & Littenberg, 2006; Yamashita & Kart, 2011) and one study reported a non-significant correlation (DeWalt et al., 2007).

In summary, A1C was used across the studies to be the indicator of glycemic control. Overall, evidence for the relationship between health literacy and glycemic control was inconsistent across studies. The studies that found a significant inverse

relationship between health literacy and A1C used different measures of health literacy including three studies that used forms of the TOFHLA (Schillinger et al., 2002; Schillinger et al., 2006; Tang et al., 2008), two studies that used forms of the REALM (Powell et al., 2007; Thabit et al., 2009), and two studies that used the Three Levels of Health Literacy scale (Ishikawa et al., 2008; Ishikawa & Yano, 2011). Six studies did not find a significant relationship between health literacy and A1C using different health literacy measurement including three studies that used forms of the TOFHLA (Kim et al., 2004; Mancuso, 2010; Morris et al., 2006), two studies that used forms of the REALM (Bains & Egede, 2011; DeWalt et al., 2007), and one used 10 items of DSHLM (Yamashita & Kart, 2011).

Numeracy

People who have limited numeracy skills might have trouble with self-management behaviors that require using numbers. In a primary care unit, people who had lower numeracy skills demonstrated a deficit in calculation skills during daily living such as inaccurately calculating portion-size servings (Huizinga et al., 2009) and difficultly understanding and interpreting nutrition labels (Rothman et al., 2006). Numeracy also impacts the communication process, especially among older adults. In older adults, numeracy is associated with understanding and interpreting received health information (Amalraj, Starkweather, Nguyen, & Naeim, 2009; LaVallie, Wolf, Jacobsen, Sprague, & Buchwald, 2012) and participating in health promotion behaviors (Bennett, Boyle, James, & Bennett, 2012). Therefore, older adults who have low numeracy might

be impacted by their ability in communication process with health care providers and decision-making in health care.

CONCEPTUALIZATIONS OF NUMERACY

Numeracy is considered to be a domain of health literacy (IOM, 2004; Parker et al., 1999; Zarcadoolas et al., 2005). Therefore, numeric skills are often included as a part of health literacy measurements such as Test of Functional Health Literacy in Adults (TOFHLA), and Newest Vital Sign (NVS, Al Sayah, et al., 2013). However, numeracy itself is an essential concept in health care that might independently impact health behaviors because people with diabetes need numeracy skills to manage their diabetes in their daily lives such as calculating carbohydrate intake, estimating food proportion, interpreting blood glucose and adjusting medication for hyperglycemia treatment, and taking oral medication. If people with diabetes lack numeracy skills, it would likely be difficult for them to manage their self-care to control glucose levels.

Numeracy has been identified as "the ability to use and understand numbers in daily life" (Rothman et al., 2006, p. 392). Numeracy is involved with a range of skills including understanding time, money, measurement, graphing, probability, and performing basic and multi-step math skills in a diabetes specific situations (Rothman, Montori, Cherrington, & Pignone, 2008). Numeracy involves four main skills; basic skills, which is the ability to identify numbers; computational, which is the ability to perform simple calculations like adding, subtracting, multiplying, and dividing; analytical, which is the ability to estimate numbers and proportions; and statistical, which

is the ability to use advanced calculation skills such as probability and risk (Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005). Although all these skills might not necessary for diabetes self-management, patients need basic and some advanced skills when they decide how much food they need or how much medication they need after monitoring of blood glucose.

NUMERACY LEVEL

In Thailand, no published studies were found that examined the relationship between numeracy and glycemic control. Therefore, this review has no information from Thailand. Yet in the U.S., many studies reported that patients with diabetes have limited numeracy skills that are related to poor diabetes-related outcomes. A study to develop and validate the DNT by Huizinga et al. (2008) found that almost 70% of adults with diabetes in the study had low numeracy skills that would compare to a less than the ninth-grade level as measured by the WRAT-3rd edition; the average correct score of DNT was 61%.

White et al. (2011) found that only 3% of a sample of Latinos with diabetes in the study had numeracy skills, measured by the WRAT-4, that were higher than the eighth-grade math skills (n = 144). Overall participants scored only 26% on the DNT, indicating poor diabetes-related numeracy skills. More than half of Latinos with diabetes in the study were deficient in diabetes-related numeracy skills such as multiplication, fractions, addition, division, and numerical hierarchy. Several participants miscalculated the serving size and carbohydrate intake using a food label in a multistep problem and also

had problems calculating insulin doses, and planning medication management. Patients with diabetes who had low numeracy were also likely to have lower health literacy (White et al., 2011), lower diabetes knowledge (Cavanaugh et al., 2008; Huizinga et al., 2008), and low self-efficacy (Cavanaugh et al., 2008; Osborn et al., 2010b).

EXISTING NUMERACY MEASUREMENT

Numeracy can be measured with generic measures of numeracy such as the Wide Range Achievement Test (WRAT), the TOFHLA, and the NVS or with diabetes-related numeracy such as the Diabetes Numeracy Test (DNT). The math section of WRAT is commonly used to assess numeric skills (Al Sayah et al., 2013). However, the WRAT was not developed to assess diabetes-related numeracy. The full version of TOFHLA has items to measure numeracy skill but the numeracy items in TOFHLA are not designed to specificity measure diabetes-related numeracy skills. The NVS, is a 6-item numeracy literacy assessment that includes food label calculations. However, the NVS uses an ice cream label, as the basis for its questions that many believe is not appropriate to use in people with diabetes. Therefore, the DNT might be more effective for people with diabetes because the DNT assess many numeracy skills needed for people with diabetes for daily self-care.

The DNT was developed to measure specific numeric skills in patients with diabetes (Huizinga et al., 2008) and has been used to test the relationship of numeracy with diabetes outcomes. The DNT is composed of items to assesses numeracy skills needed for diabetes self-management such as traditional math operations, numerical

hierarchy, fractions and percentages, and multi-step calculations it a diabetes-specific context. Items cover interpretation of blood glucose monitoring results and testing schedule, carbohydrate intake calculation, and medication management. There is a 43-item version, a 15-item version, and a 5-item version (Huizinga et al., 2008). It was also translated into Spanish (White et al., 2011).

The 43-item version of DNT consists of five domains: 9 items on nutrition, 4 item on exercise, 4 items on blood glucose monitoring, 5 item on oral medications, and 21 items on insulin administration. After the DNT-43 was tested in a convenience sample of 398 patients with diabetes, the split sample analysis produced a shortened 15-item version (Huizinga et al., 2008) that consisted of 3 items on nutrition, 1 item on exercise, 3 items on blood glucose monitoring, 1 item on oral medications, and 7 items on insulin administration. The DNT-15 was translated into a Spanish version called the DNT-15 Latino and validated with a sample of 144 Latinos with diabetes (White et al., 2011).

NUMERACY/DIABETES-RELATED NUMERACY AND DIABETES SELF-MANAGEMENT

Diabetes-related numeracy measured by DNT is significantly related to diabetes self-management. People with diabetes who had higher scores on the DNT showed better dietary intake (Bowen et al., 2013), better self-monitoring blood glucose (Huizinga et al., 2008), and better medication adherence (Cavanaugh, et al., 2008; Huizinga et al., 2008) among studies that did not adjust for confounding variables.

Bowen et al. (2013) examined the relationship between DNT scores and dietary intake in patients with T2DM (n = 150) and found that compared with patients who had

higher DNT scores, patients with lower DNT scores consumed more carbohydrates ($p = .008$), less protein ($p = .015$) and more fat ($p < .05$). However, after adjusting for age, sex, race, and income, those relationships between DNT scores and carbohydrate, protein, and fat percentages were not significant. Further analysis found that patients who reported extreme caloric intake were more likely to have lower DNT scores and patients who had lower DNT scores were more likely to report extreme energy intake (OR = 17; 95% CI 1.6, 185, $p < .05$) after adjusting for age, sex, race, and income.

The mean DNT score of patients (N = 398) in Huizinga et al.'s (2008) study was 61% (range 0-100%). Most patients (85%) answered items requiring simple interpretation of information correctly. However, only 37% of the patients in the study correctly answered items requiring multiple numerical steps and advanced interpretation such as interpreting a word problem and determining their insulin dosage. Scores on the DNT showed a significant association with frequency of blood glucose testing (rho = 0.15, $p = 0.0025$), appropriate insulin adjustment for carbohydrate intake (rho = 0.51, $p < 0.0001$), and appropriate insulin adjustment for blood glucose (rho = 0.28, $p < 0.0001$).

Cavanaugh et al. (2008) also demonstrated that low diabetes-related numeracy was common in patients with diabetes. The results showed that 26% of participants could not identify the numbers within the target range (60-120 mg/dl) for blood glucose level. In addition, patients had more difficultly with complex numeracy skills; almost 60% of participants could not calculate an insulin dose adjusted for carbohydrate intake and blood glucose level. Among patients who used insulin, Cavanaugh et al. also found that

numeracy was significantly related to the ability to adjust insulin for carbohydrate intake and blood glucose level.

However, some studies reported that diabetes-related numeracy did not demonstrate a significant relationship with overall diabetes self-management behaviors (Cavanaugh et al., 2008; Osborn et al., 2011; White et al., 2011). Osborn et al. (2011) also reported that both general numeracy, measured by WRAT-3, and diabetes-related numeracy, measured by the DNT, did not have a significant relationship with the diabetes medication adherence subscale of SDSCA.

Summary, the relationship between DNT and diabetes self-management is not clear. From literature review in this present study showed that lack of evidence to summarize the relationship between DNT and diabetes self-management that is a gap of knowledge and need further study to investigate the relationship between this two factors.

NUMERACY/DIABETES-RELATED NUMERACY AND GLYCEMIC CONTROL

Two studies reported that diabetes-related numeracy had a moderate to strong significant relationship with and ability to predict to glycemic control (Cavanaugh et al., 2008; Osborn et al., 2009). However, Cavanaugh et al. (2008) and Osborn et al. (2009) used the exact same sample in their analyses, most were African American and older people with diabetes. Cavanaugh et al. (2008) reported the mean DNT score of patients with diabetes was 65% (interquartile range, 42% to 81%). After adjusting for age, sex, race, income, diabetes type, duration of diabetes and clinical site, the DNT scores were significantly moderately related to A1C and were a significant predictor of A1C. A 10

percentage point decrease of correct DNT responses predicted an increase in A1C of 0.09 percentage points (95% CI, 0.01% to 0.16%-age points, $p = 0.027$). Osborn et al. (2009) found that the DNT scores were a strong predictor of glycemic control in path analysis ($r = -0.46$, $p < 0.001$). Lower DNT scores were related to worse A1C. Meanwhile, Osborn et al. (2010b) reported that numeracy measured by the WRAT had an indirect relationship to glycemic control through the relationship with diabetes self-efficacy in path analysis. However, White et al. (2011) reported that scores on the DNT-15 Latino were not significantly related to glycemic control in an unadjusted regression analysis.

In summary, there is a gap in knowledge about the relationship between diabetes-related numeracy and diabetes control due to lack of consistent evidence. In addition, studies that investigated the relationship between diabetes-related numeracy and diabetes outcomes used data from the same participants including the reports by Cavanaugh et al. (2008) Huizinga et al. (2008), Osborn et al. (2009), Osborn et al. (2010b), and Osborn et al. (2011). Therefore, the present study would increase knowledge about the relationship between diabetes-related numeracy and diabetes outcomes in the Thai population.

Diabetes Knowledge and Diabetes Control

Diabetes knowledge is an individual's recalled information about diabetes that involves etiology, symptoms, diabetes-related complications, diabetes self-management and treatment. Diabetes knowledge is an important concept because patients need to know how diabetes impacts their health and how they should perform their self-management behaviors. Thai people had diabetes knowledge deficit about diabetes

disease, diabetes-related complications, the interaction of alcohol with medications, and other aspects of self-management (Srisuwan, 2007). Thai older adults with diabetes were reported to lack diabetes knowledge about the cause of diabetes, appropriate food for diabetes, and food exchanges (Sanjaithum, 2006). Most Thai older adults with diabetes in Sanjaithum's study did not know that eating sweet food can cause diabetes (83.9%) and a plate of rice equals two large portions of Chinese noodles (60%).

DIABETES KNOWLEDGE AND DIABETES SELF-MANAGEMENT

Most studies have reported that diabetes knowledge was related to diabetes self-management. In Sanjaithum's (2006) study, Thai older adults just over half had moderate food selection habits (58.3%), and good food consumption (55.7%) but two-thirds had unhealthy cooking habits (67%). Having a diabetes knowledge deficit, may impact their ability for diabetes self-management. Lerman et al. (2004) reported a significant relationship between diabetes knowledge and diabetes self-management in Mexicans with T2DM in Mexico City; those who had good diabetes self-management behaviors also had higher diabetes knowledge scores (OR = 1.06; CI 1.0 to 1.1, $p = .02$). Osborn et al. (2010a) reported that diabetes knowledge was significantly related to diabetes self-management ($r = 0.22$, $p < .05$) in 130 adults with T2DM with almost half of participants were ≥ 65 years old. In China, Xu, Toobert, Savage, Pan, and Whitmer (2008) found a significant indirect relationship between diabetes knowledge and diabetes self-management in 210 older Chinese with T2DM (mean age of 61 years, women 65%) at outpatient visits in Beijing. Diabetes knowledge had an indirect relationship through

belief in treatment and self-efficacy on diabetes self-management. In a study of African American with diabetes at a community health center and one church located in the Midwestern, United States (N = 50, mean age 58.6 years, 76% female), McCleary-Jones (2011) found that diabetes knowledge had a moderate significant relationship with general diet self-management ($r = 0.299$, $p < 0.05$). In multiple regression, the overall model explained 40% (adjusted $R^2 = 36\%$) of general diet self-management variance ($F=10.35$; $DF=3,46$, $p < 0.001$). Diabetes knowledge was also significantly and independently related to diet self-management. Participants who had higher levels of diabetes knowledge tended to have higher levels of general dietary self-management. However, diabetes knowledge did not show a significant relationship with exercise in this study. Diabetes knowledge did not have a significant relationship with diabetes self-management in Chinese older adults with T2DM (Hu, Gruber, Liu, Zhao, & Garcia, 2013)

Diabetes knowledge was not tested as a predictor of SMBG, but SMBG was reported to be a significant predictor of diabetes knowledge in patients with T2DM in Australia (Bruce, et al., 2003) and in Costa Rica (Firestone et al., 2004).

In Thailand, diabetes knowledge was significantly related to diabetes self-management. Eiamrod (2009) reported that mean diabetes knowledge of Thai adults with T2DM in the community (N = 191) was 17.4 scores (SD = 2.8, possible range 0-20), which is fairly high. Most participants (64.9%) had a high level of diabetes knowledge (16-20 score), 31.4% had a moderate level (12-15 score), and only 3.7% had a low level (0-11 score). Participants who had high levels of diabetes knowledge had higher self-

management behavior scores than those who had moderate level of diabetes knowledge (mean difference = 5.95, $p < .001$) and those who had low level of diabetes knowledge (mean difference = 9.58, $p < .001$). Meanwhile, Eknithiset (2009) reported only a mean score of 22.38 for diabetes knowledge (out of 38) in Thai patients with T2DM in a hospital (N = 430).

Siwina (2003) reported that diabetes knowledge significantly predicted diabetes self-management behaviors in 311 Thai patients with diabetes. The patients had a moderate level of diabetes self-management. Diabetes knowledge was related to diabetes self-management although the correlation was fairly small ($r = .233$, $p <. 05$). In a multiple regressions analysis, diabetes knowledge, gender, age, education, marital status, family type, attitude to diabetes, and social support together accounted for 27.4% of the variance in diabetes self-management ($F = 8.605$, $p < .001$). Diabetes knowledge was a strong predictor of diabetes self-management ($b = .681$, $t = -6.126$, $p < .001$). Thus, a 1 point change in diabetes knowledge would result in .681 point increasing in diabetes self-management.

Diabetes knowledge was not a predictor of diabetes self-management in Wattanakul's (2012) study with 197 adults with T2DM in rural Thai communities. The mean diabetes knowledge score of the participants was fairly level, 16.77, indicating high score (SD = 2.61, with possible score 0-21). Mean diabetes self-management score was 77.09 (SD = 12.29 with possible scores 37-107), indicating a moderate level of self-management behaviors measured by SDSCA. Although diabetes knowledge was significantly related to diabetes self-management ($r = .253$, $p < .01$), the correlation was

small and it was not a significant predictor of diabetes self-management. Wattanakul noted that the non-significant predictive relationship between diabetes knowledge and diabetes self-management among the participants in the study was not conclusive. Most participants (88%) in her study had high diabetes knowledge. However, the participants might perform their self-management differently from recommended standards, from which the SDSCA is based. Thus, diabetes knowledge questionnaires might not measure what is truly needed for their diabetes self-management.

Diabetes knowledge had a small positive relationship with diet behavior ($r = 0.168$, $p < 0.05$; Srisuwan, 2007) among inpatients at a hospital in the middle of Thailand (N = 165, 70% female, 80% aged > 60 years, mean age 60.04, SD 11.39). Patients in Srisuwan's study had low diabetes knowledge, with a mean score of 10.48 (SD = 4.43, of a possible 21). Sanjaithum (2006) tested food selection, means of cooking, and food consumption in older Thai adults with diabetes (N =230, 70% female, mean age 69.67 years, SD = 6.31, 82% primary school education level). Older adults with diabetes had diabetes knowledge at fair level (48%), good level (30%) and poor level (21 %). Diabetes knowledge had a positive small but significant relationship with nutrition self-management ($r = 0.144$, $p < 0.05$).

In contrast, Chompusri (2007)'s study reported that diabetes knowledge did not have significant association with diet behaviors among 232 Thai patients with diabetes at a primary care unit of in the North Thailand (72% female, mean age 57.81 years). However, it was reported that the patients in the study practiced good diet control behaviors such as 83.62% who reported having three meals per day everyday, 60.78%

who ate green vegetables, and 45.65% did not consume soda, sweet water, or fruit drink every day.

In Thai people with diabetes, diabetes knowledge was significantly related to exercise in Chompusri's ($r = .18$, $p < .01$, 2007) study but Srisuwan (2007) did not found a significant relationship between diabetes knowledge and exercise (with a mostly female sample with most aged more than 60 years).

For medication behavior, in Thailand, patients with diabetes who had higher diabetes knowledge scores were more likely to adhere to medication than those who had lower diabetes knowledge (Chaimun, 2009) and diabetes knowledge had a small positive significant relationship with medication adherence (Chompusri, 2007, $r = 0.13$; Srisuwan, 2007, $r = 0.164$).

In summary, studies in Thailand were in hospitals or primary care units and found mixed results for the relationship between diabetes knowledge and self-management behaviors. Data from adult Thais with diabetes demonstrated significant relationships between diabetes knowledge and diabetes self-management behavior at low to moderate relationships, $r = 0.16$-0.48 (Chompusri, 2007; Klinprachum, 2009; Koatdok, 2009; Siwina, 2003; Thunnome, 2006; Wattanakul, 2012). People who had higher diabetes knowledge had better self-management behaviors. Three studies found a significant association between levels of diabetes knowledge scores and diabetes self-management by Chi-square analysis (Eiamrod, 2009; Eknithiset, 2009; Kaehaban, 2009). Diabetes knowledge also significantly predicted diabetes self-management in the study by Siwina (2003) but it was not a significant predictor of diabetes self-management in a study by

Wattanakul (2012). In Thailand, no published reports of the relationship between diabetes knowledge and SMBG were found. Other studies reported a non-significant relationship between diabetes knowledge and diabetes self-management among Thai patients (Borisuth, 2010; Chaikwang, 2005; Intaravichiankhacha, 2012; Phunkean, 2006; Settthamas, 2009; Vajiramethavi, 2007).

DIABETES KNOWLEDGE AND GLYCEMIC CONTROL

Diabetes knowledge is often reported to be the foundation of patients with diabetes to control their disease. McPherson, Smith, Powers, and Zuckerman (2008) reported that diabetes knowledge had a significant strong inverse relationship with A1C ($r = 0.61$, $p < 0.001$). When the patients with diabetes were categorized into poor glycemic control and good glycemic control, the patients with poor glycemic control had significantly lower diabetes knowledge scores than those who had good glycemic control.

Diabetes knowledge also significantly predicted A1C after controlling for covariates such as demographic characteristics and clinical outcomes in two studies (Bains & Egede, 2011; Nguyen et al., 2010). In their study of older adults with diabetes, Nguyen et al. (2010) found that diabetes knowledge reduced the association between executive cognitive function and glycemic control by 0.10 A1C %-age point after adjusting for sex, age, education, ethnicity, depressive symptoms, and duration of diabetes. Diabetes knowledge was significantly related to glycemic control; a 1-point-higher diabetes knowledge score was related to a 0.12 point lower A1C value ($p < 0.05$).

Osborn et al. (2010a) found a causal relationship between diabetes knowledge and glycemic control; diabetes knowledge did not have a direct effect on A1C but it was related to A1C indirectly through diabetes self-management. However, Gerber et al. 2006) reported a non-significant relationship between diabetes knowledge and glycemic control.

In Thailand, Srichana (2005) found a significant difference in diabetes knowledge among patients with T2DM. Patients who had poor diabetes knowledge had higher A1C levels than patients who had good glycemic control. However, diabetes knowledge was not a significant predictor of A1C in regression analyses. Meanwhile, some studies reported a non-significant relationship between diabetes knowledge and glycemic control (Chantrakul et al., 2007; Jantaratiratikul, 2008). These cross-sectional studies did not focus on a specific age group.

Self-Efficacy and Diabetes Control

Patients' self-efficacy plays a significant role in their performance of multiple domains of diabetes self-management. According to Bandura (1997), self-efficacy is each individual's belief in his or her power to produce outcomes. Once efficacy beliefs of each individual are formed, they regulate aspiration, behavioral choices, action and maintenance of effort, and emotional responses. Therefore, in patients with diabetes, self-efficacy is assumed to influence how people perform and maintain their diabetes self-management behaviors such as diet behavior, exercise, taking medication, and monitoring of blood glucose, as well as glycemic control directly.

SELF-EFFICACY AND DIABETES SELF-MANAGEMENT

Most studies included adult participants of all ages and found a significant strong positive relationship between self-efficacy and overall diabetes self-management (r = 0.50- 0.61, Beckerle & Lavin, 2013; Sousa, Zauszniewski, Musil, Price Lea, & Davis, 2005; Wu et al., 2013; Xu, Toobert, Savage, Pan, & Whitmer, 2008). Patients who had greater self-efficacy had better diabetes self-management. In addition, self-efficacy was a significant predictor of diabetes self-management in regression analyses (Gao et al., 2013; Wu et al., 2013; Xu et al., 2008;). In Chinese people with T2DM who visited outpatient clinics at teaching hospitals in Taiwan (N = 201, mean age 60.64 years with range 22-93 years), self-efficacy accounted for 27.9% of the variance in diabetes self-management behaviors (Wu et al., 2013).

Another cross-sectional study of 222 Chinese people with T2DM (61.7% female, mean age 54.5 years, 78.4% age > 60 years old), by Gao et al. (2013), reported path analysis results demonstrating there were significant positive direct paths from self-efficacy ($\beta = 0.41$, $p < .001$), social support ($\beta = 0.19$, $p = .007$) and provider-patient communications ($\beta = 0.12$, $p = .037$) to diabetes self-management behaviors, explaining 26% of the variability in the diabetes self-management behaviors of patients who visited a primary care center in Shanghai. Moreover, Xu et al. (2008) confirmed a causal relationship between self-efficacy and diabetes self-management from structural equation modeling analysis. Self-efficacy had a direct strong positive relationship with diabetes self-management in Chinese people with T2DM.

In Thailand, most studies found significant positive relationships between self-efficacy and diabetes self-management but the relationships varied from weak to strong (r = 0.126-0.73, Borisuth, 2010; Chaikwang, 2005; Koatdok, 2009; Wattanakul, 2012; Wuttisela, 2010). Three studies investigated the abilities of self-efficacy to predict diabetes self-management. Koatdok (2009) found that perceived self-management ability and other factors were better predictors of diabetes self-management together, accounting for 32% of the variance in diabetes self-management among outpatient Thai adults at a hospital (N = 350, 55.4% female, mean age 61.83 SD = 13.27, more than half age > 60 years). However, when examined individually, only perceived self-management ability was a significant predictor of diabetes self-management, accounting for 19% of the variance ($F = 80.98$, $p < 0.01$). Wattanakul's (2012) study of Thai adults with T2DM from outpatient diabetes clinics in rural areas (N =197, female 69%, mean age 57.21 SD = 10.47) reported that while controlling for demographic characteristics, diabetes self-efficacy, Buddhist values, risk perception, and social support were together predictive of diabetes self-management, accounting for 21% of the variance (adjusted $R^2 = 0.211$.). Diabetes self-efficacy was a significant predictor of diabetes self-management ($\beta = 0.169$, $p = 0.008$).

Strong evidence has been reported of significant relationships between self-efficacy and diet self-management behaviors (Aljasem, Peyrot, Wissow, & Rubin, 2001; Al-Khawaldeh et al., 2012; McCleary-Jones, 2011; Mishali, Omer, & Heymann, 2011; Sarkar et al., 2006). For example, in Israeli patients with diabetes there was a significant positive strong relationship between self-efficacy and diet behaviors (r = 0.50; Mishali et

al., 2011). While, in Jordan (Al-Khawaldeh et al., 2012) patients with T2DM who had greater self-efficacy were more likely to have higher optimal diabetes diet self-management (OR 0.13; 95% CI 0.07-0.23, $p < 0.01$, N = 223, male 56%). Sarkar et al. (2006) also reported that after adjusting for factors such as duration of diabetes, insulin use, race/ethnicity and health literacy, self-efficacy still significantly predicted an optimal diet, (coefficient 0.16, 0.075-0.24 in Spanish- and English-speaking patients with T2DM at two primary care units, N = 408, mean age 58.1, SD 11.4).

McCleary-Jones' (2011) study of African American patients' diet behaviors examined general diet self-management and specific diet self-management. McCleary-Jones found that self-efficacy had a strong significant positive relationship with general diet self-management ($r = 0.511$). Self-efficacy was also a significant predictor of general diet self-management, with the overall model explaining 40% of general diet self-management. However, self-efficacy was not correlated with specific diet self-management.

Aljasem et al. (2001) measured two eating behaviors, binge eating and closeness to following an ideal diet, and five domains of self-efficacy: planning efficacy, reliance efficacy, insulin efficacy, assertiveness efficacy, and sneaking food efficacy. Aljasem, et al. found that only planning efficacy and sneaking food efficacy were significantly related to binge eating and were also significant predictors of binge eating (planning efficacy, $\beta = -0.20$, and sneaking food efficacy, $\beta = 0.20$), explaining 7% of the variance in binge eating. Planning efficacy ($\beta = 0.20$) and sneaking food efficacy ($\beta = -0.17$) were also significant predictors of following an ideal diet.

In Venkataraman et al.'s (2012) study of patients with T2DM from a tertiary hospital in India (N = 507), diet behavior was not an outcome but it was a predictor of self-efficacy. The results showed that patients who had greater adherence to dietary self-management behaviors were 2.38 times more likely to believe in their ability to manage diabetes (OR 2.38; 95% CI 1.03-5.49, $p < 0.05$) after adjusting for age and gender.

Self-efficacy was significantly positively related to moderate to high levels of exercise in two studies ($r = 0.315$ in McCleary-Jones, 2011; $r = 0.67$ in Mishali et al., 2011). However, self-efficacy is not as strong a predictor of exercise behaviors. Al-Khawaldeh et al. (2012) reported that self-efficacy predicted exercise in patients with T2DM in Jordan (N = 223, men 56%, OR 0.13; 95% CI 0.07-0.23, $p < 0.01$) and Sarkar et al. (2006) also found in Spanish- and English-speaking patients with T2DM at two primary care units (N = 408, mean age 58.1, SD 11.4) that self-efficacy was a significant predictor of exercise, but the coefficient was small (= 0.10) when adjusted for factors that might be associated with exercise.

McCleary-Jones (2011) reported that the overall regression model explained only 13% of the variance in exercise self-management but after adjusting for health literacy and diabetes knowledge, self-efficacy was not significant predictor of exercise. Moreover, two studies did not find a significant relationship between self-efficacy and exercise (Aljasem et al., 2001; Shigaki et al., 2010).

Self-efficacy was found to be significantly positively related to medication adherence. Patients with diabetes who had greater self-efficacy had higher medication adherence. Mishali et al. (2011) reported a weak but significant relationship between self-

efficacy and oral medication intake (r = 0.25) in 119 patients with diabetes in Israel (mean age 57.45 years, SD = 10.91). Al-Khawaldeh et al. (2012) found that self-efficacy significantly predicted medication treatment adherence in patients with T2DM in Jordan (N = 223, men 56%, OR = 0.09; 95% CI 0.03-0.31). Aljasem et al. (2001) also found that assertiveness efficacy ("related to being assertive about dealing with others concerning one's diabetes," p. 396) was a significant predictor of skipping medication (β = -0.20, p = 0.01) but it explained only a small of increase of 2% of the variance from medication adherence.

In older adults with diabetes in Korea, Park et al. (2010) found that self-efficacy was significantly related to medication adherence in adults with diabetes, aged > 65 years (N = 108). The older adults with diabetes who had high self-efficacy were 13 times more likely to adhere to medication than those who had low self-efficacy. However, two studies reported a non-significant relationship between self-efficacy and medication adherence (McCleary-Jones, 2011; Sarkar et al., 2006).

Self-efficacy showed a positive significant relationship with monitoring blood glucose in Mishali et al.'s (2011) study at a moderate level (r = 0.47). Al-Khawaldeh et al. (2012) also reported that self-efficacy was related to more blood glucose testing and significantly predicted blood glucose monitoring (OR= 0.33, 95% CI: 0.12–0.91). Aljasem et al. (2001) found that planning efficacy (β = 0.28, p = < 0.001) and assertive efficacy (β = -0.23, p <0.001) significantly predicted blood glucose monitoring in 309 patients with T2DM. Self-efficacy explained an increase of 10% of the variance in blood glucose monitoring even after adjusting for factors in a regression analysis. Similarly in

Sarkar et al. (2006) self-efficacy was a significant predictor of blood glucose monitoring after adjusting for a duration of diabetes, insulin use, race, and health literacy in 408 Spanish- and English-speaking patients with T2DM at two primary care units (mean age 58.1, SD 11.4). However, two studies reported a non-significant relationship between self-efficacy and blood glucose monitoring (McCleary-Jones, 2011; Shigaki et al., 2010).

In summary, evidence supports a strong relationship between self-efficacy and diabetes self-management in studies in the United States (Aljasem, et al., 2001; Beckerle & Lavin, 2013; Sousa, et al., 2005) and in China (Gao et al., 2013; Wu et al., 2013; Xu et al., 2008), India (Venkataraman et al., 2012), Israel (Mishali, et al., 2011), Japan (Nakahara et al., 2006), Jordan (Al-Khawaldeh et al., 2012), Korea (Park et al., 2010), and five studies in Thailand (Borisuth, 2010; Chaikwang, 2005; Koatdok, 2009; Wattanakul, 2012; Wuttisela, 2010). However, studies both outside and in Thailand that investigated the relationship between self-efficacy and diabetes self-management did not focus on elderly patients with diabetes. Therefore, the relationship between self-efficacy and diabetes self-management in older patients is not clear.

SELF-EFFICACY AND GLYCEMIC CONTROL

Strong evidence supports the relationship of self-efficacy with glycemic control. Al-Khawaldeh et al. (2012) reported that patients with diabetes who perceived they had good diet self-efficacy were more likely to have better glycemic control (OR = 0.3; 95% CI 0.1–0.6) but medication adherence self-efficacy of the participants in the study was not related to A1C. Venkataraman et al.'s (2012) study of 507 in- and outpatients with

T2DM in India found that self-efficacy was the most important predictor of diabetes control after adjusting for age, gender and occupation group, history of hyperglycemic symptoms in the past year, current medication of diabetes treatment, and adherence to dietary restrictions. Patients in the study who had greater self-efficacy were 2.38 times more likely to have better glycemic control compared with those who had lower self-efficacy. Similarly in patients with diabetes in Myanmar, Nyunt et al. (2010) reported that patients with diabetes who had high self-efficacy were 5.29 times more likely to have better glycemic control than those patients who had fair or low self-efficacy level.

Thus, most studies found a significant negative relationship between self-efficacy and glycemic control across countries, indicating that greater self-efficacy had better glycemic control (Al-Khawaldeh et al., 2012; Gao et al., 2013; Gerber et al., 2006; Ikeda, Aoki, Saito, Muramatsu, & Suzuki, 2003; Nyunt et al., 2010; Osborn et al., 2010b; Sousa et al., 2005; Venkataraman et al., 2012; Wu et al., 2013). The relationship between self-efficacy and A1C was reported to be negative and moderate ($r = -0.21$ to -0.33; Ikeda, et al., 2003). Patients with diabetes who had greater self-efficacy had better glycemic control. Self-efficacy also was a significant predictor of A1C (Al-Khawaldeh et al., 2012; Ikeda et al., 2003; Nyunt et al., 2010; Venkataraman et al., 2012) and self-efficacy had a direct relationship with A1C in a path analysis (Osborn et al., 2010b). Yet, three studies reported a non-significant relationship between self-efficacy and glycemic control (Beckerle & Lavin, 2013; DeWalt et al., 2007; Al-Khawaldeh et al., 2012).

Non-Modifiable Selected Personal Factors

Non-modifiable selected personal factors in this study refer to age, gender, education, and duration of diabetes. Researchers in studies of diabetes care pay attention to these variables due to their association with diabetes outcomes.

AGE AND HEALTH LITERACY

People with diabetes who had low health literacy were more likely to be older (Mbaezue et al., 2010; Morris et al., 2006; Rothman et al., 2004). Mancuso (2010) found that age had a significant mild negative relationship with health literacy ($r = -0.218$, $p < 0.05$). Among Japanese people with T2DM in different age group (age < 65 years, 65-74 years, and ≥ 75 years), when health literacy was measured by the 3LHLS, people who were in older age groups (≥ 75 years) had lower levels of functional ($p = 0.01$) and critical health literacy ($p = 0.027$) but the differences in communicative health literacy were not significant among age groups (Ishikawa et al., 2008). However, some studies did not show a significant relationship between age and health literacy (Jeppesen, Coyle, & Miser, 2009). In path analysis, age did not have direct relationship to health literacy (Osborn et al., 2010b).

AGE AND NUMERIC SKILLS/DIABETES-RELATED NUMERACY

Three studies reported a relationship between age and diabetes-related numeracy. People who had low DNT scores were more likely to be of older age (Bowen et al., 2013; Cavanaugh et al., 2008) and in a path analysis study by Osborn et al. (2009), older age

was related to lower diabetes-related numeracy and diabetes-related numeracy was related to poor glycemic control.

AGE AND DIABETES KNOWLEDGE

Among studies that found a significant relationship between age and diabetes knowledge; the relationships were negative. Younger patients with diabetes had higher diabetes knowledge than those who were older (Abdullah, Margolis, & Townsend, 2001; Bruce et al., 2003; Çaliskan, Ozdemir, Ocaktan, & Idil, 2006; Firestone et al., 2004; He & Wharrad, 2007; Hu et al., 2013; McPherson et al., 2008; Murata et al., 2003; Powell et al., 2007; Soltanian, Bahreini, & Afkhami-Ardekani, 2007; Speight & Bradley, 2001). In contrast in Thailand, two studies reported a positive relationship between age and diabetes knowledge (Pongmesa, 2010; Siwina, 2003).

When patients were categorized based on age, < 65 years and, ≥65 years, younger patients had higher levels of diabetes knowledge (Bruce et al., 2003; Hu et al., 2012; McPherson et al., 2008). However, age was reported to have a weak to moderate negative relationship with diabetes knowledge ($r = -0.20$ to -0.34) in four studies (He & Wharrad, 2007; Hu et al., 2013; Murata et al., 2003; Powell et al., 2007). Age was an independent significant negative predictor of diabetes knowledge (Murata et al., 2003) and also in combination together with other variables (duration of diabetes, education, blood glucose monitoring) significantly accounted for 33% of the variance in diabetes knowledge (adjusted $R^2 = 0.33$ [$F(12,128) = 6.7$, $p < 0.0001$], Firestone et al., 2004). In older Chinese with T2DM, Hu et al. (2013) reported that age and education accounted for 18% of the

variance in diabetes knowledge but age alone was not a significant predictor of diabetes knowledge.

Studies with Thai patients found a positive relationship between age and diabetes knowledge that conflicted with other studies. In Thai patients with diabetes, Siwina (2003) found a significant small but positive relationship between age and diabetes knowledge (r = 0.167). Thai patients with diabetes who were older had higher diabetes knowledge than those who were younger. Pongmesa (2010) also reported that age significantly predicted diabetes knowledge but this study included participants with other chronic diseases. Only 3.6% of participants were people with T2DM. Thus, the results did not clearly represent patients with T2DM. Diabetes knowledge might be affected by having multiple comorbidities, which often happens with increasing age.

AGE AND DIABETES SELF-EFFICACY

The relationship between age and self-efficacy is also inconsistent. McCleary-Jones (2011) reported that age had a positive relationship with self-efficacy (r = 0.329). Older patients with diabetes had higher self-efficacy. However, Sousa et al. (2005) found a non-significant relationship between age and self-efficacy. In Thailand, two studies reported opposite results. Promkong (2006) reported that age had a positive moderate relationship with self-efficacy (r = 0.31), while Wuttisela (2010) found a non-significant relationship between age and self-efficacy. The two studies that reported a significant relationship between age and self-efficacy gave the same positive direction of relationship and used two different scales to assess self-efficacy: the 8-items Diabetes

Self-efficacy Scale (McCleary-Jones, 2011) and the 44-items Perceived Self-Care Ability Questionnaire (Promkong, 2006).

AGE AND DIABETES SELF-MANAGEMENT

In all adult age groups, McCleary-Jones (2011) found that age was significantly and moderately associated with general diet self-management ($r = 0.307$, $p < 0.05$) in African Americans with diabetes. Patients with diabetes who were older had better performance in general diet self-management. Meanwhile, some studies showed a non-significant relationship between age and diabetes self-management including studies in the United States (Mancuso, 2010; Yamashita & Kart, 2011) and one study of Chinese people with T2DM (Bohanny et al., 2013). However, in older adults with diabetes two studies reported different results. In Chinese older adults with T2DM there was no difference in diabetes self-management among patients in four categories of older age (Bai, Chiou, & Chang, 2009). In contrast, Arcury et al. (2012) found that age was a small but significant positive predictor of diabetes management in older adults with diabetes in a variety of ethnic groups in the United States, meaning that older people with diabetes had better diabetes self-management. However, the researchers noted that the prediction might reflect bias from self-reported data about diabetes self-management.

In Thailand, two studies reported a significant relationship between age and diabetes self-management (Kaehaban, 2009; Suttharattanakun, 2006). Kaehaban (2009) reported that Thai patients with diabetes in different age groups (< 51 years, 51-60 years, and > 60 years) had significantly different diabetes self-management. Suttharattanakun

(2006) demonstrated that age had a positive mild significant relationship with diabetes self-management ($r = 0.192$, $p < 0.01$); patients who were older had better diabetes self-management than those who were younger. Adding age as a predictor significantly increased the variance explained in diabetes self-management by 1.5% after illness representation and occupation were included in the regression model. However, most studies in Thailand found that self-management was not significantly different between age groups (Borisuth, 2010; Chaikwang, 2005; Eiamrod, 2009; Eknithiset, 2009; Koatdok, 2009; Setthamas, 2009; Siwina, 2003; Vajiramethavi, 2007) and age was not a significant predictor of diabetes self-management (Wattanakul, 2012; Wuttisela, 2010). Those studies included adults of all ages. The relationship between age and diabetes self-management among older adults with diabetes is not known.

Each domain of self-management requires particular skills that might be influenced by age. Several studies investigated the relationship between age and specific domains of diabetes self-management. Age showed a small but significant relationship with diet self-management in Thai patients with diabetes ($r = 0.228$, $p < 0.01$). Thai patients with diabetes who were older had better performance in diet self-management than those who were younger (Srisuwan, 2007). In the United States, age significantly predicted diet self-management in multiple regressions after adjusting for sociodemographic covariates. When comparing demographic characteristics with other variables, only age was significantly associated with diet behaviors ($\beta = 0.97$; 95% CI 0.17-1.77; Bains & Egede, 2011). Aljasem et al. (2001) found that older patients with diabetes were significantly less likely to binge eat than those who were younger (r = -

0.20, $p < 0.01$) and patients who were older got closer to following an ideal diet ($r = 0.13$, $p < 0.05$) than those who were younger.

However, some studies reported a non-significant relationship between age and diet self-management in adults at all ages (Shigaki et al., 2010) and among older adults (Arcury et al., 2012). In Egypt, the frequency of dietary management in older adults with diabetes, aged ≥ 60 years was lower than for those who were < 60 years but the difference was not significant (Mahfouz & Awadalla, 2011).

Most studies revealed that age was not significantly related to exercise behaviors in adults at all ages (Bains & Egede 2011; McCleary-Jones, 2011; in Thailand, Srisuwan, 2007) and among older adults (Arcury et al., 2012). However, patients with diabetes who were younger did more vigorous exercise than those who were older (Aljasem et al., 2001). And among patients with diabetes who had suboptimal glycemic control, Tan and Magarey (2008) reported that Malaysian patients with diabetes who were younger (age ≤ 50 years) were significantly more active in their non-leisure time.

Four studies, two in the United States (Bains & Egede 2011; McCleary-Jones, 2011), one in Egypt (Mahfouz & Awadalla, 2011), and one in Thailand (Srisuwan, 2007) reported a non-significant relationship between age and medication adherence.

Age was significantly related to SMBG in two studies (Bruce et al., 2003; Mahfouz & Awadalla, 2011). Bruce et al. (2003) found that older adults with T2DM, aged ≥65 years were less likely than those who were < 65 years to perform self-monitoring blood glucose (OR 0.68; 95% CI 0.52 to 0.89, $p = 0.004$). However, Arcury et al. (2012) reported that older adults with diabetes did not have significantly different

blood glucose monitoring frequency than those who were younger. Two studies reported a non-significant relationship between age and performing glucose monitoring ($\beta = 0.73$, Bains & Egede 2011; $r = 0.25$, McCleary-Jones, 2011).

AGE AND GLYCEMIC CONTROL

Bruce et al. (2003) reported that patients with diabetes who were 65 years or older had better glycemic control than those who were < 65 years. Age was significantly correlated with glycemic control (Nguyen et al., 2012) and predicted glycemic control but with a small relationship (Osborn et al., 2009, $r = -0.21$, Osborn et al., 2010b). When age and other personal factors such as gender and race were included into the regression model to predict glycemic control, age explained only 2.3 % to 4.8 % of the variance in A1C (Chiu & Wray, 2010; Rogvi et al., 2012). Using multiple regression, Osborn et al. (2009) reported that younger age, using insulin, longer duration of diabetes, and being of African race were together significantly predicted of worse A1C, accounting for 17% of the variance in A1C level.

However, six studies reported a non-significant relationship between age and glycemic control (Al-Khawaldeh et al., 2012; Bains & Egede 2011; Mancuso, 2010; Schillinger et al., 2002; Tang et al., 2008; Yamashita & Kart, 2011). Therefore, the relationship between age and glycemic control is inconsistent.

In Thailand, four studies reported a significant relationship between age and glycemic control including two studies using A1C data (Sowattanangoon et al., 2008; Wattanakul, 2012) and two studies using FPG data (Srichana, 2005; Srisuwan, 2007). In

contrast, seven studies reported a non-significant relationship between age and glycemic control including two studies of A1C (Jantaratiratikul, 2008; Pintong, 2005) and five studies of FPG (Chantrakul et al., 2007; Chotamara, 2006 Promkong, 2006; Siriwattanapornkul, 2006; Wuttisela, 2010).

Among studies in Thailand that found a significant but weak (r = -0.138 to –0.208) relationship between age and glycemic control, its relationship was inverse, like the results related from other countries (Srisuwan, 2007; Wattanakul, 2012). Age was found to significantly predict glycemic control in Thai patients with diabetes in three studies (Sowattanangoon et al., 2008; Srichana, 2005; Wattanakul, 2012). Wattanakul (2012) reported that age and duration of diabetes significantly predicted A1C, accounting for 6% of the variance of A1C. Srichana (2005) found that Thai patients with diabetes aged > 65 years were less likely to have poor FPG than those who were aged 50-64 years.

GENDER AND HEALTH LITERACY

Evidence of the relationship between gender and health literacy was insufficient and inconsistent. One study reported that people with diabetes who had limited health literacy were more likely to be female (Schillinger et al., 2002) but another study found that male gender predicted limited health literacy (Jeppensen et al., 2009); males were 4.46 times more likely to have limited health literacy than females (OR = 4.46; 95% CI, 1.53-12.99). In contrast, three studies found that males and females did not have significantly different health literacy levels (Ishikawa et al., 2008; Kim et al., 2004; Morris et al., 2006).

Gender and Numeracy

Few studies explored the relationship between gender and numeracy. Bowen et al. (2013) reported that patients with diabetes who did not report extreme caloric intake, and those who had low DNT scores were significantly more likely to be women. Cavanaugh et al. (2008) did not find a significant relationship between gender and numeracy.

Gender and Diabetes Knowledge

Mancuso (2010) reported that socioeconomic status (marital status, education, occupation, and gender) was significantly related to diabetes knowledge ($r = 0.264$, $p < 0.01$). However, gender was not tested separately for a relationship with diabetes knowledge. Gender was also reported as covariate of the relationship between diabetes knowledge and A1C. McPherson et al., (2008) reported that there was a significant interaction between gender and knowledge score on A1C. There was greater variation in A1C levels among women than among men for each unit change in knowledge scores. For each one-unit increase in knowledge score, A1C was lower by one-half unit in men, and 1.6 units in women.

The relationship between gender and diabetes knowledge seem to be different among countries. Women were reported to have better diabetes knowledge than men in the United States (Murata et al., 2003) and in one study in Thailand (Klinprachum, 2009); while other studies reported that men had better knowledge than women in the Middle East (Rafique, Azam, & White, 2006) where it is possible that men have better chance to access information about diabetes self-management. However, several studies reported

that gender was not related to diabetes knowledge (Bains & Egede, 2011; Firestone et al., 2004; He & Wharrad, 2007; Hu et al., 2013; McPherson et al., 2008; Powell et al., 2007; Yun, Hasan, Aziz, Awaisu, & Ghazali, 2007; including three studies in Thailand (Pongmesa, 2010; Siwina, 2003; Srisuwan, 2007).

GENDER AND DIABETES SELF-EFFICACY

Few studies report on the relationship between gender and self-efficacy. In Indian people with T2DM, Venkataraman et al. (2012) found that gender was significantly related to self-efficacy. Men had higher self-efficacy than women but being male was not a significant predictor of self-efficacy. Wu et al. (2013) reported that gender was not related to self-efficacy in Chinese people with T2DM. In Thailand, Siriwatchaiporn (1994) reported that gender was significantly related to perceived self-management efficacy ($r = -0.15$, $p < 0.05$, male =0, female = 1); men had higher perceived self-management efficacy than women.

GENDER AND DIABETES SELF-MANAGEMENT

Gender was not found to be significantly related to diabetes self-management among adults with diabetes of all ages in the U.S. (Bains & Egede 2011; Yamashita & Kart, 2011) and in Taiwan (Bohanny et al., 2013). However, in older adults with diabetes, gender was significantly related to diabetes self-management (Arcury et al., 2012; Bai et al., 2009) but the two studies reported different results for males and females. In the United States, Arcury et al. (2012) reported that females had significantly better diabetes

self-management than males. Using a regression model, Arcury et al. (2012) found that being female and older were significant predictors of higher diabetes self-management scores in older adults, but they accounted for only 4% of the variance on diabetes self-management. In contrast, in older Chinese patients with T2DM, Bai et al. (2009) reported that Chinese men with T2DM had significantly better diabetes self-management behaviors than women.

In Thailand, many studies reported that women and men were not significantly different in diabetes self-management (Borisuth, 2010; Chaikwang, 2005; Kaehaban, 2009; Koatdok, 2009; Setthamas, 2009; Siwina, 2003; Suttharattanakun, 2006; Vajiramethavi, 2007; Wattanakul, 2012). Only two studies reported a significant relationship between gender and diabetes self-management (Eiamrod, 2009; Intaravichiankhacha, 2012). Thai women with diabetes had significantly better diabetes self-management than men but the relationship between gender and diabetes self-management was weak (Eiamrod, 2009; Intaravichiankhacha, 2012).

Four studies found that gender was not significantly associated with diet self-management behaviors in patients with diabetes (Arcury et al., 2012; Mahfouz & Awadalla, 2011; Shigaki et al., 2010) including one study in Thailand (Srisuwan, 2007). One of the four studies was conducted with aging people with diabetes (Arcury et al., 2012). However, two studies reported a significant relationship between gender and diet behaviors. Aljasem et al. (2001) reported that women engaged in more binge eating than men ($r = 0.14$, $p < 0.05$) and Agborsangaya et al. (2013) found that compared with

females, males were 1.9 times more likely to never have changed diet life style (RR = 1.9; 95% CI 1.3 to 2.8).

Three studies reported that gender was not related to exercise behavior (Arcury et al., 2012; Srisuwan, 2007; Tan & Magarey, 2008) and gender was not related to changing exercise behavior (Agborsangaya et al., 2012). Of the four studies, one study was conducted with older people with diabetes (Arcury et al., 2012). Only one study reported that women did more vigorous exercise than men ($r = 0.12$, $p = 0.05$; Aljasem et al., 2001).

Few studies reported on the relationship between gender and medication adherence but two studies in Thailand reported that gender was significantly related to medication adherence (Chaimun, 2009; Srisuwan, 2007). Female Thai patients with diabetes were more likely to take medications as prescribed than those who were male patients (OR =2.075; 95% CI 1.134 – 3.759, $p < 0.05$; Chaimun, 2009). In contrast, in Egypt, gender was not significantly related to taking medication (Mahfouz & Awadalla, 2011).

Three studies reported a relationship between gender and monitoring blood glucose. Two of the studies reported a non-significant relationship between gender and monitoring blood glucose among older adults (Bruce et al., 2003) and adults of all ages (Mahfouz & Awadalla, 2011). Arcury et al. (2012) reported that older women performed significantly more blood glucose monitoring than men.

GENDER AND GLYCEMIC CONTROL

Most studies found a non-significant relationship between gender and glycemic control (Al-Khawaldeh et al., 2012; Bains & Egede 2011; Bruce et al., 2003; Chiu & Wray, 2010; Nguyen et al., 2012; Rogvi et al., 2012; Schillinger et al., 2002; Yamashita & Kart, 2011) including three studies with using A1C in Thailand (Jantaratiratikul, 2008; Pintong, 2005; Wattanakul, 2012) and four studies using FPG (Chantrakul et al., 2007; Chotamara, 2006; Srichana, 2005; Srisuwan, 2007).

EDUCATION AND HEALTH LITERACY

Evidence showed that education is important factor to health literacy in people with diabetes. Compared to those with adequate health literacy, people who had limited health literacy were more likely to have less education (Dewalt et al., 2007; Ishikawa et al., 2008; Kim et al., 2004; Mbaezue et al., 2010; Rothman et al., 2004) such as only some high school education or less (Schillinger et al., 2002). Moreover, education also was a significantly correlated with health literacy (Schillinger et al., 2006) and significantly predicted health literacy (Jeppensen et al., 2009).

However, using the Three Levels of Health Literacy measurement with Japanese people with T2DM, Ishikawa et al. (2008) reported that subjects who had higher education attainment scored higher on all subscales of health literacy. However, a significant difference between education and health literacy was found only on the critical subscale and overall health literacy. The relationships between education and functional and communicative health literacy were not significant.

Schillinger et al.'s (2006) path analysis showed that education had a positive relationship with health literacy (high school graduate, standard path estimate 0.24 and some college education, standard path estimate 0.51, all at $p < .05$). Rothman et al. (2004) found a correlation between low education and low health literacy. More than 75% of participants had REALM scores less than 61, indicating a reading level at less than 9th grade, and 55% of the participants had REALM scores less than 45, indicating a 6th grade reading level. Rothman et al. reported that REALM scores less than 45 showed a strong relationship with education attainment ($r = 0.66$). Jeppensen et al. (2009) identified the predictors of limited health literacy in people with diabetes. Education was independently related to health literacy and also found that those people who had limited health literacy were more likely to have a lower education level (OR = 1.89; 95% CI, 1.12-3.18).

EDUCATION AND NUMERACY

Four studies reported a significant positive relationship between education and numeracy. All studies found that the patients with diabetes who had low DNT scores were more likely to have lower educational attainment (Bowen et al., 2013; Cavanaugh et al., 2008; Huizinga et al., 2008; White et al., 2011). The significant relationship between DNT scores and education was at a moderate level, rho = 0.33 (White et al., 2011) and strong level, rho = 0.52 (Huizinga et al., 2008).

EDUCATION AND DIABETES KNOWLEDGE

Most studies reported that education level was significantly and positively related to diabetes knowledge in Asian samples (Abdullah et al., 2001; He & Wharrad, 2007; Hu et al., 2013; Soltanian et al., 2007; Xu et al., 2008; Yun et al., 2007) including one study in Thailand (Pongmesa, 2010), as well as Australia (Bruce et al., 2003), Europe (Speight & Bradley, 2001), South America (Firestone et al., 2004) and in the United States (Mancuso, 2010; Murata et al., 2003). Education level was related to diabetes knowledge at moderate to high levels (Hu et al., 2012; Murata et al., 2003; Xu et al., 2008); except Soltanian et al. (2007), who reported a low relationship between education and patients' awareness of diabetes, a proxy for diabetes knowledge

Education was also reported to be a significant predictor of diabetes knowledge (Firestone et al., 2004; Hu et al., 2012). In older Chinese people with T2DM, age and education level together accounted for 18% of the variance in diabetes knowledge but only education was a significant predictor. Education level was also a significant predictor in a two-level hierarchical multiple regressions in which age, education level, family history of diabetes, use of traditional Chinese medicine, and attending diabetes education class significantly accounted for 29% of the total variance on diabetes knowledge (Hu et al., 2012). In Costa Rican patients with diabetes, Firestone et al. (2004) reported that education level, together with other variables, significantly predicted diabetes knowledge (adjusted R^2=0.33 [$F(12,128) = 6.7$, $p < 0.0001$]); patients with diabetes who had higher education, younger age, longer duration of diabetes, and who monitored blood glucose had higher diabetes knowledge. Few studies reported a non-

significant relationship between education and diabetes knowledge (Bains & Egede 2011; McPherson et al., 2008; Powell et al., 2007).

EDUCATION AND DIABETES SELF-EFFICACY

Education was found to have a weak but significantly positive relationship with self-efficacy ($r = 0.148$; Xu et al., 2008). Education also significantly predicted self-efficacy in Indian people with diabetes. After adjusting for age and gender, people with diabetes who had more years of education were 2.59 times more likely to believe in their ability to manage diabetes compared with those with little or no education (Venkataraman et al., 2012). In Thailand, Siriwatchaiporn (1994) found that education was significantly related to perceived self-management efficacy ($r = 0.23$, $p < 0.001$). Thai people with diabetes who had higher education levels had greater perceived self-management efficacy. However, Wu et al. (2013) reported that education had a non-significant relationship with self-efficacy.

EDUCATION AND DIABETES SELF-MANAGEMENT

In older Chinese patients with T2DM, Bai et al. (2009) reported that there was significant difference in diabetes self-management behaviors due to education level. Older Chinese adults with T2DM who had higher education levels had better diabetes self-management than those who had lower education levels. Older Chinese with T2DM in the study who had completed senior high school, college or university had higher diabetes self-management than those who were illiterate. Also, college and university

graduates had better diabetes self-management than those who finished only elementary school. In multiple regression, after adjusting for all variables in the model, education, duration of diabetes, and social support were significant predictors of diabetes self-management, explaining 35.6% of total variance (Bai et al., 2009). However, education was not significantly related to diabetes self-management in studies conducted in the United States (Bains & Egede 2011; Yamashita v& Kart, 2011), or China (Bohanny et al., 2013; Xu et al., 2008)

In Thailand, three studies reported a significant relationship between education and diabetes self-management (Eknithiset, 2009; Siwina, 2003; Suttharattanakun, 2006). Suttharattanakun (2006) found a significant positive small relationship between education and diabetes self-management in Thai adults with T2DM ($r = 0.233$); Thai adults with T2DM who had more education had better diabetes self-management. However, Siwina (2003) reported a relationship with the opposite direction. Siwina found that education, diabetes knowledge and other variables together were significant predictors of diabetes self-management, accounting for 27.4% of the variance, but education was a negative predictor of diabetes self-management ($\beta = -0.173$). Moreover, education was not significantly related to diabetes self-management in many studies in Thailand (Borisuth, 2010; Chaikwang, 2005; Eiamrod, 2009; Kaehaban, 2009; Koatdok, 2009; Phunkean, 2006; Setthamas, 2009; Siwina, 2003; Vajiramethavi, 2007; Wattanakul, 2012).

Education was significantly related with specific domains of diabetes self-management. Mahfouz and Awadalla (2011) found that Egyptians with diabetes who had different education levels had significant differences in diet self-management. A quarter

of patients in the study who were illiterate were not compliant in diet self-management. Patients who had low education levels might have more difficulty changing diet behaviors. In Canada, Agborsangaya et al. (2013) reported that compared with post-secondary graduates, patients with T2DM who were educated at less than the secondary education level were more likely to have never changed diet behaviors (RR = 1.7; 95% CI 1.2 – 2.4). In contrast, two studies reported a non-significant relationship between education and diet self-management including one study in older adults (Arcury et al., 2012) and one study in adults at all ages (Shigaki et al., 2010). In Thailand, no published reports of the relationship between education and diet behaviors were found.

Only two studies reported on the relationship between education and exercise behaviors. In older adults with diabetes, there was not a significant difference in education levels and exercise behavior (Arcury et al., 2012) but Agborsangaya et al. (2013) found that compared with patients with diabetes who had post-secondary graduate education, participants who had less than secondary education were more likely to have never changed exercise behavior (RR = 1.3, 95% CI 1.1 -1.7). In Thailand, there was no published study of the relationship between education and exercise.

Little is known about the relationship between education and medication adherence among patients with diabetes. Tan and Magarey (2008) found that among Chinese patients with diabetes who had suboptimal glycemic control, those who had secondary education and above were more likely to adhere to taking prescribed medication. Two studies found a non-significant relationship between education and

medication adherence including one study in Egypt (Mahfouz & Awadalla, 2011) and one study in Thailand (Chaimun, 2009).

Education was significantly related to blood glucose monitoring in adults with diabetes of all ages (Aljasem et al., 2001; Mahfouz & Awadalla, 2011). Aljasem et al. (2001) found a significant but weak relationship between education and blood glucose monitoring ($r = 0.16$); patients with diabetes who had higher education levels had more frequent blood glucose monitoring. However, in older adults with diabetes, education was not associated with blood glucose monitoring (Arcury et al., 2012; Bruce et al., 2003). In Thailand, published reports about the relationship between education and blood glucose monitoring were not found.

EDUCATION AND GLYCEMIC CONTROL

Studies found that education predicted A1C level (Rogvi et al., 2012; Schillinger et al., 2002). Rogvi et al. (2012) reported that education predicted A1C but education with other sociodemographics only explained 2.3% of the variance in A1C among Danish patients with T2DM. Schillinger et al. (2002) also reported that education significantly predicted A1C in unadjusted analyses but after adjusting for age, sex, race, insurance, language, social support, diabetes education, depression, treatment, and duration of diabetes, education became a non-significant predictor. Moreover, Schillinger et al. (2006) found that education was significantly associated with A1C but in path analysis, after health literacy was included in the model, the relationship between education and

A1C became non-significant. Therefore, health literacy mediated the relationship between education and A1C.

However, some studies in several countries reported that education was not significantly related to glycemic control (Al-Khawaldeh et al., 2012; Bains & Egede 2011; Bruce et al., 2003; Chiu & Wray, 2010; Nguyen et al., 2012; Tang et al., 2008; Yamashita & Kart, 2011). In Thailand, most studies reported a non-significant relationship between education and A1C including four studies using A1C measurement (Howteerakul et al., 2007; Jantaratiratikul, 2008; Pintong, 2005;Wattanakul, 2012) and two studies using FPG (Chantrakul et al., 2007; Chotamara, 2006). Although education together with age and gender predicted A1C, accounting for 5% of the variance in A1C, education was not a significant predictor of A1C (Sowattanangoon et al., 2008).

DURATION OF DIABETES AND HEALTH LITERACY

Studies showed the same trend for the relationship between duration of diabetes and health literacy. People with diabetes who had limited health literacy were more likely to have longer diabetes duration (Mbaezue et al., 2010; Morris et al., 2006; Schillinger et al., 2002). However, two studies reported a non-significant association between duration of diabetes and health literacy (Kim et al., 2004; McCleary-Jones, 2011).

Only one study examined the relationship between duration of diabetes and numeracy. Duration of diabetes was not significantly related to DNT scores (Cavanaugh et al., 2008) and was not a significant predictor of DNT scores in path analysis (Osborn et al., 2009).

DURATION OF DIABETES AND DIABETES KNOWLEDGE

Most studies found that duration of diabetes was not related to diabetes knowledge (Bruce et al., 2003; He & Wharrad, 2007; McCleary-Jones, 2011; Murata et al., 2003; Powell et al., 2007; Xu et al., 2008; Yun et al., 2007). However, some studies reported a significant positive relationship between duration of diabetes and diabetes knowledge (Çaliskan et al., 2006). Patients with diabetes who had a longer duration of disease were more likely to have higher diabetes knowledge. Firestone et al. (2004) reported that duration of diabetes and other variables (age, education, blood glucose monitoring) significantly predicted diabetes knowledge in Costa Rican patients with T2DM (adjusted R^2= 0.33 [$F(12,128) = 6.7$, $p < 0.0001$]). Similarly in Thailand, two studies reported a positive significant but small relationship ($r = 0.25$-0.27) between duration of diabetes and diabetes knowledge (Intaravichiankhacha, 2012; Srisuwan, 2007).

DURATION OF DIABETES AND SELF-EFFICACY

Few studies reported a significant relationship between duration of diabetes and self-efficacy. In African Americans with diabetes, McCleary-Jones (2011) reported a positive significant relationship between duration of diabetes and self-efficacy at a moderate level ($r = 0.313$). Two studies of Chinese people with diabetes reported a weak positive significant relationship between duration of diabetes and self-efficacy ($r = 0.14$; Wu et al., 2013; and $r = 0.16$; Xu et al., 2008). The patients with diabetes who had longer duration of diabetes had greater self-efficacy. In contrast, three studies in Thailand found

a non-significant relationship between duration of diabetes and self-efficacy (Promkong, 2006; Siriwatchaiporn, 1994; Wuttisela, 2010).

Duration of Diabetes and Diabetes Self-Management

Among the studies that reported a significant relationship between duration of diabetes and diabetes self-management, the relationship was found to be in the same positive direction in two studies of Chinese people with diabetes (Bai et al., 2009; Xu et al., 2008). In Chinese with T2DM, the duration of diabetes was found to have a small but significant relationship ($r = 0.197$ to 0.227) with diabetes self-management; those who had longer duration of diabetes had better diabetes self-management (Bai et al., 2009; Xu et al., 2008). In addition, among Chinese older adults with T2DM the duration of diabetes was a significant predictor of diabetes self-management. After adjusting for several variables in the multiple regression model, duration of diabetes, education, and social support were significant predictors of diabetes self-management, accounting for 35.6% of the total variance (Bai et al., 2009). In contrast, Intaravichiankhacha (2012) reported a significant negative weak relationship between duration of diabetes and diabetes self-management. Thai patients with diabetes who had lower education had better diabetes self-management.

In summary, most studies reported a non-significant relationship between duration of diabetes and diabetes self-management including one study in older adults in the United States (Arcury et al., 2012), two studies in Chinese people with diabetes (Bohanny et al., 2013; Wu et al., 2013) and seven studies in Thailand (Borisuth, 2010; Chaikwang,

2005; Setthamas, 2009; Suttharattanakun, 2006; Vajiramethavi, 2007; Wattanakul, 2012;Wuttisela, 2010). However, some studies found a significant relationship between duration of diabetes and diabetes self-management including two studies in China (Bai et al., 2009; Xu et al., 2008) and five studies in Thailand (Eiamrod, 2009; Eknithiset, 2009; Kaehaban, 2009; Koatdok, 2009; Intaravichiankhacha, 2012). In addition, duration of diabetes was reported to be a significant predictor of diabetes self-management in older adults (Bai et al., 2009) and had a direct relationship to diabetes self-management (Xu et al., 2008).

Duration of diabetes was not significantly related to diet self-management behaviors in four studies (Agborsangaya et al., 2013; Arcury et al., 2012; McCleary-Jones, 2011; Shigaki et al., 2010). However, in Thai people with diabetes, duration of diabetes was found to have a significant positive moderate relationship with diet behavior ($r = 0.297$); Thai people who had longer duration of diabetes had better in diet behavior of diabetes self-management (Srisuwan, 2007).

Two studies reported a significant relationship between duration of diabetes and exercise behavior but in opposite directions. In older adults with diabetes in the United States, Arcury et al. (2012) reported that those who had diabetes less than 10 years were significantly more likely to exercise than those who had diabetes ≥ 10 years. However, in Thailand, Srisuwan (2007) reported that duration of diabetes had a significant small positive relationship with exercise behavior ($r = 0.257$). Thai people with diabetes who had diabetes for longer better performed exercise behaviors.

Two studies reported a positive relationship between duration of diabetes and medication adherence (Osborn et al., 2011. In Thailand, (Srisuwan, 2007) patients with diabetes who had longer duration of diabetes had better medication adherence although the correlation was weak. In the U.S. Osborn et al. (2011) found from path analysis that duration of diabetes was significantly associated with medication adherence $r = 0.13$, $p < 0.01$). However, two other studies reported a non-significant relationship between duration of diabetes and medication adherence (Mahfouz & Awadalla, 2011; McCleary-Jones, 2011).

Most studies reported a significant relationship between duration of diabetes and SMBG but the direction of the relationship was not consistent. One on hand, among older adults with diabetes, Arcury et al. (2012) found that those who had diabetes less than 10 years were less likely to perform blood glucose monitoring than those who had diabetes for 10 years or more. In addition, McCleary-Jones (2011) reported a significant positive moderate relationship between duration of diabetes and blood glucose monitoring in African American with diabetes. Patients who had longer duration of diabetes also more frequently monitored blood glucose.

In contrast, two studies reported that patients with diabetes who had shorter duration of diabetes had more frequent SMBG than those who had longer duration of diabetes (Bruce et al., 2003; Mbaezue et al., 2010). Bruce et al. (2003) found that patients who had diabetes ≥4 years were less likely to perform blood glucose monitoring than those who had duration for less than 4 years (OR = 0.64; 95% CI 0.48-0.85, $p < 0.01$). Mbaezue et al. (2010) reported that patients who had diabetes > 10 years were less likely

to perform blood glucose monitoring than those who had diabetes for 10 years or less (OR = 0.33; 95% CI 0.11-0.99). However, Mahfouz and Awadalla's (2011) study of Egyptian patients with diabetes reported a non-significant relationship between duration of diabetes and blood glucose monitoring. In Thailand, no published reports of the relationship between duration of diabetes and blood glucose monitoring were found.

DURATION OF DIABETES AND GLYCEMIC CONTROL

Duration of diabetes was a significant predictor of A1C; patients with diabetes who had shorter duration of diabetes had better A1C among studies. Bruce et al. (2003) showed that patients with diabetes who had diabetes for less than four years had better A1C levels than those who had diabetes for ≥ 4 years. Osborn et al. (2009) reported that longer duration of diabetes and other variables such as younger age, using insulin, and race together significantly predicted higher A1C, accounting for 17% of variance in A1C levels.

Chiu and Wray (2010) found that duration of diabetes and the number of chronic diseases added to a multiple regression model that included age and race significantly increased the variance of A1C, explaining from 4.8% to 7.6%. Furthermore, Rogvi et al. (2012) reported that adding only duration of diabetes in multiple regressions with gender, age, and education, significantly accounted for 8.5% of the variance in the A1C levels in Danish patients with T2DM. Similarly, duration of diabetes was still a significant predictor of A1C after adjusting for gender, duration of diabetes, having insurance, patient's awareness, diabetes self-management, and health literacy in Chinese patients

with T2DM (Tang et al., 2008). Moreover, Osborn et al. (2010b) also found that longer duration of diabetes had a direct effect on higher A1C.

In a secondary analysis study, duration of diabetes was a significant predictor in all aged adults but in patients with diabetes who were ≥ 65 years, duration of diabetes was not a significant predictor of A1C (Chiu & Wray, 2010). Schillinger et al. (2002) reported that duration of diabetes became a non-significant predictor of A1C after adjusting for age, sex, race, education, insurance, language, social support, diabetes education, depression, treatment, duration of diabetes and education. Al-Khawaldeh et al. (2012) also reported a non-significant relationship between duration of diabetes and A1C.

In Thailand, three studies reported that duration of diabetes was a significant predictor of A1C (Jantaratiratikul, 2008; Wattanakul, 2012) and FPG (Promkong, 2006). Thai patients with diabetes of longer duration had worse glycemic control. Duration of diabetes and age were together significant predictors of A1C accounting for 6.1% of the variance in A1C levels (Wattanakul, 2012). In older patients with T2DM, Promkong (2006) demonstrated that duration of diabetes and other variables such as age, body mass index, physical activity, perceived self-management ability, family support accounted for 16% of the variance in plasma glucose level but only duration of diabetes and physical activity were significant predictors. In contrast, many studies reported a non-significant relationship between duration of diabetes and glycemic control (Chantrakul et al., 2007; Chotamara, 2006; Howteerakul et al., 2007; Pintong, 2005; Siriwattanapornkul, 2006; Srichana, 2005;Wuttisela, 2010).

Summary of Literature Review

Ongoing diabetes self-management is important for patients to achieve glycemic control and avoid diabetes-related complications. This literature review examined correlations between the modifiable factors (health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy), diabetes self-management, and glycemic control. This literature review showed that self-efficacy demonstrated the strongest correlations with diabetes self-management. However, several studies, though not all, demonstrated that patients with diabetes who had higher health literacy, higher diabetes numeracy, higher diabetes knowledge, and greater self-efficacy had better diabetes self-management and better glycemic control.

The mechanism of the relationships among modifiable and non-modifiable factors with diabetes self-management and glycemic control was not explicated in the literature review. Although there are increasing numbers of studies in diabetes self-management and glycemic control research findings are still inconsistent about relationship among factors relevant to diabetes self-management and glycemic control. The gap in knowledge is greater when focusing on older adults with T2DM. Most studies about diabetes self-management and glycemic control have been conducted with adults of all ages and include patients with both T1DM and T2DM, which might not produce clear information about the relationships among those factors on diabetes self-management and glycemic control in older adults with T2DM.

CHAPTER 3: METHODOLOGY

This chapter describes the methodology used to conduct the study. The purposes of this study were to 1) create a linguistically and conceptually equivalent version of the Diabetes Numeracy Test (DNT) that was appropriate for Thai culture; 2) evaluate the psychometrics of the Thai version of DNT (Thai-DNT) with data from Thai older adults with T2DM; and 3) explore the relationships among non-modifiable selected personal factors (age, gender, education level and duration of diabetes), modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management, and glycemic control in Thai older adults with T2DM. This chapter includes the description of the research designs and methods used in the study, including the development of the Thai-DNT, translation process, population and sample, research setting, protection of rights of human subjects, procedures of data collection, instruments, pilot studies, and procedures of data analysis.

Design and Methods of the Overall Study

The study was conducted in two phases. Phase 1 was composed of instrument adaptation, translation and preliminary testing of the Thai DNT. Phase 2 was a correlational study. The steps of Phase 1 and Phase 2 are presented in Table 3.1. In Phase 1, multiple steps were conducted to assure validity and reliability for the Thai DNT including defining the diabetes related-numeracy concepts relevant to Thailand,

instrument selection, forward translation, modifications of the translated DNT for cultural equivalence, consulting experts, cognitive interviews, and back translation to English.

In Phase 2, the revised Thai-DNT was administered with other validated questionnaires to investigate the correlational and predictive relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management behaviors, and glycemic control in Thai older adults with T2DM.

Protection of Rights of Human Subjects

Before beginning Phase 1 and Phase 2, the researcher obtained approval from the Institutional Review Board (IRB) at The University of Texas at Austin (Appendix E) and from the committees that protected the rights of the older adult patients with T2DM in their care. These committees acted in place of a local Thai IRB (Appendix D). However, the primary care units and the community hospital used as research settings were training sites for nursing students from Ramathibodi School of Nursing. The researcher obtained permission to collect data in those areas after approval from the Institutional Review Board (IRB) from the Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Thailand (Appendix F). Then, the researcher asked for permission to collect data by providing the approved document from both IRB committees to the Putthamoltol District Public Health Chief Officer and the Director of Putthamonthon Community Hospital, Nakhon Pathom Province, Thailand.

There is a monthly diabetes clinic that rotates between primary care units in Phutthamonton district. At the community hospital, there is diabetes care clinic from Tuesday to Thursday. The researcher did not contact the potential participants directly but the researcher met the potential participants after referrals from health care providers and health volunteers at each primary care unit; the participants also contacted the researcher who described the study's purpose, data to be collected, risks, benefits, rights to refuse participation and to withdraw, and provided contact information. The potential participants were told that their participation was voluntary and that their decision to participate in the study would not affect their health care services with any health care setting or organization or any relationships with health care providers, community leaders, or the researcher. The participants could deny or withdraw participation in the study at any time. The participants were assured that the researcher would keep participant information confidential; results of the study would be presented in the aggregate. The participants were informed that their names would not be on the questionnaires. The completed questionnaires were identified only with a participant identification number (ID) and were stored in locked and secure file. The master code list with names and participant ID was saved in a password protected computer file of the researcher. The researcher conducted data analysis with help from an advisor. Her personal computer was used for data analysis and there was no identifying names in the data file. In addition participants were told that there was no cost to participate in the study. The study posed a low risk of injury; potential risks were no more than occur in daily life. The researcher protected the participants' confidentially. Each participant

received compensation of $3 (estimated about 100 Thai Baht) at the time of interview for participating in the study, which included participating in the cognitive interview process or completing the surveys.

When the participants agreed to participate in the study, the participants were asked to consent to participating in the study at the time of the interview. The researcher or research assistants gave the participants a copy of the informed consent document, then the researcher read them the consent document and answered any questions before the participant gave written consent to participate in the study. The participants received a copy of obtained written consent for their own record.

Research assistants in the study were doctoral students in health care professional fields from Chulalongkorn University. The curriculum at Chulalongkorn University includes content on the Protection of Rights of Human Subjects in the Advanced Statistics and Research Design course that is required of all graduate health care professional students. The content was similar to content required by the UT IRB but specific to Thailand. The course addressed ethical principles of autonomy, confidentiality, privacy and their application to vulnerable populations; participants' rights to risks and benefits of the research; right to refuse or quit; right to privacy and confidentiality and ways to maintain confidentiality and privacy; and importance of not burdening the participant (e.g., allowing rest if fatigued). The researcher trained the research assistants on how to screen and enroll participants, collect the data, and maintain scientific integrity of the study. The researcher described the study's purpose, enrollment, risks, benefits, rights to refuse participation and participants' right to withdraw. The

researcher instructed the research assistants about the study protocol and answered any questions and observed the assistants in practicing screening, enrolling, and data collection before the research assistants interacted with potential participants. Each research assistant got $10/day for data collecting and received expense reimbursement for transportation.

Target Population, Setting, and Inclusion Criteria

The target population in the study was Thai older adults with T2DM, aged 60 or older. The minimum age was set at 60 years old because in Thailand, 60 years or more is the criterion to determine older age in which people who work for the government receive the retirement. The samples for both Phase 1 and Phase 2 were recruited from Klong YongI Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, and Mahasawat Tambon Health Promoting Hospital. For Putthamonthon Community Hospital, the data were only collected for Phase 2. All research settings were located in Putthamoltol District, Nakhon Pathom Province, Thailand.

Recently, primary care units in Thailand were changed to Tambon Health Promoting Hospital following by Public Health Ministry to upgrade the primary care unit to hospitals. The policy of Tambon Health Promoting Hospital is to increase responsibility in health care, such as increasing their focus on health promotion instead of the primary care units' past focus on disease treatment.

Tambon is a subdistrict in Thailand. Tambon Health Promoting Hospitals were established for every subdistrict. The administration of Tambon Health Promoting Hospitals is the responsibility of the District Public Health Chief Officer. Klong Yong I Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, and Mahasawat Tambon Health Promoting Hospital are under the administration of Putthamoltol District Public Health Chief Officer, Putthamoltol District, Nakhon Pathom Province, Thailand. After the Putthamoltol Distric Public Health gave permission to collect data for Tambon Health Promoting Hospitals, the approval document passed from Putthamoltol District Public Health office to Tambon Health Promoting Hospitals. For Putthamonthon Community Hospital, after approval from the UT IRB and the Faculty of Medicine Ramathibodi Hospital, Mahidol University, the researcher informed and provided the approved document from IRB to ask a permission to collect data from the Director of Putthamonthon Community Hospital and its diabetes clinic.

Phutthamonton, Nakhon Pathom province, Thailand, is a district in the East of Nakhon Pathom. Nakhon Pathom province is located in the central area of Thailand, approximately 50 kilometers from Bangkok, the capital city. The area of Nakhon Pathom province is 76,329 km^2, which is almost 50 times bigger than the Bangkok area. The total population is 26,138 of which 12,845 are males and 13,293 are females. The density is 204.64 person/ $km.^2$ Phutthamonton is one of six districts of Nakhon Pathom province and has 27 sub-districts and 121 villages (Amphoe Information Service, 2014). The researcher was able to access the communities and there were key persons available to facilitate data collection for the study.

The Participant Screening Sheet (Appendix H) was used to screen participants. If the potential participants did not meet the inclusion criteria or met some exclusion criteria, they were not enrolled in the study. Thai older adults with T2DM from the Phutthamonton district primary care units, and a community hospital were recruited using the following inclusion criteria: of Thai nationality aged 60 years or older, diagnosed with T2DM for at least one year, and able to hear and speak Thai language. The duration of diabetes of at least one year was used for inclusion criteria because it was assumed that Thai older adults with T2DM who participated in this study would receive diabetes education. Exclusion criteria for the study included participants who had a current physical or mental health problem that might interfere with making a decision, loss of memory, and participants who were hospital inpatients or residents of a skilled nursing home, assisted living facility, or prison.

Phase 1: Instrument Translation and Preliminary Testing

Phase 1 had seven steps that are listed in Table 3.1.

Table 3.1 *Steps of Phase 1*

Step	Process
Step 1	Define the diabetes related-numeracy concepts relevant to Thailand
Step 2	Instrument selection of diabetes-related numeracy
Step 3	Forward translation: a) Translate DNT from English to Thai independently by two bilingual nurses with doctoral education; b) Compare the original version and the two translated versions (the Thai-DNT A and B versions); c) Reconcile the Thai-DNT A and B versions to establish the 1st Thai-DNT
Step 4	Evaluate the 1st Thai-DNT for cultural equivalence and modify it to achieve cultural equivalence to establish the 2rd Thai-DNT
Step 5	Consult experts and incorporate experts' feedback to establish the 3rdThai-DNT
Step 6	Cognitive Interviews with 10 Thai older adults with T2DM: Conduct cognitive interviews with 5 people using the 3rdThai-DNT (A version), revise the 3rd Thai-DNT A from comments and suggestions to establish the 3rd Thai-DNT B, conduct cognitive interviews with the next 5 people using the 3rd Thai-DNT B, revise to establish the 3rd Thai-DNT C
Step 7	Back Translation to English: a) Back-translate 3rd Thai-DNT C from Thai to English by two new bilinguals, independently; b) compare the original version and the two back-translated versions (the 3rd Thai-DNT D and E versions); and c) reconcile the 3rd Thai-DNT D and E versions

STEP 1: DEFINING THE DIABETES RELATED-NUMERACY CONCEPTS RELEVANT TO THAILAND

This study used Rothman et al.'s (2006) definition of numeracy, "the ability to use and understand numbers in daily life" (p. 392). Diabetes-related-numeracy refers to the ability of patients with diabetes to understand and apply numbers in daily life to achieve glycemic control. Patients use numeracy skills to calculate carbohydrate intake, estimate food proportion, read and understand food labels, interpret blood glucose monitoring, appropriately take medications, and perhaps adjust insulin dose.

In Thailand, patients with diabetes are not routinely taught about carbohydrate intake and nutrition labels. Instead, most patients are given information about diet control in terms of food proportions. In addition, in daily life most Thai people buy food from fresh markets or prepare food by themselves and those foods do not come with nutrition labels. Therefore, calculating carbohydrate intake from nutrition labels is not common in Thailand at present. In addition, although self-monitoring blood glucose supplies and equipment are available, many Thai people with diabetes might not have access to them or cannot afford to perform blood glucose self-monitoring because expensive strips are not covered by governmental health insurance and reimbursements.

Food labels in Thailand became a concern of pubic health decades ago. Thailand has had code of Federal Regulations about food by the Food and Drug Administration since 2000 (Thai FDA, 2013) that specifies groups of food products that need to have nutrition labels. For example, food products that claim they are nutritious, use nutrition value to promote selling, and are sold for specific consumer group require food labels.

The FDA made an amendment for Federal Regulations to add information about food labels that cover a variety types of food products, such as food and drink products in packages. In addition, the food manufacturers need to provide nutritional information for food products to Thai consumers. In particular, all instant ready-to-eat food contained in packages need to show the new style of food label that consists of Guidelines for Daily Amounts (GDA) of nutrients for snacks including fried or baked potato, pop corn, cracker or biscuit, and wafers filled with cream. However, fresh fruits, vegetables, meat and food sold by restaurants and street vendors do not require food labels. Although food labels are not commonly used in Thailand, food labels are becoming more common. Therefore, Thai people with diabetes will need diabetes-related food label skills in the near future.

STEP 2: INSTRUMENT SELECTION OF DIABETES-RELATED NUMERACY: DNT

For an effective adaptation, the adapted instrument should measure the same concepts as the original instrument. The adapted instrument should incorporate the same aspects of the existing instrument such as the purpose, measurement framework, population, setting, time perspective, and conceptual bias (Waltz, Strickland, & Lenz, 2005). The DNT was an appropriate tool to adapt for Thai culture because the DNT concepts were the ones that were of interest to this study while other instruments, such as WRAT, assessed numeracy skills but the questions did not cover diabetes self-management. The literature review showed that the DNT had stable psychometric properties and measured the diabetes-related numeracy skills that patients with diabetes

need for diabetes self-management. The DNT assesses the patient's ability to apply a variety of math skills such as traditional math operations (adding, subtracting, multiplying, and dividing), numerical hierarchy, fractions and percentages, and multi-step calculations. Respondents were asked to solve the calculations common in diabetes self-management situations including interpretation of blood glucose levels, carbohydrate intake calculation, and medication dosages. The original DNT has 43-items that were developed by an expert panel and refined using cognitive response interviews (Huizinga et al. 2008).

The DNT has also been used cross-culturally with patients with diabetes who speak Spanish (White et al., 2011). Therefore, it should be possible to adapt the DNT to Thai culture. Adaptation of the DNT to be appropriate with Thai language and culture has advantages over developing a new instrument: adapting the DNT would cost less money and time, build from existing knowledge, and allow for systematic comparisons across time and space among different populations that would not be possible if developing a new instrument (Waltz et al., 2005).

STEP 3: FORWARD TRANSLATION

Using the instrument with people of a different culture might expose a combination of language and cultural differences that impact the usefulness of the information generated from the instrument (Hendrickson, 2003). Achieving cultural equivalence and functional equivalence of the translated instrument depends on the translation process. Therefore, the translation process in this study was not merely a

word-by-word translation. Rather, the translation used a symmetrical translation approach that focused on cultural appropriateness of the items and established as much conceptual equality as possible between the source language instrument and the target language instrument. Forward translation and back translation methods were used to achieve a valid and reliable for instrument for use in Thai people with diabetes (Brislin, 1970; Jones, Lee, Phillips, Zhang, & Jaceldo, 2001). The permission to translate the DNT to Thai and to modify it as needed was obtained from Mimi Huizinga, M.D., MPH, Assistant Professor of Medicine, Vanderbilt University (Appendix C).

The aim of forward translation was to achieve linguistic equivalence. Two bilingual translators with health care backgrounds independently translated the full DNT from English into Thai. One of the two bilingual translators finished a doctoral degree in Nursing, in the United States and the other was a doctoral candidate in Nursing in the United States. They were instructed about the purpose of translation and the methods used in translation. The translators independently translated the original DNT English version to the Thai language. Then, the researcher reviewed the two separate Thai versions of DNT translation (called the 1st Thai-DNT A and B version). The ambiguous items were revised after reaching consensus between the researcher and the translators. This process resulted in the 1st Thai-DNT C version.

STEP 4: MODIFY THE FIRST THAI-DNT FOR CULTURAL EQUIVALENCE

Because the DNT was developed in the United States, the questions pertain to Western culture. Therefore, the Thai-DNT items were adjusted and adapted to fit with

Thai culture. For example, one item in the DNT asked about the serving size of potatoes, which are not commonly eaten in Thailand; this item was reworded to ask about a rice serving or another common Thai food. In summary, during this process, the researcher modified and added items of the 1st Thai-DNT, C version and created the second version Thai-DNT (the 2rd Thai-DNT).

STEP 5: CONSULTING EXPERTS

This step was used to answer Research Question 1: What is the content validity of Thai Version of the Diabetes Numeracy Test?

Five Thai experts were consulted to evaluate the 2nd Thai DNT for use with Thai older adults with T2DM (see Appendix G for the invitation letters). These experts were a nurse specialist who worked with patients with diabetes, one faculty of nursing who was an expert in geriatric care, one faculty of nursing who was an expert in nutrition and worked with patients with diabetes, one faculty of nursing with expertise area of diabetes, and one faculty of nursing who was expert in community health care. The experts were told the purpose of developing the Thai-for Thai older adults with T2DM.

The experts were asked to rate the content and cultural relevance of each item on a four-point scale (1 = totally irrelevant content and 4 = extremely relevant content). The expert suggestions to improve items rated below 3 or 4 would be used to modify the questionnaire. The result was the third version Thai DNT (the 3thThai-DNT).

The scores were used to calculate the Content Validity Index (CVI), an indicator of content validity, for each item and the total instrument (Lynn, 1986; Streiner &

Norman, 2008). Two types of CVI were analyzed including the CVI for items (I-CVI) and the CVI for scales (S-CVI). I-CVI was computed by the number of experts giving a rating of either 3 or 4 to the item divided by the total number of experts. The I-CVI should not be less than 0.78 (Lynn, 1986). S-CVI was computed by the sum of scores of I-CVI divided by the number of items. The S-CVI should be 0.80 or higher to indicate good content validity (Davis, 1994; Polit & Beck, 2004).

STEP 6: COGNITIVE INTERVIEWS

Cognitive interviews used to evaluate the items and format of the 3rd Thai-DNT to gain a better understanding of how respondents perceive the instrument (Polit & Hungler, 1995). A convenience sample of ten Thai older adults with T2DM who met the inclusion criteria were recruited from the research settings.

The researcher announced the cognitive review portion of Phase 1 at the research settings such as Klong YongI Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, and Mahasawat Tambon Health Promoting Hospital, Putthamoltol District, Nakhon Pathom Province. The staff at the Tambon Health Promoting Hospitals contacted the potential participants to describe the study. Potential participants who were interested in participating in Phase 1 of the study were referred to meet the researcher to be screened against the inclusion criteria. The possible participants were also directly contacted the researcher if they were interested in participating in the study. The Participant Screening Sheet (Appendix H) was used to screen and recruit participants. If the potential participants did not meet the inclusion criteria or had some

exclusion criteria, they were not recruited in the study. Participants provided their written informed consent and received a copy of the consent form to keep for their own. The researcher read the Thai-DNT to each and every participant in a one-on-one face-to-face interview lasting about 30-45 minutes conducted in a private area in the clinics or other location of the participant's preference. The participants were able to views a copy of survey while the researcher read the questions and documented the participant's answers on the survey. There was no audio-recording of this process. The participant's responses were hand written. A calculator was provided to participants if they wanted to use it to calculate answers for the DNT (Huizinga et al., 2008). The researcher read each item and asked the participants to answer the following questions about the items:

1. What did you think this item means? Or, what was your understanding of this question?
2. What did you do to find the answer to the question?
3. If this question was not clear, what suggestions did you have to make it clearer?
4. Was the item response format appropriate and was it easy to understand? If not, what it should look like?

Each participant received $3 or a gift of equal value at the time of interview for participating in the study. Participants who participated in the cognitive interview were not invited to participate in Phase 2. The researcher interviewed the five Thai older adults with T2DM. Then, their feedback was used to modify the 3thThai-DNT (A version)

in consultation with experts. This step resulted in 3thThai-DNT B version and tested in the same process with five different Thai older adults with T2DM. Finally, the 3thThai-DNT B version was revised and became the 3thThai-DNT C version.

STEP 7: BACK TRANSLATION

Next, two different bilingual translators with health care professional backgrounds who had no knowledge of the wording in the English version of the instrument, independently back-translated the 3thThai-DNT C version to the English language. In this last step of the translation process, the researcher made a table to compare the original full DNT, the 3thThai-DNT, C Thai language version, and the 3thThai-DNT, C in English language that was back translation from Thai language to English language. Using the table, the researcher determined the Thai-DNT items that were culturally appropriate for Thai older adults with T2DM and how equivalent the versions were in the content and concepts.

Phase 2: Correlation study

Phase 2 gathered evidence of the psychometric properties (test-retest and internal consistency reliability, construct validity) of the final version of the Thai-DNT and investigated the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, diabetes related-numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management, and glycemic control in Thai older adults with T2DM.

RESEARCH DESIGN

A descriptive correlational, cross-sectional design was appropriate to use for correlation analysis because the purpose of Phase 2 was to investigate the relationships among variables (Polit & Beck, 2006). A correlational design was also appropriate when the independent variables such as age, gender, education, duration of diabetes, and other factors could not be or would not be manipulated (Polit & Beck, 2006). The disadvantage of a correlation study is that the relationships among variables cannot be attributed to a causal relationship (Polit & Beck, 2006).

A cross-sectional study was used for data collection at one point of time. This design is appropriate to find the relationships among variables at fixed time (Polit & Beck, 2004). In addition, cross-sectional designs are appropriate for time-related purposes within the circumstances such as having a strong theoretical framework guiding the study (Polit & Beck, 2004). In this study, the literature review showed evidence and logical reasoning of the relationships between independent variables and outcomes. Also, the theoretical framework of this study guides the analysis of the results. In addition, the cross-sectional design is cost-effective and practical.

SAMPLE SIZE

Determining the appropriate sample size is important for ethical and statistical reasons (Duffy, Munro, & Jacobsen, 2005). The sample size needed for Phase 2 was at least 165 participants. The sample size was determined based on the statistical analysis to be used in Phase 2, which was multiple regression to investigate the predictive

relationships among four non-modifiable selected personal factors (age, gender, education, and duration of diabetes), four modifiable variables (health literacy, diabetes related numeracy, diabetes knowledge, and self-efficacy), diabetes self-management, and the outcome glycemic control.

Green (1991) offered a formula of sample size calculation for regression analysis in which the minimum required sample size to test R^2 in a regression model should be more than 50 + 8k, where k equals the number of independent variables. This formula assumes a medium –sized relationship between variables. In this study, there were nine independent variables. Therefore, the minimum sample size would be at least 122 participants. However, calculating sample size from Green's formula had some weaknesses such as assuming a medium effect size among variables and the formula did not clearly show about the power level of the test in calculating sample size.

Power analysis is a more accurate way to estimate sample size that is based on probability standards to reject the null hypothesis and accept the existing relationship among variables in the study. Power analysis involves four parameters of statistical inference that function together. They are power level, significance criterion, sample size, and effect size (ES). If three parameters are fixed, the other is a consequence outcome (Cohen, 1988). Power level is the probability to reject a false hypothesis. For this study, power level was set at 0.80, which is an acceptable power level in general (Duffy et al., 2005). The significance level, or alpha, representing the probability of making a Type I error (Cohen, 1988), was set at 0.05 in this study. The effect size is the strength of the correlations (Cohen, 1988). Cohen identified a small effect size as $f^2 = 0.02$, a medium

effect size as $f^2 = 0.15$, and a large effect size as $f^2 = 0.35$. In this study, effect sizes were estimated from a literature review that investigated similar relationships between variables in this study (see Table 3.2). The effect size (f^2) was calculated by Effect Size Calculator for Multiple Regression software, available from http://www.danielsoper.com/statcalc3/calc.aspx?id=5 (Soper, 2014). The calculated effect sizes from previous studies were small to large with mean of effect size of 0.30, range from 0.075 to 0.562. When the effect size was set at $f^2 = 0.3$, with alpha level at 0.05, and power level 0.80, the sample size needed for Phase 2 was 62 participants. However, the calculated effect sizes from previous studies were problematic for this present study because the effect sizes from those studies represented multiple correlations among factors adjusted for covariate variables and some of those factors were not investigated in present study (e.g., marital status, diabetes education, employment, race, and diabetes treatments).

Therefore, it was appropriate to use the smallest effect size 0.075 from literature review in McCleary-Jones's (2011) study to calculate sample size for this study. When the effect size was set at small $f^2 = 0.075$, significant alpha level at 0.5, and power level 0.8, the sample size need was 165 participants, which was closer to that obtained using Green's formula. Therefore, the sample size need for this study was at least 165 participants who were Thai older adults with T2DM.

Table 3.2

Effect Sizes of Related Variables

Studies	Relationships	Effect Size
Powell et al. (2007)	Recent hemoglobin A1C, and health literacy adjusting for education, age, gender, race, and diabetes treatment	$f^2 = 0.370$
McCleary-Jones (2011)	Health literacy, diabetes knowledge, self-efficacy, and exercise self-care	$f^2 = 0.075$
McCleary-Jones (2011)	Health literacy, diabetes knowledge, self-efficacy, and general diet self-care	$f^2 = 0.562$
Bohanny et al. (2013)	Health literacy, diabetes education, employment, and self-efficacy	$f^2 = 0.157$
Siwina (2003) (Thai)	Diabetes knowledge, gender, age, education, marital status, family type, attitude to diabetes, social support, and diabetes self-management	$f^2 = 0.377$
Wattanakul (2012) (Thai)	Diabetes self-efficacy, Buddhist values, risk perception, social support and diabetes self-management	$f^2 = 0.266$

PROCEDURES FOR DATA COLLECTION

The study protocol was approved by the Institution Review Board (IRB) for Protection of Human Subjects at the University of Texas at Austin, the United States, the Faculty of Medicine, Ramathibodi Hospital, Thailand, NaKhon Pathom Public Health District for three primary care units and the Director of a primary hospital outpatient diabetes clinic in Phutthamonton, Thailand.

The researcher announced Phase 2 of the study at the research settings: Klong Yong I Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, Mahasawat Tambon Health Promoting Hospital, and Putthamonthon Community Hospital, Putthamoltol District, Nakhon Pathom Province. There is a monthly diabetes clinic that rotates between Tambon Health Promoting Hospitals as above in Putthamoltol District. In addition, there is a diabetes clinic from Tuesday to Thursday every week at Putthamonthon Community Hospital. The researcher and research assistants went to these diabetes clinics. The staff at each research setting and health volunteers at each clinic assisted with identification of the potential participants and described the study. Potential participants who were interested in participating in Phase 2 of the study were referred to meet the researcher or research assistant to be screened against the inclusion criteria. The Participant Screening Sheet was used to screen participants. If the potential participants did not meet the inclusion criteria or met some exclusion criteria, they were not enrolled in the study. The possible participants were also able to directly contact the researcher if they were interested in participating in

the study. Participants who participated in the cognitive interview were not invited to participate in Phase 2.

The researcher or research assistant described the study's purpose, data to be collected, risks, benefits, participants' rights to refuse participation and to withdraw, and provide contact information. The participants were able to ask questions about the study before written informed consent was obtained. In the consent process participants were informed that they might be invited to complete the Thai-DNT a second time to help gather information about the questionnaire's stability. Participants provided their written informed consent and received a copy of the consent form to keep for their own records. The researcher or research assistant read the questionnaires (Thai-version) that included the Personal Information Sheet, the Three Levels of Health Literacy Scale (TLHLS), the Diabetes Numeracy Test (DNT), the General Knowledge of Patients with Diabetes (GKPTD-T), the Diabetes Management Self-Efficacy Scale (DMSES) and the Summary Diabetes Self-Care Activities (SDSCA) to each and every participant in a face-to-face interview lasting about 45-60 minutes in a private area in the clinics or other location of the participant's preference. Face-to-face interviews were costly because the interviewer and the respondents needed to devote time to collecting data, however, it was the best way to collect data because the face-to-face interview decreased the likelihood of a low response rate and decreased missing data. Moreover, face-to-face interviews were also appropriate because some respondents had vision or movement problems or low education levels that would impact their ability to read or fill out the questionnaire

themselves (Polit & Beck, 2006). The participants were able to view a copy of survey while the researcher or research assistant read the questions and documented the participant's answers on the survey. A calculator was provided to participants if they wanted to use it to calculate answers for the DNT (Huizinga et al., 2008).

After data collection was completed, for test-retest reliability of the Thai-DNT, the convenience sample of 30 participants who were available to meet for a second face-to-face interview lasting 20-40 minutes were recruited. The time interval between the first and the second interview was at least two weeks. Each participant received $3 at the time of interview for participating in the study.

INSTRUMENTATION

Five instruments were used to collect data: the Personal Information Sheet, Thai-The Three Level of Health Literacy Scale, Thai-DNT, General Diabetes Knowledge-Thai version, the Thai Version of the Diabetes Management Self-Efficacy Scale (T-DMSES), and the Summary Diabetes self-management Activities (SDSCA)—Thai version. The investigator obtained permission from the instruments' developers to use the instruments before data collection (Appendix C). The variables and the instruments used to measure them are presented in Table 3.3 and the psychometric properties of the instrument used in the study are shown in Appendix B.

Table 3.3

Operational Variables Used in the Study

Variables	Indicators
Age	Personal Information Sheet - self-reported number of years since birth
Gender	Personal Information Sheet - self-reported as male or female
Education	Personal Information Sheet - self-reported received formal education level
Duration of Diabetes	Personal Information Sheet - self-reported number of years since diagnosis with diabetes
Health Literacy	Thai Three Level of Health Literacy Scale
Diabetes Related Numeracy	Thai Diabetes Numeracy Test
Diabetes Knowledge	General Diabetes Knowledge (Thai language)
Self-Efficacy	Thai Diabetes Management Self-Efficacy Scale (T-DMSES)
Diabetes self-management	Thai Revised Summary Diabetes Self-management Activities (SDSCA)
Glycemic control	Glycosylated Hemoglobin A1C from chart review

The Personal Information Sheet (Appendix I) was used to record a participant's demographic and clinical data including gender, age, educational level, occupation, self-

report of family income, other medical conditions, number of years since receiving a diagnosis of diabetes, diabetes treatments, and most recent hemoglobin A1C from medical record.

The Three Levels of Health Literacy Scale (TLHLS) (Appendix J) was developed by Ishikawa et al. (2008) in Japan to evaluate the functional, critical, and communication types or levels of health literacy. The TLHLS measures the participants' assessment of their own health literacy in comparison to the TOFHLA and REALM, which measure health literacy directly and more objectively by assessing participants' reading and comprehension skills. The instrument consists of 14 items measured with a four-point response scale (1 = never to 4 = often) with higher scores indicating higher health literacy. The original TLHLS was used to measure health literacy in a sample of 138 Japanese outpatients with diabetes. The internal consistency of each subscale of the health literacy questionnaire was satisfactory (Functional $\alpha = .84$, Critical $\alpha = .77$, and Communication $\alpha = .65$). Content validity was supported by exploratory factor analysis and construct validity was supported by correlations between health literacy and other measures (Ishikawa et al., 2008). However, Ishikawa et al did not designate scores into low to high levels of health literacy like the TOFHLA and REALM did.

The TLHLS was translated into Thai using cultural appropriate methods and back-translated and checked by a health literacy expert to create a version that is culturally appropriate for Thai people while it maintains the same concepts in the English language version (Chontichachalalauk, unpublish 2014). The TLHLS-Thai version has 14 items including 5 items measuring functional health literacy, 5 items measuring critical

health literacy, and 4 items measuring communication health literacy. Possible scores are from 14 to 60. A higher score indicates higher health literacy. The instrument was tested in 10 Thai people and evaluated in cognitive interviews to verify content validity. The Thai TLHLS was tested in a pilot study of 31 adult Thai patients with diabetes living in the United States. The internal consistency of the functional, communicative, and critical health literacy subscales was excellent ($\alpha = 0.933$, $\alpha = 0.899$, and $\alpha = 0.871$, respectively; Chontichachalalauk, 2014).

The Diabetes Numeracy Test (DNT)- Thai version developed in Phase 1 and then was used in Phase 2, see Appendix K. The original DNT, developed by Huizinga et al. (2008), is a 43-item measure of the diabetes related numeracy skills that patients with diabetes need for diabetes self-management. After the DNT-43 was tested in a convenience sample of 398 patients with diabetes, the split sample analysis produced a shortened 15 items version (Huizinga et al., 2008). The DNT-15 was translated into a Spanish version called the DNT-15 Latino and validated with a sample of 144 Latinos with diabetes (White et al., 2011). Both English versions of the DNT and the DNT Latino showed good reliability and validity (Huizinga et al., 2008; White, et al., 2011). The DNT-43 was developed from an a priori hypothetical model, supporting concept validity. The DNT-43 showed relationships with expected outcomes include education ($\varrho = 0.52$), income ($\varrho = 0.51$), literacy (REALM, $\varrho = 0.54$), math skills (WRAT, $\varrho = 0.62$), and diabetes knowledge (DKT, $\varrho = 0.71$), indicating construct validity. The Kruder-Richardson (KR) internal consistency reliability of DNT was excellent with a coefficient of 0.95 (Huizinga et al., 2008).

The DNT-15 items measured five domains of diabetes self-management: 3 items on nutrition, 1 item on exercise, 3 items on blood glucose monitoring, 1 item on oral medications, and 7 items on insulin administration. The DNT-15 also demonstrated good reliability and construct validity. The KR-20 of the DNT-15 in the development sample and in confirmation sample was 0.90 and 0.89, respectively. The DNT-15 was highly related to the full DNT (Huizinga et al., 2008).

The DNT-15 Latino version was developed and tested in 144 Latinos with diabetes and showed adequate internal reliability with KR-20 of 0.78 and demonstrated construct validity with significant relationships with expected outcomes such as health literacy ($\varrho = 0.291$), general numeracy ($\varrho = 0.5$), education ($\varrho = 0.361$), and income ($\varrho = 0.270$; White et al., 2011).

The General Knowledge of Patients with Diabetes (GKPD-T), Appendix L was developed by Wongwiwatthananukit et al. (2004) and was used to assess general diabetes knowledge and follow up with patients who received diabetes education. The investigators claimed that in Thailand, prior to the development of the GKPD -Thai scale, diabetes knowledge did not show a relationship with diabetes control. It is possible that existing diabetes knowledge measurements in Thailand were not valid to demonstrate relationships between diabetes knowledge and diabetes outcomes. The GKPD-Thai consists of 40 items generated from a literature review. The answer choices consist of true, false, and unknown. Eight persons of an expert review panel provided evidence of content validity. A pilot study of the instrument was tested in 15 patients with diabetes, then, the study was tested for psychometric properties in 753 patients with diabetes from

21 hospitals in a variety of areas in Thailand. Item analysis reduced the instrument to 21 items. The questionnaire consists of 4 parts following 1) general knowledge of diabetes and diagnosis 5 items; 2) diabetes related-complications 5 items; 3) self-care on daily basis and on sick day 6 items; and 4) taking medication to control diabetes 5 items. The 21 items demonstrated good internal consistency with Kruder-Richardson 20 of 0.81 and the difficulty index of items ranged from 0.18 to 0.87 (Wongwiwatthananukit et al., 2004). In addition, Wattanakul (2012) examined factors influencing diabetes self-management behaviors in patients with T2DM living in rural Thai communities using the GKPD-Thai with 26 Thai healthy adults near Chicago, in the United States. Wattanakul reported the Cronbach's alpha was 0.848 and the difficulty index of the items ranged from 0.31 to 0.88.

The Diabetes Management Self-Efficacy Scale (DMSES), Appendix M, was developed by Bijl, Poelgeest-Eeltink, and Shortridge-Baggett (1999) in the Netherlands. The DMSES is self-reported 20-item questionnaire that assesses the respondents' confidence in their ability to follow multiple domains of diabetes self-management such as using medication, controlling diet, physical exercise, and other aspects needed to control the blood glucose levels. Five experts in diabetes and four self-efficacy experts were asked to evaluate the original 42 items for relevance and clarity. The CVI of the 42 items was adequate but somewhat low at 0.78, so Bijl et al. deleted items until a satisfactory CVI was obtained for 20 items. The internal consistency of the overall scale in 94 adults with T2DM was 0.81 and the test-retest reliability with a five week interval was adequate at $r = 0.79$, $p < 0.001$ (Bijl et al., 1999).

The DMSES was translated into Thai (Iamsumang, 2009) and was tested in 209 Thai older adults from a variety of parts of Thailand, all with T2DM. The initial Thai-DMSES had 20 items with a 5-choice Likert response scale (1 = definitely not; 2 = probably not; 3 = maybe yes/maybe no; 4 = probably yes; and 5 = definitely yes) and possible scores ranged from 20 to 100; higher scores indicate higher self-efficacy. There was semantic equivalence between the original English version and Thai version with an Intra-class Correlation Coefficient (ICC) of 0.88. The scale-level CVI was 0.96 and the item-level CVI was 0.80 and higher, indicating acceptable content validity. Further psychometric testing using exploratory and confirmatory factor analysis suggested the T-DMSES has three subscales using 19 items. Iamsumang (2009) reported evidence of the convergent validity of the Thai-DMSES with a moderate correlation of Thai-DMSES scores with the Thai-General Self-Efficacy-Scale ($r = 0.36$, $p < 0.01$). There was high internal consistency with Cronbach's alpha of 0.95 and test-retest reliability with ICC of 0.69 (see Appendix B).

The Summary of Diabetes Self-Care Activities (SDSCA), Appendix N, was developed in 1994 but updated in 2000 It is self-report questionnaire of diabetes self-management behaviors covering general diet, specific diet, exercise, blood glucose monitoring, foot care and smoking (Toobert, Hampson, & Glasgow, 2000). SDSCA data from seven different studies was reviewed for reliability, validity and normative data (N = 1.988 people with diabetes). The original SDSCA had adequate internal and test-retest reliability, and showed validity and sensitivity to change. The revised SDSCA consists of a core set of 11 items from the original SDSCA with simplified scoring. Toobert, et al.

(2000) added items to assess foot care and smoking because these items were essential for patients with diabetes.

The revised SDSCA assesses patients' diabetes self-management activities during the past 7 days with 17 items covering aspects of healthy eating activities (5 items), physical activities (2 items), medication adherence (3 items), blood glucose monitoring test (2 items) and foot care (5 items) and uses a 7-point Likert scale; possible scores range from 0 to 7. The inter-item correlations ranged from 0.11 (specific diet) to 0.80 (exercise) with average inter-item correlations of 0.47, indicating an acceptable level. Test-retest correlations over 3-4 months were moderate, with mean r = 0.40, ranging from r = -0.05 (for medications) to 0.78 (for glucose testing, Toobert et al., 2000).

The revised SDSCA was translated into Thai and tested in 197 adults Thai with T2DM by Wattanakul (2012). The Cronbach's alpha of the SDSCA-Thai was 0.752. The Cronbach's alpha of each scale was 0.952 for general diet, 0.588 for specific diet, 0.624 for exercise, 0.459 for blood glucose testing, 0.947 for medication adherence, and 0.547 for foot care. For this study the general diet, specific diet, exercise, medication adherence, and foot care subscales were used, but the blood glucose testing subscale was not used.

Glycosylated hemoglobin (A1C) is a physiological indicator of diabetes control. Red blood cells live in the body for about three months. A1C is a measure of glucose attachment to the hemoglobin protein that carries oxygen in red blood cells. A1C represents a person's average level of blood glucose over the past three months and reflects the glycemic control level of an individual with diabetes (Michael, 2011). In this study, participants' A1C was taken from chart review at primary care units and a

community hospital as a secondary data. The most recent measure of A1C was used, all within one month of the survey administration.

Data Analysis for Phase 2: Correlation study

DATA MANAGEMENT

All data were entered into SPSS program version 21. To prepare for data analysis, the data were cleaned and double-checked by the researcher and one other person to detect data entry errors. One person read data from questionnaires and the other checked data on files via SPSS program. This study had little missing da ta because the researcher collected data by face-to-face interviews with all participants. Assumptions for the statistical analyses such as normal distribution, outliers, homogeneity of variance, multicollinearity of variables, independence, and linear relationships were checked before data analysis. The level of significance, alpha, was set at 0.05 for all data analyses.

DESCRIPTIVE STATISTICS

Descriptive statistics were used to describe the sample characteristics and major variables using frequencies, percentages, means, ranges, and standard deviations. Cronbach's alpha reliability test was conducted to test internal consistency for all questionnaires.

DATA ANALYSIS FOR RESEARCH QUESTIONS 2-9

Research question 2: What is the evidence for construct validity of the Thai-DNT?

Pearson correlation coefficient was used to explore the bivariate relationships between the Thai-DNT and variables expected to correlate with diabetes numeracy, such as education, health literacy, and diabetes knowledge.

Research question 3: What is the evidence for internal consistency and test-retest reliability of the Thai-DNT?

A Cronbach's alpha was used to evaluate the internal consistency reliability of the Thai-DNT. The range of Cronbach's alpha value is between 0 to 1, with higher values indicating better internal consistency (Polit & Beck, 2004). Item analysis was evaluated for inter-item and item to total correlations. Items with corrected item total correlations < 0.3 or > 0.8 would be evaluated to determine if they could be deleted from the scale, remain, or be revised to enhance higher value of Cronbach's alpha and avoid redundancy.

The intra-class correlation coefficient (ICC) from SPSS program version 21 was used to examine the stability (test-retest reliability) for the participants who completed the Thai-DNT twice. The single measure ICC was used. Higher ICC estimation was interpreted to mean the instrument was more stable (Yen & Lo, 2002). The ICC should be more than 0.4, the level of ICC < 0.40, indicating low stability (Fleiss, 1981).

Research question 4: What is the level of health literacy? And

Research question 5: What is the level of diabetes-related numeracy?

Descriptive statistics were calculated for research questions 4 and 5 to determine the level of health literacy and diabetes-related numeracy including scores, summary scores, mean, standard deviation, and percentage.

Research question 6: What are the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management and glycemic control in Thai older adults with T2DM?

Pearson correlation coefficient and point biserial correlation were used to explore the bivariate relationships between the variables.

Research question 7: Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) contributed significantly to the prediction of diabetes self-management after controlling for the effects of non-modifiable selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?

Hierarchical multiple regression analysis was used because multiple regression analysis allowed the variables to be entered into the models in a sequence based on logic and the theoretical framework to test the effects of main independent predictors on outcome. The personal factors (age, gender, education, and duration of disease) were

entered as a block in Step 1. Then, health literacy, diabetes related-numeracy, diabetes knowledge and self-efficacy were entered as a block in Step 2.

Research question 8: Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) and diabetes self-management contributed significantly to the prediction of glycemic control after controlling for the effects of non-modifiable selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?

From the hierarchical multiple regressions analysis in research question 7, diabetes self-management was entered in Step 3.

CHAPTER 4: RESULTS

This chapter describes the findings of this study, which was guided by a conceptual framework depicting the relationships between non-modifiable selected personal factors and modifiable factors diabetes self-management, and glycemic control among Thai older adults with T2DM. The findings of the study are presented in two phases: Phase 1 involved translation and preliminary testing of the Thai DNT and Phase 2 was a correlation study to gather evidence of the psychometric properties (test-retest and internal consistency reliability, construct validity) of the final version of the Thai-DNT and examine the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, diabetes related-numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management, and glycemic control in Thai older adults with T2DM.

Phase 1: Instrument Translation and Preliminary Testing

Phase 1 involved translation and preliminary testing of the Thai-Diabetes Numeracy Test-Thai DNT. Translation consisted of seven steps: Step 1: "defining the diabetes related-numeracy concept;" Step 2: "instrument selection;" Step 3: "forward translation;" Step 4: "modify the Thai-DNT for cultural equivalence;" Step 5: "consulting experts;" Step 6: "cognitive interviews;" and Step 7: "back translation to English". Step 1 and Step 2,were described in Chapter 3. Therefore, the five steps from Step 3 to Step 7 are presented in the following sections.

STEP 3: FORWARD TRANSLATION OF THE DNT

The original English language version of the DNT contains 43 items. Two bilingual translators with health care backgrounds independently translated the full DNT from English into Thai. The aim of forward translation was to achieve linguistic equivalence. The method used was a symmetrical translation focused on the cultural appropriateness of the items aimed at obtaining conceptual equality between the English and Thai instruments. The researcher reviewed the accuracy of the two separate Thai translations, referred to as the 1st Thai-DNT A and B. Minor discrepancies were found. For example, in item 2 of the 1st Thai-DNT A: the phase, "if you have ½ cup of pasta…" was incorrect because the same phase in the original English version is "if you have 1 cup of pasta…". The error was corrected. Other issues arose from the fact that multiple Thai words can sometimes be used for a single word in English. For example, "eat" may be represented in Thai as "กิน" and "รับประทาน". The translator of the 1st Thai-DNT A version used the word "กิน,"which is an informal expression of eating while the translator of the 1st Thai-DNT B version chose "รับประทาน", which is an academic term. In other situations, one translator chose transliterated words and the other chose roughly equivalent Thai words such as "ชิพ" (chips) versus "มันฝรั่งทอด" (fried potatoes). Another source of discrepancy is the use of similar but semantically different Thai words to translate the word "points" to something more like "unit" "หน่วย" (unit) and "จุด" (point). Some number values are also translated in different ways. For example, half value was represented such as ½, 0.5, or the word "half." In item 7 of the original DNT English version the phase,

"ate 1 and ½ cups…" could be translated as "กินหนึ่งถ้วยครึ่ง" (ate one and half cup), "กิน 1 ½ ถ้วย" (ate 1 ½ cups), or "กิน 1 ถ้วยครึ่ง" (ate 1 cup and half). In addition, the chronological conceptions of time introduced translation differences. For example, in item 10 the phase "at 2:00 PM…" may use the words "บ่าย 2 โมง…" (afternoon 2 pm…) or "14 น...." (14:00…). Thai people have the chronological conceptions of time to tell the time in communication that might be different from one person to others. The researcher discussed with the translators and made a decision to use the informal words or "talking language" that seem more suitable for Thai older adults in the target communities. Moreover, the researcher consulted with experts who have relevant experience with the study topic and with research participants to identify the most appropriate expressions of words, numbers, and time to use in the cognitive interviews. Eventually, the 1stThai-DNT A and B versions were reconciled to establish the 1st Thai-DNT C version.

STEP 4: MODIFYING THE FIRST THAI-DNT FOR CULTURAL EQUIVALENCE

The DNT is used to evaluate diabetes related-numeracy in people with diabetes that need to understand and apply a variety of math skills in their daily self-management. However, the DNT was developed in a Western environment that differs in language and culture from Thailand. The original DNT was developed and tested in a group of patients with type 1 and type 2 diabetes, aged from 18 to 80 years (mean = 54.2 years) but the target population in this study was Thai older adults with T2DM, age ≥ 60 years. In addition, 83% of the test population of the original DNT had attained a high school level of education, while the Thai sample was expected to have a lower level of education or

even no education. The target population of this study was people aged ≥ 60 years, meaning people who were born prior to 1955 (B.E. 2498). In 1935 (B.E. 2478) Thailand passed the first Education Act, which required Thais to complete four years of primary school. However, the occurrence of World War II in which Thailand was involved in the years 1942-1945 (B.E. 2485-2488) was believed to have limited formal educational opportunities for this generation (Legislative Institutional Repository of Thailand, 2015). Therefore, for the target group of this study care was taken to adapt the DNT to the comprehension level of and to be cultural appropriate for Thai older adults.

The original English version of the DNT consists of 43 questions in five domains: nutrition, exercise, blood glucose monitoring, oral medications, and insulin (see Appendix O for the original full version of DNT-43 items). Each domain consists of the items presented in Table 4.1.

Table 4.1

The Domains of the Original English Version of DNT 43 Items.

Domain	**Question number**
Nutrition	1-9
Exercise	10-13
Blood Glucose Monitoring	14-17
Oral Medications	18-22
Insulin	23-43

Nutrition Domain

The nutrition domain of the original version of DNT consisted of 9 questions to evaluate the ability of patients to understand and properly apply food labels, food proportion, and carbohydrate count. Currently in Thailand, food labels are available for pre-packaged foods. Most Thai older adults, particularly those in smaller communities, often buy freshly prepared foods from farmers' markets and street vendors where food labels are not provided. Health care providers in Thailand stress the importance of using food labels for self-management in people with diabetes. Food label training is provided in diabetes education classes but these classes are not required for patients with diabetes. As a result, food labels are often misunderstood and not commonly used. Dietary patterns are also different in Thailand. Some of the foods in the original DNT are not commonly eaten in Thailand: potatoes, pasta, and carrots, for example. Thai older adults do not often eat snack foods like potato chips or processed foods like canned pineapples. Nutrition-related vocabulary may be somewhat foreign to the target group. Thai older adults might not clearly understand words such as "carbohydrate" and "calories" because the Five Food Groups were not taught to this generation.

In Thailand, the Bureau of Nutrition, the Department of Health, and the Ministry of Public Health use the Food-Based Dietary Guideline to promote health for Thai people, including those with chronic illnesses such as diabetes (Sirichakawan & Suthasworavut, 2012). The Nutrition Flag is used to present the strategy for proper eating in daily life. The goal is to introduce the general Thai population to the benefits of proportion, quantity, and food variety. It was designed to be easy to understand by using

graphic pictures, including familiar Thai foods, choosing easy language, and avoiding scientific terms. The recommendations on the flag are based on Thai-specific research that has determined the appropriate daily needs of Thai people, considering food behaviors, and socioeconomic factors, as well as using units of containers commonly present in Thai households (Sirichakawan & Suthasworavut, 2012). The Nutrition Flag is shaped as a vertical pennon flag (or upside down pyramid), which represents the food groups, and their corresponding proportions suitable for consumption each day. In addition, it is worth noting that the categories of food such as vegetables, fruits, and milk might be grouped differently from the Nutrition Flags of other countries, accounting for Thai dietary preferences. General food terms are favored over scientific terms. For example, "rice" or "flour" is used instead of "carbohydrate." The portion sizes are chosen to be appropriate for Thai households. For example, portions appear as "8-12 ladles of rice per a day" and "1-2 glasses of milk per a day". The Nutrition Flag consists of the groups rice (such as rice, sticky rice, noodle, rice vermicelli, potatoes, and bread); vegetables and fruits; milk and meat; and oil, sugar, and salt.

Because the target study group does not commonly utilize food labels, with expert consultation, three of the nine original DNT questions in the Nutrition domain were eliminated from the 1st Thai-DNT, C version. They were replaced by four questions that focused instead on portion control. These additional questions also aim to evaluate the respondent's math skills and maintained the concept of diabetes related-numeracy. The first new question is "A medium sized ripe mango is equal to 2 portions of flour. If you want 1 portion of flour, how many mangoes do you have to eat?" The second question is

"the Nutrition flag recommends an intake of 8-12 ladles a day of foods in the rice and flour group for general Thais. If you have 3 ladles for breakfast, 3 ladles for lunch, how many ladles would you have for dinner to make it 8 ladles in total a day?" The third question is "The suggested intake of vegetables is 6 ladles per day, divided into 3 meals equally. How many ladles of vegetable per meal will you have?" The last question provides a picture and a table of food proportion and asks the question, "You have 2.5 portions of Thai rice noodles and 8 pieces of pineapple of suitable sizes. How many portions of flour are equal to the rice noodles plus pineapple?"

The remaining six questions in the nutrition domain were adapted from their original DNT counterparts in order to fit with Thai culture and the target population of this study. The questions about food labels were adjusted to use a simplified food label limited to serving size and servings per container. Western food and food labels were replaced with Thai food and Thai food labels. For example, rice appears instead of potatoes and soybean instead of pasta. In some questions, the researcher inserted photos of foods to help older adults with T2DM better understand food proportion calculations. In item 8 of the original DNT, the sample of fruits and vegetables was changed to Thai foods, and the color pictures of those foods were inserted to better illustrate the question. The units of measurement were adapted. For example, a "ladle of rice" is used instead of a "cup of potatoes".

Exercise Domain

The exercise domain of the original DNT has 4 items, which evaluate ability to count carbohydrates and administer insulin for exercise. The researcher kept all four

questions of the exercise domain virtually the same as in the original version of DNT but some statements were adjusted for the Thai version. For example, item 10 of the original DNT stated "When you lift weights, you need to eat 20 grams of carbohydrate within 15 minutes after you finish. If you finish weight training at 2:00 PM, by when should you eat the carbohydrates? The researcher kept the concept of asking time from the original DNT but the phrase "lift weights or weight training" was adjusted to "walk for exercise" because it is not common for Thai older adults to lift weights. The word "carbohydrates" was also changed to "crackers" or "flour" depending on the context of each question because many Thai older adults might not understand the word "carbohydrate." The researcher was concerned about item 12 in the original DNT that stated, "Before working in the yard you are to decrease your meal insulin by half, if the meal and yard work are two hours or less apart. You usually take 8 units for lunch. If you eat lunch at 12:30 and are going to cut the grass at 2:00 PM, how much insulin should you take?" This question is long and is not practical for Thai people because most patients with diabetes, especially older adults, do not adjust insulin doses by themselves in this manner. However, the researcher decided to keep this question in the Thai DNT adaptation and seek expert opinion in the next step.

Blood Glucose Monitoring Domain

The Blood Glucose Monitoring domain has four items that evaluate the understanding and interpretation of blood glucose values and hemoglobin A1C as well as the administration of SMBG. As with the exercise domain, the researcher kept all four questions of the blood glucose monitoring domain virtually the same as in the original

DNT but some questions were adjusted for the Thai version. For example, item 15 asked the respondent to estimate the A1C value when the average blood sugar was given. The original version of the DNT does not provide a caption for the picture that accompanies the question but the researcher added a caption to summarize that the picture below this question compared A1C and average blood sugar values. The original item 17 states, "you test your blood sugar 3 times per a day. You purchase a prescription of 50 strips on March 5th. Of the dates below, by when will you need to buy new strips?" This question asks the respondent about when to buy new strips but it requires multiple calculation steps. One must calculate how many days 50 strips will last. That number must be overlaid onto the calendar to answer the question. The number of "50 strips" was changed to "30 strips". However, the bottles of the strips were sold with 25 or 50 strips and the researcher believed that might make confuse patients about the quantity of strips from a new bottle. Therefore, the question was changed to "A doctor asks you to test your blood sugar level 3 times a day. On March 5th, you have 30 test strips. When do you have to buy some more test strips?" This question did not mention about purchasing a new bottle of strip but mention that the patients already had strips and when they needed to purchase for new strips.

Oral Medications Domain

The Oral Medications domain in the original version of DNT consists of 5 items that evaluate knowledge of oral medication administration for people with diabetes. The health care systems in Thailand and the United States are different. At present, the primary care units in Thailand have regularly scheduled appointments for patients to visit

a doctor or a nurse practitioner at a diabetes clinic within a one to three month period depending on the patient's conditions. After visiting the doctor, patients would receive enough medicine to last until the next visit. The questions in the original DNT asked the patients about the time to refill prescriptions by mail. In addition, the drug "repaglinide" referenced in item 18 is not commonly used to treat diabetes in Thailand. Although metformin is commonly prescribed for patients with diabetes many patients do not know it by that name because it is not the Thai name. Moreover, when a doctor prescribes pills to the patients, the prescriptions will have complicated instructions. For example, item 19 of the original DNT that states, "…Take 1 tablet with supper each night for the first week. Then, increase by 1 tablet each week for a total of 4 tablets daily with supper…. How many tablets should you take with supper each night the second week?" To produce an appropriate 1st Thai-DNT, C version the researcher used the generic phrase "pills to decrease the blood sugar" when referring to medication for diabetes treatment rather than introducing potential confusion with specific medication names.

Some of the original DNT questions in this domain were considered inappropriate for Thai older adults with T2DM under the health care systems in Thailand and were cut from the Thai version. They were replaced with questions based on oral medication administration for the target population that retained the goals of the original DNT with respect to time of dosage. For example, item 18 of the original version of DNT states, "You have a prescription for repaglinide 1 mg pills. The label says, 'Take 2 mg of repaglinide with breakfast, 1 mg with lunch and 3 mg with supper.' How many pills should you take with supper?" This question evaluates the patient's understanding of time

and medication dose. However, most health care providers in Thailand would specifically indicate the number of pills patients need per meal. The patients do not often need to perform calculations based on the milligram content of medication. This question is replaced by the question "If you have several underlying diseases and need to take the following drugs;

half a tablet of a medication to lower blood sugar before breakfast

a tablet of a medication to lower blood sugar after breakfast and dinner

a tablet of a blood pressure lowering medication after breakfast

a tablet of a cholesterol lowering medication before bedtime

Only after breakfast, how many tablets do you have to take?

This question is less complicated and evaluates the administration of medication in terms of both dosage and time.

Items 20-22 in the oral medication domain of the original DNT evaluate the number pills patients have and their refill frequency. Those questions were replaced by three new questions in the Thai DNT adaptation. The first new question is "You have to take half a tablet of a medication to lower blood sugar before your breakfast everyday. If you will be away for 2 weeks, how many tablets, at least, should you prepare?" The second new question is, "You have to take 1 tablet of a medication to lower blood sugar after breakfast and dinner. You see your doctor once a month and get enough pills for a month. How many tablets of this drug should you get? (There are 30 days in a month.)". The last new question is, "If you take a tablet for diabetes twice a day, how many days will you spend to take 60 tablets?" In addition, one question about time was added to say,

"You have to take a tablet of a of a medication to lower blood sugar half an hour before your breakfast. If you have breakfast at 8:00 am, when should you take this drug?".

Insulin Domain

The Insulin domain in the original version of the DNT consists of 21 items that evaluate the ability of patients with diabetes to administer and adjust their insulin dose in a variety of situations such as for a medical procedure, exercise, and based on carbohydrate intake. The original version of the DNT devoted many questions to the insulin domain. The original DNT administration included adults of all ages with diabetes and included both type 1 and type 2 diabetes, for which insulin administration might be a common treatment. The target population of this study is Thai older adults who were aged ≥ 60 years old with T2DM. There are a few patients in this group who have had the education to adjust insulin by themselves. However, most Thai people with diabetes administer insulin following only doctor recommendations. They might be able to adjust insulin dosage according to insulin administration guidelines after checking their blood glucose, but not based on the quantity of food intake or exercise. In addition, it is impractical for Thai patients with diabetes to calculate carbohydrate intake for every meal. For example, item 28 of the original DNT gives the example that you "take 1 unit of insulin for every 7 grams of carbohydrate you eat." The question then asked how much insulin to take when you eat 49 grams at breakfast. To answer this question, the patients need to know exactly how much carbohydrate they eat per each meal. Thai people in the study group might not able to calculate how many carbohydrates they get in each meal due to factors discussed previously (e.g., low education levels, lack of food labeling).

The English names of medications used from the original DNT version would probably be unknown to Thai older adults with diabetes in this study. Also, Thai older adults bought foods from street food vendors and fresh food market that did not provide food label. Therefore, the revised questions refer to "insulin injection" instead the commercial name of insulin. In the 1st Thai-DNT twelve questions relating to carbohydrate intake and adjusting insulin dose were deleted (item 28-30 and item 35-43). In the remaining questions the general term "insulin" was used instead of the commercial names of insulin such as NPH, Lispro, and Glargine. The resulting Thai-DNT (the 2rd Thai-DNT) better covers self-management behavior for the target population of Thai older adults with diabetes in this study.

STEP 5: CONSULTING EXPERTS

Five Thai experts who are health care professionals and bilingual were invited to evaluate the content validity of the second version Thai-DNT (the 2rd Thai-DNT). This step addresses Research Question 1: What is the content validity of the Thai Version of the Diabetes Numeracy Test? The expert panel consisted of one assistant professor in nursing with expertise in gerontology, one assistant professor in nursing with expertise in diabetes, one associate professor in nursing with expertise in nutrition and diabetes, one associate professor in nursing with expertise in the communities and chronic illness, and one advanced nurse practitioner in a diabetes clinic.

The 2rd Thai-DNT has 33 items consisting of 5 domains including nutrition (10-items), exercise (4-items), monitoring blood glucose (4-items), oral medication (6-items),

and insulin (9-items). Through discussion in person with experts, the 2rd Thai-DNT was determined to be an appropriate instrument to measure diabetes-related numeracy skills for Thai older adults with T2DM. The experts rated the content and cultural relevance of each item on a four-point scale (1 = totally irrelevant content to 4 = extremely relevant content) for all 33 items. The Content Validity Index (CVI), which consists of the CVI for items (I-CVI), and the CVI for scales (S-CVI) were calculated. The I-CVI of each item ranges from 0.6 to 1. The I-CVI should not be less than 0.78 (Lynn, 1986). However, it was found the I-CVI of two items were below 0.78 including item 1 and item 5 of the 1st Thai DNT. Item 1 of the 1st Thai DNT asked about food label. The experts were concerned that it might be difficult to understand for Thai older adults. Item 5 of the 1st Thai DNT asked about how much blood sugar would increase if the patients had 20 grams of carbohydrates. The experts were concerned that older adults would not know what carbohydrate was, and then, how much carbohydrate 20 grams was. Therefore, these two items were improved in next process. The S-CVI is 0.93, which is good: the S-CVI should be 0.80 or higher to indicate good content validity (Davis, 1994; Polit & Beck, 2004). The 2rd Thai-DNT was revised based on the experts' comments and suggestions as discussed in the following sections. The 2rd Thai-DNT shows content validity as a result of these revisions.

Nutrition Domain

Experts were concerned about the questions regarding food labels such as item 1, which were rated with I-CVI of 0.6. At present, health care providers give information about food label to Thais with diabetes. However, the level of comprehension is

unknown, especially, in older adults. Older adults might not know or understand nutrition-related vocabulary such as "carbohydrate" and "calories" because those were not part of the primary education provided to that generation of students. Moreover, some older adults might not have received education at all. Some experts were concerned that these challenges impacted the validity of the instrument. The experts suggested that the Thai DNT contains questions based on food labels but they should be limited to simple reading of food labels and the questions that follow should not be complicated. An expert in gerontology suggested that the researcher should clarify what the objective is of asking about food labels. If the objective is to evaluate food label comprehension, the term "carbohydrate" might be replaced with "sugar" because older adults are more familiar with "sugar" than "carbohydrate". Sugar is also categorized under carbohydrates on the food label. It is important for patients with diabetes to know about controlling sugar consumption too. Although sugar was not used to calculate insulin adjustments, it is worth knowing how much sugar they should eat per day. Therefore, one question of sugar calculation in food labels was added: " how many grams of sugar will you get if you drink half a box of fruit juice?" The experts were concerned about food label detail that required a lot of data to be read. They suggested deleting unnecessary information that was not required to answer to the question. The eventual consensus was that there is value in evaluating food label comprehension in Thai older adults.

The issue of food proportion was the target of some comments and suggestions. Some experts commented that the term "nutrition flag" should not appear in questions because older adults might not know this term and it also made the questions much

longer. For example, item 8 had a statement about the recommendation of dietitians to patients. In Thailand, health care providers (i.e., nurses, doctors, and public health workers) gave patients with diabetes information about how to eat correct food proportions. Therefore, the phase might be adjusted to say “health care professional” instead of “dietitian.”

Item 5 of the original DNT was the other item that rated an I-CVI of 0.6. It stated, “1 gram of carbohydrate elevates your blood sugar level 3 points. How much will 20 grams of carbohydrate elevate your blood sugar?” In the adaptation of the Thai DNT, this item was modified to “1 gram of food in the rice-flour group elevates your blood sugar level 3 points. How much will 20 grams of food in rice-flour group elevate your blood sugar?” Although the word “carbohydrate” was modified to “foods in rice-flour group”, one expert who had expertise in nutrition commented that this question was not meaningful in daily life. The question evaluates the patient’s numeric skills but patients might have no idea how much is 1 gram of food in the rice-flour group. This expert suggested identifying the type of food and using the quantity of a typical food container in Thai household. Therefore, this question was changed to “If a gram of cooked rice can increase 3 units of blood sugar level, how many units of blood sugar level can be increased by a ladle of cooked rice if a ladle of cooked rice is 55 grams?"

Exercise Domain

All four items of the exercise domain from the original version of DNT were retained in the Thai DNT but some wording was adjusted to be culturally appropriate for Thai older adults. In this process, the experts’ comments were as follows. In items 10-12,

the word “carbohydrate” should instead identify a specific type of Thai snack or food. Therefore, “corn on the cob” was used instead of “carbohydrate” in items 10 and 11 because corn is a common food in the Thai communities. Using a specific type of Thai food such as corn would help older adults to better understand the question. In addition, one expert suggested moving item 12 to the insulin domain because the question asked about insulin adjustment by exercise. In item 13, an expert in nutrition suggested that the item should specify the physical size and flour (carbohydrate) content of the cracker in question. Therefore, in the final adaptation of the Thai DNT, the statement “a piece of cracker of 2.5 inches in size contains 5 grams of flour “ was added in item 13. A phrase in item 10, “lift weights or weight training” was replaced by “walk for exercise” to fit with Thai older adults in the communities.

Blood Glucose Monitoring Domain

The experts provided comments for four items in the blood glucose monitoring domain. One expert was concerned about the word “hemoglobin” in item 15 because it was spelled as a transliterated word after adaptation to Thai. It is a medical term that older adults with diabetes might not understand. Therefore, the word “hemoglobin” was replaced by the term ”A1C” (translated to Thai) which is the average cumulative amount of blood sugar in the last 3 months.

Oral Medication Domain

The experts rated all of the items in the oral medication domain for I-CVI greater than or equal to 3. However, the experts suggested deleting item 20 because the question did not evaluate calculation skills. Item 20 stated “a doctor tells you to take a pill for

lowering blood sugar, 1 pill before breakfast and 2 pills before dinner," and asks, "How many pills do you take before breakfast?" Since the answer is provided directly in the text of the question it merely assesses reading comprehension, which is not the target of this study. The experts expressed no concerns for the remaining questions in the oral medication domain.

Insulin Domain

Experts agreed with the researcher's recommendation to delete items related to insulin dose self-adjustment when based on the patient's activities or carbohydrate. This is not a common practice for Thai older adults with diabetes. One expert commented that items 23 and 24 should use photos of an insulin syringe or insulin injection pen. Another expert was of the opinion that the commercial name of products should not be in the questionnaire because it could be interpreted as bias toward the manufacturer.

Eventually, this process established the 3rd Thai-DNT with eleven items in the nutrition domain, three items in the exercise domain, four items in the blood glucose monitoring domain, five items in the oral medication domain for lowering blood sugar, and ten items in the insulin domain. The next step was to perform a pilot study of cognitive interviews to evaluate the Thai DNT in a live research setting.

STEP 6: COGNITIVE INTERVIEWS

Approval was given by the Department Review Committee (DRC) at the University of Texas at Austin, School of Nursing, the Institutional Review Board (IRB) at The University of Texas at Austin, and the Faculty of Medicine at Ramathibodi

Hospital, Mahidol University, Thailand and written permission was received from the Director of NaKhon Pathom Public Health Primary Care Units, Thailand before the pilot study for cognitive interviews were conducted. The pilot study consisted of two interviewing sessions at primary care units that are the research settings. Convenience sampling was used to recruit five Thai older adults with T2DM, aged 60 or older. The participants provided written consent before participating in the study at the time of the interview. A structured interview to administer the 3rd Thai-DNT (A version) was conducted by the researcher. Although a calculator was provided for the participants, most did not know how to use it.

Four of the five participants were female, mean age 61.6 (SD = 2.30), with ages ranging from 60-63 years. Four participants received primary school education; one had no education. The mean duration of diabetes was 12 years (SD = 4.12), with durations ranging from 7-18 years. Four of the participants took only oral medication for lowering blood sugar. One participant took both oral medication and insulin injection. The mean duration of the cognitive interviews of the 3rd Thai-DNT (A version) was 50 minutes (SD = 11.73), ranging from 30 to 60 minutes.

Comments from the pilot participants were collected. In general, the participants complained that the number of questions was too large and that many of the questions were too long. Some participants said that they had forgotten the beginning of the question by the time the end of the question was reached. The researcher needed to repeat the questions. In addition, the pilot participants commented that some of the

questions were too complicated. Each domain is evaluated in detail in the following sections.

Nutrition Domain

In the nutrition domain, only one of five participants was able to answer the questions about food labels. This participant took both oral medications to lower blood sugar and insulin injections. The participants who were not able to answer the food label questions commented that they did not know or understand terms such as "carbohydrate" and "energy." In addition, they also complained that the food label had a lot of detail such as numbers, percentages, and the letters were very small, rendering them difficult to read and comprehend. Two of the five participants indicated that a nurse at their primary care units had provided information about food labels but they did not understand how to read it. Two of the five said that they never knew about food labels. They often bought food or fruits from fresh markets or street vendors in their neighborhood and ate fresh fruits.

In response to the participants' comments, the experts suggested the addition of a short statement to explain a little bit more about carbohydrates or give an idea about what foods contain carbohydrates for the food label questions related to carbohydrates. The DNT was modified to include a clarification for the word "carbohydrate" in the text of the questions. For example, "…how many grams of carbohydrates (which is in the group of fiber, flour and sugar) will you get?" For two questions that used photos of food composed with the question text participants commented that they did not understand and suggested that the pictures should be reformatted to indicate the portion size of the foods under (or near) the picture to explain how much of the food equals one portion of flour

(carbohydrate). The two questions were reformatted accordingly. For example, in item 9, the caption, “2 ladles of fresh vegetable,” was added to its picture. The remaining questions in the nutrition domain did not receive significant comments.

Exercise Domain

For the exercise domain, one of five participants was not able to answer the question about time due to an inability to read watch time. Participants commented that item 13 was too difficult to understand. Item 13 stated, “You have to have crackers containing 5 grams of flour every 30 minutes during your walk for exercise. A piece of cracker of 2.5 inches in size contains 5 grams of flour. If you take a one hour walk, how many pieces of crackers do you have to have?” The participants did not understand why they needed to have crackers when they exercise. The researcher asked the participants to clarify what they understood and how the question could be adjusted. The researcher modified the question with the participants' assistance. A short statement was inserted to help patients better understand how having crackers related to exercise. Two participants told the researcher that people in their communities often said “half hour” instead of “30 minutes.” Therefore, the statement of item 13 was changed to, “When you take a walk, you will have food in rice and flour group such as crackers for energy. You have to have crackers containing 5 grams of flour every half an hour during your walk. If you take a one hour walk, how many pieces of crackers do you have to have? (a piece of cracker of 2.5 inches in size contains 5 grams of flour.)”

Blood Glucose Monitoring Domain

For the blood glucose monitoring domain none of the pilot participants used the information from the table that was provided to answer item 15. All participants understood that they needed to determine the answer by looking at the numbers in the table to correlate the average cumulative amount of blood sugar in the last 3 months (A1C) with blood sugar level. However, the participants commented that when they looked at the table, they did not understand what the table told them. Only one of the five participants who took both oral medications to lower blood sugar and insulin injections knew the term "A1C." The other participants indicated that when they went to see a doctor, they received only information that their sugar was low or high. Two of the five participants knew their recent blood sugar value and could interpret that it was in a low or high range. Three of the five participants knew the value of their target blood sugar. Therefore, based on the participants' comments and suggestions, a statement was added to item 15 (item 14 of final version of Thai DNT): "In the table below, the left column is the average cumulative amount of blood sugar in the last 3 months (A1C) compared with the right column,...". An arrow was also added at each side of the table between A1C of 6% and blood sugar of 120 for better understanding.

Oral Medications Domain

In the oral medication domain, item 18 stated "You have to take a tablet of a drug lowering blood sugar half an hour before your breakfast. If you have breakfast at 9.00 am, when should you take this drug?" Many participants gave the information that they got up early at 4-5 am every day, and that their breakfast was finished before 9:00 am.

Therefore, they had already taken medication and had moved on to their daily activities by 9:00 am. The researcher talked with many Thai older adults with diabetes about what time they got up in the morning and had breakfast. Eventually, the time “9:00 am” in this question was adjusted to 8:00 am. One participant said that she did not have a regular time for breakfast and sometimes did not have breakfast at all. Other participants had regular breakfast schedules. Therefore, this question is worth keeping in the Thai DNT. Item 20 stated, “You have to take half a tablet of a drug lowering blood sugar before your breakfast everyday. If you will be away for 2 weeks, how many tablets, at least, should you prepare?” One participant said that she did not calculate how many pills she needed to prepare when she would be away for 2 weeks. She just took them all. However, four of five said that they understood the question well and correctly answered this question. The participants understood the rest of the questions in the oral medications domain.

Insulin Domain

In the insulin domain, only one participant was using insulin injection. He said that he understood the questions but indicated that the DNT questionnaire was very long with many questions. Some questions covered similar information. For example, two questions regarding syringe measurement could be combined into a single question. Three of the questions related to adjusting insulin according to doctor's instructions. He stated that if people understand the instructions, they could answer all three questions because they were essentially the same with different numbers. The researcher asked the other four participants who did not take insulin to answer the insulin domain questions to gauge general understanding of the questions. Three of the four could not answer all of

the insulin related questions. They told the researcher that they did not know the term "insulin" and they did not know the syringe. The final participant understood the questions but answered incorrectly by guessing a syringe of 100 units when the correct answer was a syringe of 50 units. She did not take insulin but she understood the questions of insulin and could provide an answer. Based on the participants; responses the three redundant items in the insulin domain were deleted from the 3rd Thai DNT.

The researcher also discussed with health care providers at the primary care units about insulin administration for older adults with T2DM. The researcher was informed that most patients who used insulin injections under the responsibility of the primary care units would be referred to a community hospital because those patients were determined to have uncontrolled diabetes or complicated diabetes conditions. Patients with diabetes in these communities did not adjust their insulin dose following physical activities. Eventually, the 3rd Thai DNT A version was revised based the participant's feedback combined with the experts' suggestions, which resulted in the 3rdThai DNT B version.

Three of five participants in the second round of cognitive interviews were female, mean age 67.6 (SD = 4.83), with ages ranging from 61-72 years. Four of the five participants received primary school education while one had middle school education. The mean duration of diabetes was 15.20 years (SD = 10.94), with durations ranging from 3-30 years. The mean duration of the cognitive interviews of the 3rdThai-DNT (B version) was 42 minutes (SD = 5.7), ranging from 35 to 50 minutes.

The 3rdThai DNT B version consisted of ten items in the nutrition domain, three items in the exercise domain, four items in the blood glucose monitoring domain, five

items in the oral medications domain, and five items in the insulin domain. In the nutrition domain, only one participant was able to correctly answer item 1 to calculate carbohydrates but the participant could not answer item 2, which required the addition of carbohydrates from two food labels, and she did not how to find the calories. Two participants said that they did not know carbohydrates and calories while one participant said he never cared about food labels and he did not drink soybean in a package. Item 12 stated, " Half a corn on the cob has 15 grams of flour. How many corn do you need for 30 grams of flour?" This item was deleted from final the version of Thai DNT in response to an expert's comment that this question was more relevant with nutrition domain. However, in the nutrition domain already had the questions that ask the participants to calculate carbohydrate intake. Because this question was similar to other question in nutrition domain, it was deleted. The participants understood the other domains such as blood glucose monitoring, oral medications, and insulin.

The pilot study for the cognitive interviews in this study did not thoroughly test the instrument's reliability because the sample size of each phase was very small. The purpose of pilot study was to test the comprehensibility using cognitive interviews and to refine the Thai DNT for cultural appropriateness with Thai older adults with diabetes. The participants' responses and verbal feedback were incorporated into a final revision of the Thai DNT instrument. The Thai older adults with T2DM who participated in the pilot suggested revising the content slightly for better understanding and cultural orientation. Therefore, the cognitive interview process produced the 3rdThai DNT C version (Final

version). This final version has 25 items. The number of items for each domain is presented in Table 4.2

Table 4.2

The Domains of the Final Version of the Thai DNT 25 Items (Final Version)

Domain	**Question number**
Nutrition	1-9
Exercise	10-11
Blood Glucose Monitoring	12-15
Oral Medications	16-20
Insulin	21-25

In addition, to evaluate the diabetes-related numeracy skills of Thai older adults with T2DM in their self-management in daily life, the final version of the Thai DNT covered a variety of math skills, correlating with the original DNT as much as possible. The math skills needed for each item in the Thai DNT (final version) are presented in Table 4.3.

Table 4.3

The Math Problem Type of Items of the Thai DNT (Final Version)

Math Problem Type	**Question number**
Addition	3, 19, 22
Subtraction	3
Multiplication	1,13, 20, 23
Division	2, 5, 8, 9, 24
Fractions/Decimals	7, 17
Multi-step mathematics	4, 6, 11, 18
Time	10,
Numeration/Counting/Hierarchy	12, 14, 15, 16, 21, 25

STEP 7: BACK TRANSLATION

Two different bilingual translators blindly and independently back-translated the 3rdThai DNT C version to English, called the 3rdThai DNT C English version. The two bilingual translators were chosen for their health care professional backgrounds from two institutes of language in Thailand: The Academic Development and Service Department, Chulalongkorn University Language Institute and Chalermprakiat Center of Translation and Interpretation, Faculty of Arts, Chulalongkorn University. The researcher compared the two back-translations of the 3rdThai DNT C version. There was no discrepancy between the two versions.

Appendix O is a table showing the comparison of the original full DNT to the 3thThai-DNT, C version and the 3thThai-DNT, C English version. The comparison of the original DNT English version to the back-translation version was done to evaluate the semantic equivalence and comparability of concepts, not by comparing item by item because the Thai-DNT version was adapted for Thai language and cultural appropriateness. The original DNT proved difficult to use without adaptation for the target population in this study.

In the nutrition domain, the final version of the Thai DNT has nine items, equivalent to the original DNT in English, but the questions related to food labels were deleted and replaced by food portion questions. In addition, the selection of foods and the units of measure were changed to be appropriate for Thai older adults.

In the exercise domain, two items from original DNT were deleted from the final Thai DNT because one item did not relate to exercise and the other was not practical for older adults with T2DM. The remaining questions were adjusted to be appropriate for Thai older adults such as changing the activities "lifting weights" to "walk for exercise." Therefore, the final Thai DNT contains two questions to evaluate diabetes-related numeracy in the exercise domain.

For the blood glucose monitoring domain, all four question from the original DNT were retained in the final version of the Thai DNT; however, some words and phases were adjusted.

The oral medications domain contains five questions in the final Thai DNT, equal to the original DNT. However, four new items were introduced because of health care

system differences between Thailand and the United States so that the administration of refilled medication is not the same.

In the insulin domain, there are five items to assess diabetes related numeracy in in the final version of the Thai DNT while the original DNT contains twenty-one items. The reasons for deleting the items in the Thai DNT were outlined in detail previously. To recall an example, many of the original items asked the respondents to calculate an insulin dose following physical activities or to determine proper carbohydrate intake in grams. These calculations are not relevant for Thai older adults with T2DM. The overall length of the interview session was another consideration that favored the removal of redundant questions.

Phase 2: Correlation Study

The following sections cover characteristics of sample, descriptive statistics of major variables, psychometric testing of the instruments, correlation analysis, and multiple regression. The findings of each research question are described following the order of the variables appearance in the conceptual model.

THE SAMPLE CHARACTERISTICS

A sample of 170 Thai older adults with T2DM was recruited from Klong Yong 1 (39 patients, 22.9%), Klong Yong 2 (78 patients, 45.9%), Mahasawat (11 patients, 6.5%), and from a community hospital in Phutthamonthon (42 patients, 24.7%). The sample characteristics are presented in Table 4.4.

More than half of the Thai older adults with T2DM who participated in Phase 2 were female, with a mean age of 67 years. Most of the older adults with T2DM were in early late adulthood (aged 60-69 years old). The large majority completed a primary school education while 12% had no formal education. Almost 80% were married or living together; most lived with a spouse, significant other, children, or grand children, on average there were about four other people in the house. More than half of older adults in this study were still working but almost half had very low family income per month at < 5,000 Baht (US 148 dollars, calculated exchange rate at 33.8 baht/dollar). Almost all participants had the universal coverage scheme for health care cost follow by health policy of Thai government.

Three quarters had diabetes for one to 10 years with mean of nearly 9 years. Most had a hemoglobin A1C value in the target range for glycemic control (A1C < 7.5%, identified as the target range for older adults with diabetes, ADA, 2014) with mean of A1C of 7.27% but the range of A1C varied widely, from 4-19%. The vast majority of the participants received oral medication treatment for the control of diabetes while only a very few participants received insulin treatment. Not many participants smoked. Most knew of the existence of food labels but rated their understanding in using food labels at a medium level. Moreover, among the people who knew of food labels, half of them seldom or never consulted food labels when making food purchase decisions.

It is noted that in this study, only 15 participants in the sample of 170 received insulin treatment, which is not considered to be a significant sample for comparison.

Therefore, Thai DNT items 21-25 were not included in the reliability analysis, correlation analysis, and multiple regression analysis.

Table 4.4

The Sample Characteristics (N = 170)

Characteristics	*N*	*%*	*Mean*	*SD*	*Range*
Gender					
Male	67	39.4			
Female	103	60.6			
Age (years)			67.82	.49	60-86
60-64	61	35.9			
65-69	52	30.6			
70-74	29	17.1			
75-79	15	8.8			
≥ 80	13	7.6			
Education					
No formal education and unable to read and/or write	8	4.7			
No formal education but able to read/write	13	7.6			
Primary school	136	80			
Middle school	4	2.4			
High school/Vocational training	6	3.5			
Bachelor's degree or above	3	1.8			
Marital status					
Married/ Living together	133	78.2			
Separated/Divorced/ Widowed	32	18.8			
Never married	5	2.9			

Table 4.4 (continued)

The Sample Characteristics (N = 170)

Characteristics	*N*	%	*Mean*	*SD*	*Range*
Living arrangement					
Living with spouse/significant other/children/grandchildren	163	95.9			
Living alone	5	2.9			
Other such as friends	2	1.2			
Number of other people at house			3.74	2.14	0-14
Employment status					
Housework/do not work	72	42.4			
Farmer/Agriculture	47	27.6			
Merchandizer/self-business	25	14.7			
Employed for wages	22	12.9			
Other such as retired	4	2.4			
Family income/month					
< 5,000 Baht	84	49.4			
5,000-10,000 Baht	57	33.5			
>10,000-15,000 Baht	14	8.2			
>10,000-15,000 Baht	15	8.8			
Health care cost payment					
Universal coverage scheme	151	88.8			
Reimbursement from the government welfare scheme	13	7.6			
Self-paid	6	3.5			

Table 4.4 (continued)

The Sample Characteristics (N = 170)

Characteristics	*N*	%	*Mean*	*SD*	*Range*
Duration of diabetes (years)			8.95	6.38	1-30
1-10	126	74.1			
11-20	36	21.2			
21-30	8	4.7			
Hemoglobin A1C (%)			7.27	1.92	4-19
A1C < 7.5 %	116	68.2			
A1C ≥7.5 %	54	31.8			
Diabetes treatment					
Only diet	2	1.2			
Oral medication treatment	153	90			
Insulin shot 1 or 2 time a day	4	2.4			
Insulin shot 3 or more times a day	1	.6			
Both oral and insulin treatment	10	5.9			
Current smoking					
No	152	89.4			
Yes	18	11.6			

Table 4.4 (continued)

The Sample Characteristics (N = 170)

Characteristics	*N*	%	*Mean*	*SD*	*Range*
Know about food label					
No	38	22.4			
Yes	132	77.6			
-If yes, understanding in using food label* (n = 132)			4.19	3.07	1-10
-Frequency of making a decision to buy food by consulting food labels* (n = 132)					
Never	54	40.9			
Seldom	15	11.4			
Sometime	22	16.7			
Often	24	18.2			
Always	16	12.1			

Participants' other health problems and comorbidities are shown in Table 4.5. More than half had vision problems that made it difficult to read (n = 95, 56%) and among them 71.6% need to wear glasses when they read. Few had difficulty hearing (n = 22, 13%), with only three needing a hearing aid.

Table 4.5

Other Health Problems and Comorbidities (N = 170)

Health Problems	n	%
Have difficultly reading due to vision problem		
No	75	44.1
Yes	95	55.9
If yes, wearing glasses while reading (n = 95)		
No	27	28.4
Yes	68	71.6
Have any difficulty hearing		
No	148	87.1
Yes	22	12.9
If yes, wearing a hearing aid (n = 22)		
No	19	86.4
Yes	3	13.6
Comorbidities*		
Hypertension	129	75.9
High cholesterol	91	53.5
Neurological problems	40	23.5
Cardiovascular diseases	12	7.06
Other (i.e. stroke, asthma, thyroid problems, rheumatoid, gout, renal diseases)	15	8.82

Note. *Participants might have more than one health problem.

DESCRIPTIVE STATISTICS FOR MAJOR VARIABLES

Major variables in this study included non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors including health literacy measured by Thai- Three Levels of Health Literacy Scale (Thai-3LHLS),

diabetes related-numeracy measured by Thai-Diabetes Numeracy Test (Thai-DNT), diabetes knowledge measured by the General Diabetes Knowledge-Thai version, self-efficacy measured by the Thai Version of the Diabetes Management Self-Efficacy Scale (T-DMSES), diabetes self-management measured by the Summary Diabetes self-management Activities (SDSCA)—Thai version, and hemoglobin A1C (A1C).

Non-Modifiable Selected Personal Factors

Age had a positively skewed distribution. Participants at the young end of the range were more heavily represented. The Kolmogorov-Smirnov test of normality was significant at a probability of $p < .001$, indicating that age did not have normal distribution. The boxplot showed only one outlier. According to the outlier check for normal distribution (Field, 2009), the values for absolute z-scores should be distributed so that 5% of the scores >1.96, 1% of the scores >2.58, and none of the scores >3.29. The absolute z-scores in the >1.96 and >3.29 were as expected but 1.8 % of absolute z-scores were greater than 2.58, somewhat higher than the expected value. However, when the frequency table of age was checked, the data showed a continuous range.

For gender, the level of measurement is nominal. More than half of the participants were female (n = 103, 61%). The level of education is ordinal. The large majority completed a primary school education (n = 136, 80%). The level of education of other participants were 2.4 % finished middle school, 3.5% finished high school, and 1.8% completed high school; while 12.3% of older adults had no formal education.

The duration of diabetes distribution was positively skewed at 1.44, but the value of skewness was less than 2. Most of the sample had duration of diabetes on the shorter

end of the range. The Kolmogorov-Smirnov test of normality was significant at $p < .001$, indicating that duration of diabetes did not have normal distribution. Five extreme values were identified and 2.9 % of the absolute z-scores were greater than 3.29, indicating a non-normal distribution. The values of duration of diabetes from the frequency table show the trend. It was found that there is continuous data for the duration of diabetes and it is possible that since this study recruited only people who were ≥ 60 years, those older adults might have a longer duration of diabetes.

Modifiable Factors

Health literacy (HL) has three subscales; functional HL, communication HL, and critical HL. The mean total overall health literacy was at a moderate level (mean = 38.15, SD 7.70), with a range of 17-56. The scores on overall health literacy (3LHLS) and the two subscales of communication HL and critical HL were somewhat negatively skewed, ranging from -.12 to -.58 while only functional HL was positively skewed. The Kolmogorov-Smirnov test of normality was not significant for overall HL but was significant at $p < .001$ for all three subscales, indicating that overall HL was normally distributed, while each of the three subscales of HL was not. The boxplot showed four outliers on the low end of overall health literacy scores and four outliers in the low end of critical health literacy scores but the four outliers from overall health literacy and critical health literacy were different people. However, the outlier check for normal distribution from the absolute z-scores found that overall HL, and the three subscales do meet the criteria of normal distribution. In addition, the histogram shows the distribution of

functional HL to be bipolar in shape, in which most participants in the study seem to have low score function HL and high score of function HL.

The mean total score for DNT was at a fair level, (mean = 12.37, SD 4.98), with a range of 0-20. Represented as a percentage, the mean score of Thai DNT items 1-20 item was 61.85%. The DNT scores had some negative skewness, indicating that most participants had a higher score one the DNT. The Kolmogorov-Smirnov shows a significant test of normality at $p < .001$, indicating that the DNT was not normally distributed. There were no outliers found on the DNT from the boxplot and absolute z-scores.

The mean total score for diabetes knowledge was at a moderate level, (mean =13.57, SD 4.16), with range 0-21. Represented as a percentage, the mean score of diabetes knowledge was 65%. The diabetes knowledge distribution was negatively skewed at -1.05, indicating that most participants tended to have high scores in diabetes knowledge. The Kolmogorov-Smirnov normality test was significant at $p < .001$, showing that diabetes knowledge did not have a normal distribution. There were three outliers identified by the boxplot check in diabetes knowledge but no absolute z-scores over the acceptable level were found.

The mean total score of self-efficacy was 59.42, SD 11.75, with range 19-95. For self-efficacy, the skewness value is .00, indicating that the distribution was nearly normal. The Kolmogorov-Smirnov shows non-significance at $p > .05$, further indicating normal distribution for self-efficacy. The boxplot showed two outliers but the absolute z-score also indicates normal distribution.

Diabetes Self-Management

Diabetes self-management (SDSCA) has six subscales: general diet, specific diet, exercise, self-monitoring blood glucose, medication, and foot care. The participants in this study did not self-monitor their blood glucose. Therefore, the self-monitoring blood glucose subscale was deleted from the analysis. The mean score on the overall SDSCA was 4.63, SD 1.38, with a range of 1.33-7. When scores for each subscale were determined, it was found that the participants had moderate level scores for general diet (mean = 8.80, SD, range 0-14), specific diet (mean = 13.16, SD, range 0-21), exercise (mean = 8.12, SD, range 0-14), and foot care (mean = 23.18, SD, range 0-35). Participants had a good level of medication self-management (mean = 6.79, SD, range 0-7), The scores on the overall SDSCA and four subscales were all somewhat negatively skewed, indicating that most participants rated themselves at the higher end of overall diabetes self-management, general and specific diet, exercise and foot care behaviors. The medication subscale scores were very negatively skewed (value at -5.81), indicating that most participants reported they took their medication regularly. The Kolmogorov-Smirnov normality test for the SDSCA and the subscales of general diet, specific diet, exercise, and foot care were significant, indicating that SDSCA and subscales did not have normal distribution. According to the boxplot, there was only one outlier in the specific diet subscale while the overall SDSCA and other subscales had no outliers. The absolute z-score analysis of the overall SDSCA also indicates a normal distribution.

Glycemic Control (A1C)

A1C scores were very positively skewed at 2.45, indicating a tendency towards lower A1C levels. The mean A1C was 7.27%, SD 1.92, with a range of 4-19.10, indicating that most participants were able to control their glycemic levels within the target range for older adults with diabetes. However, the range of A1C varied widely. The Kolmogorov-Smirnov normality test was significant indicating a non-normal distribution. There were three extremely high values of A1C identified by the boxplot check. In addition, the absolute z-score analysis showed less than 5% of scores were greater than 1.96, less than 1% of the scores were greater than 2.58, but 1.8% of the absolute z-scores were greater than 3.29, indicating outliers. The frequency table for A1C shows that the participants in the study had continuous scores from low to high, not indicating outliers. A1C was converted to a dichotomous various for the correlation and in the multiple regression analyses.

Table 4.6

Descriptive Statistics of Major Study Variables (N=170)

Variable	M	SD	Actual range	Possible range	Skew	Kurtosis
Age (years)	67.82	.49	60-86	60 to highest possible	.80	-.06
Duration of diabetes	8.95	6.38	1-30	1 to highest possible	1.44	2.27
Health literacy (HL)	38.15	7.70	17-56	14-56	-.12	.43
Functional HL	12.44	4.85	5-20	5-20	.11	-1.14
Communication HL	14.19	3.76	5-20	5-20	-.58	-.28
Critical HL	11.53	2.93	4-16	4-16	-.41	.13
Thai DNT (20 item)	12.37	4.98	0-20	0-20	-.83	-.14
Diabetes knowledge	13.57	4.16	0-21	0-21	-1.05	.75
Self-efficacy	59.42	11.75	19-95	19-95	.00	.50
Mean SDSCA	4.63	1.38	1.33-7	0-7	-.27	-1.05
General diet	8.80	4.12	0-14	0-14	-.29	-.86
Specific diet	13.16	4.63	0-21	0-21	-.02	-.45
Exercise	8.12	4.65	0-14	0-14	-.18	-1.12
Medication(n=168)	6.79	0.94	0-7	0-7	-5.81	36.23
Foot care	23.18	9.77	0-35	0-35	-.54	-.79
A1C	7.27	1.92	4-19.10	As actual	2.45	9.56

PSYCHOMETRIC PROPERTIES FOR MAJOR VARIABLES

The internal consistency was calculated for the scales and subscales of each questionnaire in the study (Thai-3LHLS and FHL, Communicative HL, and Critical HL subscales, Thai DNT, Diabetes knowledge, T-DMSES, and SDSCA-Thai version), and Cronbach's alphas are presented in Table 4.7. Although some subscales had only two items such as the general diet and exercise of SDSCA, it is worth observing the reliability of each scale. Internal consistency reliability is concerned about the homogeneity of the items in scales. High inter-item correlations indicated that items measured the same concept. The relationships among items account for the relationships of items to the latent variable. If scale items are strongly related to their latent variable, items would have strong relationship at each other. The internal consistency reflects the reliability of each item to measure the same thing (DeVellis, 2012).

The internal consistency reliability coefficients (Cronbach's alpha) of all instruments used in the study were found to be in the acceptable to high range: .77-.92. The possible range of Cronbach's alpha value is between 0 to 1, with higher values indicating better internal consistency (Polit & Beck, 2004). The medication subscale of SDSCA contained only one item, so, the internal consistency reliability for that subscale is not appropriate to measure.

Table 4.7

Psychometric Properties of Major Study Variables (N=170)

Variable	Number of Items	α
3LHLS	14	.81
Functional HL	5	.92
Communication HL	5	.84
Critical HL	4	.83
Thai DNT (20 item)	20	.88
Diabetes knowledge	21	.81
Self-efficacy	19	.89
SDSCA	13	.83
General diet	2	.84
Specific diet	3	.84
Exercise	2	.80
Medication (n=168)	1	N/A
Foot care	5	.77

Note. 3LHLS = The Three Level of Health Literacy Scale, HL = health literacy, DNT = the Diabetes Numeracy Test, SDSCA = the Summary of Diabetes Self-Care Activities, α = Cronbach's Alpha Coefficient

FINDINGS FOR RESEARCH QUESTIONS 2-9

Research question 2: What is the evidence for construct validity of the Thai-DNT?

Evidence for construct validity of the Thai DNT was obtained from one-tailed Pearson correlations with education, health literacy and diabetes knowledge. The Thai-DNT has a moderately positive and significant relationship with education ($r = .373$, $p < .01$), diabetes knowledge ($r = .344$, $p < .01$), and health literacy ($r = .421$, $p < .01$). Older adults with T2DM who had higher Thai-DNT scores had higher education levels, greater health literacy, and higher diabetes knowledge scores. In summary, Thai-DNT demonstrates evidence of construct validity because numeracy was conceptualized to be related to education, health literacy, and diabetes knowledge and the Pearson correlations are positive and significant.

Research question 3: What is the evidence for internal consistency and test-retest reliability of the Thai-DNT?

Cronbach's alpha was computed to evaluate the internal consistency reliability of the Thai-DNT as shown in Table 4.8. The Cronbach's alpha value of the Thai DNT is 0.88 (in a range of 0.0-1.0), indicating very good internal consistency. Higher values of Cronbach's alpha indicate better internal consistency (Polit & Beck, 2004).

Item analysis was performed to evaluate inter-item and item-to-total correlations of the Thai DNT. The corrected item to total correlations ranged from .11 to .63, see Table 4.9. Items with corrected item total correlations < 0.3 or > 0.8 were evaluated to determine if they could be deleted from the scale, remain the same, or be revised to

enhance the value of Cronbach's alpha and avoid redundancy. There were two items that had corrected item to total correlations < 0.3: item 6 and item 12. Item 6 evaluates the participant's understanding of food proportions for daily self-management. It is a multi-step calculation requiring addition and subtraction. Item 12 evaluates the participant's understanding of the target goal of glycemic control by choosing a blood sugar value that is in the target range. These two questions are important concepts in diabetes self-management and the Cronbach's alpha of Thai-DNT is high. Therefore, these two items remain in the Thai-DNT. However, participants complained that Item 6 was difficult to understand because of the format of the table. Future revisions might place the information and question before the table. In addition, the line separating pictures between left side and right side could be deleted to make the table easier to read.

For test-retest reliability, the intraclass correlation coefficient (ICC) with a two factor mixed effects model and consistency method type was used to examine the stability (test-retest reliability) for 30 participants who completed the Thai-DNT twice (referred to as Thai-DNT first time and Thai-DNT second time, two weeks apart. The results showed that the participants scored better the second time than the first. The mean score of DNT time 1 was 15.8 SD = 2.3, and the mean of Thai-DNT time 2 was 18.93 SD = 1.4. A moderate degree of reliability was found between Thai-DNT time 1 and Thai-DNT time 2; the average measure ICC was .543 with a 95% confidence interval from .04 to .78, Table 4.8.

Table 4.8

Psychometric Properties of the Thai-DNT (N=170)

Instrument	Internal Consistency	Test-retest stability
Thai- DNT (20 items)	.876	.54

Table 4.9

Internal Consistency of Each Item of the Thai-DNT Item 1-20 (N = 170)

Thai DNT	*M*	*SD*	Correct Item Total Correlation	Alpha if Item Deleted
Item 1	.79	.41	.44	.87
Item 2	.62	.49	.43	.87
Item 3	.82	.38	.55	.87
Item 4	.29	.45	.45	.87
Item 5	.85	.36	.49	.87
Item 6	.35	.48	.11	.88
Item 7	.32	.47	.53	.87
Item 8	.78	.42	.51	.87
Item 9	.75	.44	.63	.87
Item 10	.38	.49	.43	.87
Item 11	.46	.50	.41	.87
Item 12	.61	.49	.25	.88
Item 13	.60	.49	.58	.87
Item 14	.72	.45	.61	.87
Item 15	.61	.49	.53	.87
Item 16	.70	.46	.58	.87

Table 4.9 (continued)

Internal Consistency of Each Item of the Thai-DNT Item 1-20 (N = 170)

Thai DNT	*M*	*SD*	Correct Item Total Correlation	Alpha if Item Deleted
Item 17	.73	.45	.59	.87
Item 18	.71	.45	.62	.87
Item 19	.54	.50	.37	.88
Item 20	.75	.43	.58	.87

Research question 4: What are the levels of health literacy?

Health literacy is measured by the Three Levels of Health Literacy Level (14 total items with a possible range of 1-4 for each item), consisting of three subscales; functional health literacy, communicative health literacy, and critical health literacy. A higher score indicates higher health literacy. The mean overall health literacy of Thai older adults with T2DM in the study was 2.72 (SD = 0.55) out of 4, indicating fairly good health literacy. Mean scores were highest on the critical health literacy subscale and lowest in the functional health literacy subscale. Most participants in the study had better skills in critical analysis of health information and applicable decision making. Meanwhile, participants had worse scores on reading the instructions or heath information due to difficulties in reading. The results were presented in Table 4.10

Table 4.10

Health Litreracy Scores of Thai Older Adults with T2DM in the Study (N = 170)

Scales and subscales	*M*	*SD*
Functional health literacy	2.49	0.97
1. found that the print was too small to read	2.48	1.31
2. found characters and words that you did not know	2.44	1.06
3. found that the content was too difficult	2.48	1.11
4. needed a long time to read and understand them	2.47	1.08
5. needed someone to help you read them	2.57	1.18
Communicative health literacy	2.84	0.75
6. collected information from various sources	2.69	1.08
7. extracted the information from you wanted	2.79	.96
8. understood the obtained information	2.89	.85
9. communicated thoughts about your illness to someone	2.90	.97
10. applied the obtained information to your daily life	2.92	.92
Critical health literacy	2.88	0.73
11. considered whether the information was applicable to your situation	2.94	.88
12. considered the credibility of the information	3.08	.84
13. checked whether the information was valid and reliable	2.66	1.00
14. collected information to make health-related decisions	2.85	.87

Research question 5: What are the levels of diabetes-related numeracy?

The Thai Diabetes Numeracy Test (Thai-DNT) was used to measure diabetes-related numeracy. After translation and adaptation of the original DNT's 43 items, 25 items were retained or adjusted so that the final Thai-DNT version contained items 1-20 for all participants, and items 21-25 for participants who received insulin treatment either alone or with oral medication. The results of DNT items 1-20 are presented in Table 4.11.

The mean of the Thai-DNT items 1-20 is 12.37 (SD = 4.98), with a range of 0-20. Represented as a percentage, the mean score of Thai DNT items 1-20 item is 61.85%. The problem areas as determined by mean score of item less than 50% included a lack of understanding of the relation between carbohydrate intake and increased blood sugar level (item 4, 28.8%), food proportion of each meal per day (item 6, 34.7%), translating food proportion to carbohydrate count (item 7, 31.8%), knowing the correct time for carbohydrate intake after exercise (item 10, 37.6%), and preparing carbohydrate intake for exercise (item11, 46.5%) which required math skills such as fractions and multistep math skills. However, most participants were able to correctly answer the simpler calculations for the food proportions of daily meals (item 3, 82.4% and item 5, 85.3%).

Table 4.11

DNT Score Items 1-20 (N = 170)

Item	*% Correct answer*
1…how many portions of flour are equal to two ladles of cooked rice?	79.4
2…If you want 1 portion of flour, how many mangoes do you have to eat?	62.4
3…If you have 3 ladles for breakfast, 3 ladles for lunch, how many ladles would you have for dinner to make it 8 ladles in total a day?	82.4
4…how many units of blood sugar level can be increased by a ladle of cooked rice?	28.8
5.The suggested intake of vegetables is 6 ladles per day, divided into 3 meals equally. How many ladles of vegetable per meal will you have?	85.3
6…If you want to have 5 portions of vegetable and fruit a day, how many ladles of cooked vegetable should you have?	34.7
7.You have 2.5 portions of Thai rice noodles and 8 pieces of pineapple of suitable sizes. How many portions of flour will you get?	31.8
8….how many grams of sugar will you get if you drink half a box of the fruit juice?	77.6
9…. if you drink half a box of this soymilk, how many grams of carbohydrates (which is in the group of fiber, flour and sugar) will you get?	74.7
10… If you finish your walk at 2 pm., by what time should you have the cooked corn?	37.6
11. …If you take a one hour walk, how many pieces of crackers do you have to have?	46.5
12. If your goal is to control your blood sugar level to be between 60 and 120. Circle a number below that is in the range of your goal.	60.6
13.If you want to self-monitor your blood sugar level 4 times a day for 30 days, how many test strips do you need?	60.0

Table 4.11 (continued)

DNT Score Items 1-20 (N = 170)

Item	*% Correct answer*
14. ..if your blood sugar level is 240, how much is your average cumulative amount of blood sugar ?	71.8
15…test your blood sugar level 3 times a day. On March 5th, you have 50 test strips. When do you have to buy some more test strips?	60.6
16… If you have breakfast at 8.00 am, when should you take this drug?	70
17…. If you will be away for 2 weeks, how many tablets, at least, should you prepare?	72.9
18…take1 tablet of a drug lowering blood sugar after breakfast and dinner. You see doctor once a month and get the pill for a month. How many tablets of this drug should you get?	71.2
19.If you have several underlying diseases and need to take the following drugs;…**Only after breakfast,** how many tablets do you have to take?	53.5
20.If you take a tablet for diabetes twice a day, how many days will you spend for taking 60 tablets?	75.3

The Thai DNT items 21-25 measured diabetes-related numeracy related to insulin usage. Only the participants who used insulin (n=15) answered items 21-25. Most answered the items regarding insulin scale incorrectly. The question needed the participants to underline the value of 54 units on a picture of a 100-unit insulin syringe (item 21, 40%). However, 80% of the participants were able to correctly calculate the dosage of insulin used when the participants needed to receive a medical procedure such as colonoscopy. The results are presented in Table 4.12.

Table 4.12

DNT Score Items 21-25 (n= 15)

Item	*% Correct answer*
21. If you have to inject 54 units of insulin by using a 100 units syringe, please underline the number representing 54 units in the syringe below.	40.0
22…you have to inject two types of insulin, 10 units for type 1 and 16 units for type 2. How many units of insulin do you have to inject in total?	73.3
23…. If you have 6 portions of food in the rice and flour group, how many units of insulin do you have to inject?	60.0
24…. When you have your colon checked, a doctor tells you to reduce its amount to half of this number…., how many units of insulin will you inject?	80.0
25.If your blood sugar level is 295, how many units of insulin will you inject?	60.0

Research question 6: What are the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes), modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy), diabetes self-management and glycemic control in Thai older adults with T2DM?

To determine the relationships among non-modifiable selected personal factors (age, gender, education level, and duration of diabetes), modifiable factors (health literacy, DNT, diabetes knowledge, and self-efficacy), diabetes self-management behaviors, and A1C, Pearson correlation coefficients and Point biserial correlations were

used to explore the bivariate relationships. The results are presented as a sequence of relationship among factors, in Table 4.13.

Age. Age showed a low negative, and significant relationship with education ($r = -.16$, $p < .05$) and a low to moderate negative and significant relationship with diabetes knowledge ($r = -.22$, $p < .01$). Older participants reported lower education and scored lower on diabetes knowledge. However, age was not significantly related to gender, duration of diabetes, health literacy, DNT, self-efficacy, diabetes self-management behaviors, or A1C.

Gender. Gender (code 0 = male, 1 = female) showed a small negative and significant relationship with education ($r = -.23$, $p < .01$), health literacy ($r = -.18$, $p < .05$), DNT ($r = -.18$, $p < .05$), and diabetes knowledge ($r = -.20$, $p < .01$). Males tended to have higher education, higher health literacy and numeracy, and greater diabetes knowledge. Meanwhile, gender was not significantly related to age, duration of diabetes, self-efficacy, diabetes self-management behaviors, or A1C.

Education level. Education showed a low positive significant relationship with health literacy ($r = .26$, $p < .01$) and a moderate positive, significant relationship with DNT ($r = .37$, $p < .01$), diabetes knowledge ($r = .28$, $p < .01$), and self-efficacy ($r = .30$, $p < .01$). Thai older adults with T2DM in this study who had higher education levels had higher DNT scores, greater diabetes knowledge, and better self-efficacy. Education level was not significantly related to duration of diabetes, diabetes self-management behaviors, or A1C.

Duration of diabetes. Duration of diabetes showed only a small positive, significant relationship with A1C ($r = .22$, $p < .01$). Thai older adults with T2DM in this study who had longer duration of diabetes had higher A1C (worse A1C).

Health literacy. Health literacy showed a moderate positive, significant relationship with DNT ($r = .42$, $p < .01$), diabetes knowledge ($r = .35$, $p < .01$), self-efficacy ($r = .34$, $p < .01$), and diabetes self-management ($r = .29$, $p < .01$). Thai older adults with T2DM in this study who had greater health literacy had higher DNT score, greater diabetes knowledge, better self-efficacy, and better diabetes self-management behaviors. However, health literacy was not significantly related to A1C.

DNT. DNT showed a moderate positive, significant relationship with diabetes knowledge ($r = .34$, $p < .01$), and self-efficacy ($r = .28$, $p < .01$). Respondents with higher scores on the DNT had greater diabetes knowledge and better self-efficacy. DNT was not significantly associated with diabetes self-management behaviors or A1C.

Diabetes knowledge. Diabetes knowledge showed a moderate positive, significant relationship with self-efficacy ($r = .36$, $p < .01$), diabetes self-management behaviors ($r = .28$, $p <. 01$) and showed a weakly positive, and significant relationship with A1C ($r = .24$, $p < .01$). Thai older adults with T2DM in this study who had higher diabetes knowledge had better self-efficacy and self-management behaviors, but higher A1C (worse A1C).

Self-efficacy. Self-efficacy showed a strong positive, and significant relationship with diabetes self-management ($r = .54$, $p < .01$). Participants with higher self-efficacy

scores also tended to have better diabetes self-management behaviors. However, self-efficacy was not significantly related to A1C.

Diabetes self-management. Scores on diabetes self-management were not significantly associated with A1C.

In summary, the relationships among non-modifiable selected personal factors (age, gender, education, and duration of diabetes) and the modifiable factors of health literacy, DNT, diabetes knowledge, self-efficacy with diabetes self-management and A1C were proposed in the Conceptual Framework that guides this study. The study demonstrated that age was significantly positively related only to diabetes knowledge, not, as proposed, a significant correlate with diabetes self-management and A1C. Gender was significantly negatively related to health literacy, DNT, and diabetes knowledge but it was not significantly associated with diabetes self-management and A1C. Education was significantly positively associated with all the modifiable factors (health literacy, DNT, diabetes knowledge, and self-efficacy) but education was not significant related to diabetes self-management and A1C. Duration was not significantly associated with any of the modifiable factors but duration of diabetes was significantly associated with A1C. The modifiable factors of health literacy, diabetes knowledge, and self-efficacy were significantly positively related to diabetes self-management but they were not significantly related to A1C. The DNT scores were not significantly related to either diabetes self-management or A1C. Diabetes self-management was also not significantly associated with A1C (See Table 4.13).

Table 4.13

Correlations among Non-Modifiable Selected Personal Factors, Health Literacy, Thai-DNT, Diabetes Knowledge, Self-Efficacy, Diabetes Self-Management, and A1C (N = 170)

	1	2	3	4	5	6	7	8	9	10
1. Age	1									
2. Gender	-.12	1								
3. Education	-.16*	-.23**	1							
4. Duration of diabetes	.09	-.02	.05	1						
5. Health literacy	-.05	-.18*	.26**	-.02	1					
6. DNT	-.13	-.18*	.37**	-.08	.42**	1				
7. Diabetes knowledge	-.22**	-.20**	.28**	.10	.35**	.34**	1			
8. Self-efficacy	-.03	-.01	.30**	.15	.34**	.28**	.36**	1		
9. SDSCA	.14	.00	.13	.05	.29**	.12	.28**	.54**	1	
10. A1C	-.10	-.05	.11	.22**	.09	-.02	.24**	.11	.02	1

Note. DNT = Thai Diabetes Numeracy Test 20-item, SDSCA = Diabetes self-management, A1C = glycosylated hemoglobin A1C, * significant at the .05 level, ** significant at the .01 level, two-tailed

Research question 7: **Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) contribute significantly to the prediction diabetes self-management after controller the effects of non-modifiable selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?**

Hierarchical multiple regression analysis was used to answer Research question 7 because multiple regression analysis allows the variables to be entered into the models in a sequence determined based on logic and the theoretical framework to test the effects of main independent predictors on outcome (Polit & Beck, 2004). The personal factors (age, gender, education, and duration of diabetes) entered as a block in Step 1. Then, health literacy, diabetes related-numeracy (DNT), diabetes knowledge and self-efficacy were added as a block in Step 2. The results are shown in Table 4.14.

The correlations among the predictor variables (age, gender, education, duration of diabetes, health literacy, DNT, diabetes knowledge and self-efficacy) included in the study were tested in correlation analysis and the results among these relationships were presented in Table 4.13. All correlations were weak to moderate, ranging between .16, $p < .05$ and $r = .42$, $p < .01$, indicating that multicollinearity was unlikely. The three modifiable factors were statistically related to diabetes self-management in correlation analysis, indicating support for a relationship between predictors and outcome. The relationship between potential predictors and diabetes self-management were weak to strong, ranging from $r =. 28$, $p < .01$ to $r = .54$, $p < .01$.

In first step of hierarchical multiple regression, four variables were entered: age, gender, education, and duration of diabetes. This step (model 1) was not statistically significant ($F [4,165] = 2.05$; $p > .05$) and explained 4.7% of the variance in diabetes self-care (Table 4.14). After including health literacy, DNT, diabetes knowledge, and self-efficacy as step 2 (model 2), the total variance explained by the model as a whole was 35.4% ($F [8,161] = 11.00$; $p < .001$). Adding these modifiable factors (health literacy, DNT, diabetes knowledge, and self-efficacy) explained an additional 30.6% of the variance in diabetes self-management (R^2 Change = .31; $F [4, 161] = 19.06$; $p < .001$). In the final model, three out of eight predictor variables were statistically significant with self-efficacy achieving a higher Beta value ($\beta = .49$, $p < .001$) than age ($\beta = .20$, $p < .01$), and diabetes knowledge ($\beta = .15$, $p < .05$), see Table 4.14.

Table 4.14

Hierarchical Multiple Regression to Predict Diabetes Self-Management in Thai Older Adults with T2DM (N = 170)

	R	R^2	R^2 *Change*	*B*	*SE*	*β*	*t*
Step 1	.22	.05					.83
Age				.04	.02	.17*	2.22
Gender (0 = Male; 1 = female)				.18	.22	.06	.80
Education				.30	.14	.17*	2.10
Duration of diabetes				.01	.02	.03	.34
Step 2	.60	.35***	.31***	-2.76			
Age				.04	.01	.20**	2.90
Gender (0 = Male; 1 = female)				.18	.19	.06	.91
Education				-.02	.13	-.01	-.16
Duration of diabetes				-.01	.01	-.06	-.90
Health literacy				.02	.01	.13	1.77
DNT20				-.03	.02	-.09	-1.24
Diabetes knowledge				.05	.03	.15*	2.03
Self-efficacy				.06	.01	.49***	6.63

Note. Statistical significant: * p < .05; ** p < .01; *** P < .001

To be able to generalize the results of the multiple linear regression, the predictors should not have non-zero variance, should not be multicollinear, and the independent errors should not have autocorrelation, meaning that "the residuals of two observations in a regression model are correlated"(Field, 2009: p.781). In addition, each level of predictor variables should have homoscedasticity, in which "the variance of the residuals

at every set of values for the independent variable is equal" (Shevllin & Miles, 2010: p.85). Each variable should be normally distributed, and the relationship between the independent variables and dependent variable should be linear (Field, 2009). The data were screened to see if it met the assumptions for multiple regressions: normality, linearity, and homoscedasticity. Histograms showed the normal distribution of the relationship between regression standardized residual and dependent variable (diabetes self-management).

For normality of residuals, the P-P plot showed the points were positioned around a straight diagonal line. The scatter plots of the residuals against the predicted values of the dependent variable showed a rectangular distribution with most scores concentrated in the center (closer to the 0 point). The plots of residuals against predicted values were checked for a funnel shape, which would indicate heteroscedasticity. However, a funnel shape was not seen. The zero-order correlation of all variables in the study did not show correlations between each other more than .85.

The Durbin-Watson test of homoscedasticity was 1.7, indicating homoscedasticity because the value is close to 2. Durbin-Watson values <1 or >3 are indicative homoscedasticity. To check for multicollinearity, Tolerance and VIF were determined. Tolerance should be far away from zero and Tolerance values of < 0.1 or 0.2 indicate multicollinearity, which is a problem. VIF values > 10 also indicate a problem with multicollinearity (Field, 2009). For the model predicting diabetes self-management, the Tolerance statistics were all well above 0.2 and all VIF values were below 10; therefore, the data were not multicollinear. The mean of Cook's distance is 0.006 with a maximum

of 0.08, indicating no problematic cases. A Cook's distance of more than 1 suggests a cause of concern (Field, 2009).

In summary, hierarchical multiple regression was performed to test the effects of health literacy, DNT, diabetes knowledge and self-efficacy to predict diabetes self-management, after controlling for personal factors such as age, gender, education, and duration of diabetes. Preliminary analyses were conducted to ensure the data did not violate the assumptions of normality, linearity, and homoscedasticity.

Research question 8: Do modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and diabetes self-efficacy) and diabetes self-management contribute significantly to the prediction of glycemic control after controller the effects of non-modifiable selected personal factors (age, gender, education, and duration of diabetes) in Thai older adults with T2DM?

The correlations among non-modifiable selected factors (age, gender, education, duration of diabetes), modifiable factors (health literacy, DNT, diabetes knowledge, and self-efficacy), and diabetes self-management included in the study were tested in correlation analysis and the results among these relationships were presented in Table 4.13. All correlations were weak to moderate, ranging between .16, $p < .05$ and $r = .42$, $p < .01$, indicating multicollinearity was unlikely. Duration of diabetes and diabetes knowledge were statistically correlated to A1C, indicating support for the relationship between potential predictors and outcome. The relationships between potential predictors and the outcome A1C were weak, ranging from $r = .22$, $p < .01$ to $r = .24$, $p < .05$).

Hierarchical multiple regression was performed to test the predictive relationship between non-modifiable selected personal factors (age, gender, education, and duration of diabetes), and modifiable factors (health literacy, DNT, diabetes knowledge and self-efficacy), and diabetes self-management on A1C (Table 4.15).

In first step of hierarchical multiple regression, four variables were entered: age, gender, education, and duration of diabetes. Model 1 was statistically significant ($F [4,165] = 3.01; p < .05$) and explained 6.8% of variance in A1C (Table 4.15). After Step 2 in which health literacy, DNT, diabetes knowledge, and self-efficacy were added to the model, the total variance explained by the model (model 2) as a whole was 11.5% ($F [8,161] = 2.62; p < .05$). The addition of the four modifiable variables in Step 2a n explained additional 4.7% variance in A1C (R^2 Change = .05; $F [4, 161] = 2.15; p >. 05$).

Diabetes self-management was added to the model in step 3. The total variance explained by model 3 as a whole was 11.9% ($F [8,160] = 2.40; p < .05$). Diabetes self-management explained an additional 0.4% variance in A1C (R^2 Change = .00; $F [1, 160] = .68; p >. 05$). In the final model, two out of nine predictor variables were statistically significant. Diabetes knowledge had a higher Beta value ($\beta = .23, p < .05$) than duration of diabetes ($\beta = .18, p < .05$). See Table 4.15.

Table 4.15

Hierarchical Multiple Regression to Predict Hemoglobin A1C (N = 170)

	R	R^2	R^2 *Change*	*B*	*SE*	*β*	*t*
Step 1	.26	.07*					
Age				-.03	.02	-.11	-1.43
Gender (0 = Male; 1 = female)				-.17	.31	-.04	-.55
Education				.17	.20	.07	.88
Duration of diabetes				.07	.02	.22**	2.93
Step 2	.34	.12*	.05				
Age				-.02	.02	-.07	-.93
Gender (0 = Male; 1 = female)				-.05	.31	-.01	-.17
Education				.15	.21	.06	.71
Duration of diabetes				.06	.02	.19*	2.43
Health literacy				.02	.02	.06	.68
DNT20				-.06	.03	-.14	-1.61
Diabetes knowledge				.10	.04	.21*	2.43
Self-efficacy				.00	.01	.00	.04
Step 3	.35	.12*	.00				
Age				-.02	.02	-.06	-.72
Gender (0 = Male; 1 = female)				-.04	.31	-.01	-.11
Education				.15	.21	.06	.70
Duration of diabetes				.06	.02	.18*	2.37
Health literacy				.02	.02	.07	.79
DNT20				-.06	.03	-.15	-1.68
Diabetes knowledge				.10	.04	.23*	2.53
Self-efficacy				.01	.02	.04	.42
Diabetes self-management				-.11	.13	-.08	-.82

Note. Statistical significant: * p < .05; ** p < .01; *** P < .001

Preliminary analyses were conducted to ensure no violations of the assumptions of normality, linearity, and homoscedasticity. The data were screened to see if assumptions were met. Histograms showed a normal distribution for the relationship between regression-standardized residuals and the dependent variable (A1C). For normality of residuals, the P-P plot showed the points were situated around a straight

diagonal line. The scatter plots of the residuals against the predicted values of the dependent variable showed a rectangular distribution with scores concentrated in the center. The plots of residuals against predicted values were checked and did not indicate heteroscedasticity. The zero-order correlation of all variables in the study did not show correlations between each other more than .85.

The Durbin-Watson test of homoscedasticity was 1.7, indicating homoscedasticity. To check multicollinearity, Tolerance and VIF were determined. For the model predicting glycemic control, the Tolerance statistics were all well above 0.2 and all VIF values were below 10; therefore, the data were not multicollinear.. The mean of Cook's distance is 0.06 with a maximum of 0.24, indicating no problematic cases.

In summary, hierarchical multiple regression was performed to test the effects of health literacy, DNT, diabetes knowledge and self-efficacy, and diabetes self-management to predict after controlling for personal factors such as age, gender, education, and duration of diabetes. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, and homoscedasticity.

CHAPTER 5: DISCUSSION

This chapter presents a summary and discussion of the study findings, the limitations of the study, implications for research, practice, nursing education, policy in Thailand, and recommendations for future study.

The purpose of this descriptive correlation, cross-sectional study was to create a conceptually equivalent version of the Diabetes Numeracy Test (DNT) for Thai older adults with T2DM and explore the correlations among non-modifiable selected personal factors (age, gender, education level and duration of diabetes), modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, diabetes self-efficacy), diabetes self-management, and glycemic control in Thai older adults with T2DM as guided by the conceptual framework of the study.

Summary of Study Findings

This study established the validity and reliability of the Thai-DNT to evaluate diabetes-related numeracy of Thai older adults with T2DM in the communities. The Thai DNT has 25 items; items 21-25 are only for respondents who use insulin treatment. Psychometric analysis of the final version of the Thai DNT reveals good reliability (internal consistency, and test-retest) and validity (content validity and construct validity) as a test of diabetes-related numeracy in Thai older adults with T2DM. The DNT scores had some negative skewness. There were no outliers found on the DNT from the boxplot and absolute z-scores. Scores on the Thai DNT were moderately positively and

statistically significantly correlated with education, diabetes knowledge, and health literacy.

Discussion of the Findings Related to Sample Characteristics

The convenience sample of 170 Thai older adults with T2DM were recruited from three primary care units and a community hospital in a suburban area, Nakhon Pathom province, Thailand. Most were female in early late adulthood and had low education. Three quarters of the participants had been diagnosed with diabetes for less than 10 years. Most older adults with T2DM in the study had fair scores in diabetes knowledge, self-efficacy, and fair to good diabetes self-management. Two thirds of the sample had a hemoglobin A1C value in the target range for glycemic control (A1C < 7.5%, identified as the target range for older adults with diabetes (ADA, 2014; Sue Kirkman et al., 2012). However, A1C is skewed, which can attenuate correlations with other variables in this study.

Interestingly, 20% of the participants in the study had A1C in the range 4%-6%, which is considered within the normal range for adults without diabetes. A possible reason for the low A1C in Thai older with T2DM in the study was that almost 100% of the participants received diabetes medication treatment (90% oral medication treatment, 3% insulin, and 6% both oral and insulin medication treatment), and those older adults reported high medication adherence in the scale of diabetes self-management (mean = 6.79, range 0-7). In addition, all participants were patients in the clinic or hospital and received regular examinations and follow-up.

During data collection it was found that there are some older adults with T2DM who do not see a health care provider at primary care units. The reasons were explained. Some older adults do not want to receive diabetes treatment from clinics, while some had difficultly with transportation to clinics or did not have anyone to take them to the clinics. In addition, some older adults were still working and did not have time to receive care at the clinic. Therefore, data in this study did not include older adults who did not see a health care provider at primary care unit research settings.

Health Literacy Scores

Thai older adults with T2DM scored fairly well in overall health literacy but had worse scores in functional health literacy, perhaps because they perceived diffiicultes in understanding health instructions or heath information because of reading or listening deficiencies. It is possible that deteriorative changes in older adults might result in physical impairments, less efficiency in sensory organs, and reduced functional abilities (Eliopoulos, 2014). Therefore, age-related changes might impact the abilities of older adults to receive health information. In this study, over half (56%) of the older adults with T2DM had difficulty reading due to vision problems and most (72%) of those who had difficulty reading needed to wear glasses while reading.

In comparison to Thai immigrants in the US with T2DM in Chontichachalalauk's pilot study (unpublished, 2014) the Thai older adults with T2DM in the present study had higher functional health literacy, lower communication health literacy, and lower critical health literacy. Functional health literacy relies on the ability to read and understand health information. Most Thai immigrants in the pilot study finished a high school

education while most Thai people in the present study finished only elementary school. A possible reason for the lower functional health literacy score in the pilot study is that Thai people who live in the United States might have more difficulty comprehending health information in the English language. The reliability of each subscale of the Three Levels of Health Literacy Scale (TLHLS): functional, communication, and critical heath literacy showed excellent internal consistency in both the pilot study (Chontichachalalauk, unpublished 2014) and the present study.

Diabetes Numeracy Scores

Thai older adults with T2DM demonstrated diabetes-related numeracy deficiencies; participants correctly answered only 62% of the questions. The problem areas in diabetes-related numeracy are the following: a lack of understanding of the relation of carbohydrate intake with increased blood sugar level (item 4), food proportion of daily meals (item 6), translating food proportion to carbohydrate count (item 7), knowing the correct time for carbohydrate intake after exercise (item 10), and preparing carbohydrate intake before exercise (item11) which required ability to manipulate fractions and use multistep math skills.

Only the participants who used insulin answered items 21-25 of the Thai DNT. The problem area in diabetes-related numeracy for this group was the question that required the participants to identify the correct units on a picture of a 100-unit insulin syringe (item 21).

Awareness of these deficiencies informs health care providers where to focus attention in education programs designed to improve diabetes-related numeracy skills in

this population. Other studies using DNT to evaluate diabetes-related numeracy reported that those patients with diabetes also had limited diabetes-related numeracy (Cavanaugh et al., 2008; Huizinga et al., 2008; White et al., 2011). The average score of DNT from other studies was reported at 26.4% (DNT-15 Latino version, White et al., 2011), and 61% (full version of DNT, Huizinga et al., 2008). However, in terms of average percent correct, the sample of Thai older adults in this sample scored 61.85%, indicating fairly good score. Because the Thai DNT was translated and adapted for cultural appropriateness in Thai older adults with T2DM, it may not meaningful to compare scores across other populations. However, this study found that Thai older with T2DM had a diabetes related numeracy deficit similar to other patient samples.

The psychometric properties of the Thai DNT are acceptable. The content validity index (CVI) was evaluated from five experts. The Scale-CVI was good but the Items-CVI of two items was low. Therefore, these two items were adjusted before testing in the cognitive interviews. The Cronbach's alpha value of the final version of Thai DNT indicated good internal consistency. Some items with had low corrected item total correlations, especially, Item 6. This question asked about food proportions that need multistep calculations and required respondents to use a table with pictures of food and explanations of the pictures. It is possible that the explanations and the table might have been confusing for the respondents. The low item to total correlation for Item 6 might impact the internal consistency. The test-retest correlation of the Thai DNT scores was acceptable. However, the intra-class correlation coefficient (ICC) of the Thai DNT in this study was 0.54 according to Fleiss' (1981) statement that ICC < 0.40 indicated low

stability. The test-retest stability of the Thai DNT could have been low because older adults with T2DM in the study may have learned a lot of information about diabetes related numeracy just by responding to the questions in the Thai DNT first time they took the test. The participants scored better the second time than the first. Some participants commented that they sought information after taking the Thai DNT by talking with health care providers, family member, or reading some document that they received from diabetes education class.

Discussion of the Regression Results

Central to the conceptual framework of this study, the prevention of diabetes-related complications requires the patients to perform diabetes self-management and to achieve glycemic control. This study investigated non-modifiable selected personal factors (age, gender, education, and duration of diabetes) and modifiable factors (health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy) that were expected to contribute significantly to diabetes self-management behaviors and glycemic control. Hieratical multiple regression analysis was used to predict diabetes self-management and glycemic control.

Predicting Diabetes Self-Management

Only age and education were found to significantly predict diabetes self-management in the first model. However, in the final model, after entering the four modifiable factors of health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy, education became a non-significant predictor in diabetes self-management.

Age, diabetes knowledge, and self-efficacy contributed significantly to the prediction of diabetes self-management while gender, education, duration of diabetes, health literacy and diabetes-related numeracy were not significant predictors of diabetes self-management in Thai older adults with T2DM, although health literacy had a significant bivariate relationship with diabetes self-management.

Diabetes Knowledge and Diabetes Self-Management

This finding suggests that patients need to have diabetes knowledge, such as to know how diabetes complications impact their health and how they are able to manage diabetes-related activities such as taking medication, and eating appropriate food. In other Thai research studies, higher diabetes knowledge was related to better diet behavior (Sanjaithum, 2006; Srisuwan, 2007), more exercise (Chompusri, 2007), and better medication taking (Chaimun, 2009; Chompusri, 2007; Srisuwan, 2007). Eknithiset (2009) found that Thai patients who did not understand the instructions could not apply the information to their daily life practices. The result of the present study is similar to previous studies in Thai people in which greater diabetes knowledge indicated better diabetes self-management (Chompusri, 2007; Klinprachum, 2009; Koatdok, 2009; Siwina, 2003; Thunnome, 2006; Wattanakul, 2012).

Diabetes knowledge and self-efficacy were significant predictors of diabetes self-management. Thai older adults with T2DM who were older age, had higher diabetes knowledge, and higher self-efficacy had better diabetes self-management. The present study also found a significant positive moderate relationship between diabetes knowledge and self-efficacy; Thai older adults with T2DM in the study who had better diabetes

knowledge had greater self-efficacy. These findings suggest that to promote diabetes self-management, providing adequate diabetes knowledge and increasing self-efficacy for older adults with T2DM is necessary. However, Xu et al. (2008) found that diabetes knowledge and self-efficacy did not have direct relationships to diabetes self-management; rather diabetes knowledge had an indirect relationship with diabetes self-management behaviors through belief in treatment and self-efficacy. The modifiable factors in the present study accounted for 30.6% of the variance in diabetes self-management behaviors but only diabetes knowledge and self-efficacy were significant predictors of diabetes self-management while the non-modifiable personal factors accounted for only 4.7% of the variance in diabetes self-management behaviors. The present study did not perform path analysis to explore relationships among factors to predict self-management. Therefore, the results of present study did not provide the information about direct or indirect relationships among diabetes knowledge, self-efficacy, and other modifiable factors in the study and diabetes self-management behaviors.

Self-Efficacy and Diabetes Self-Management

Self-efficacy is each individual's belief in his or her power to produce outcomes (Bandura, 1997). Strong evidence has been reported of significant relationships between self-efficacy and diabetes self-management both outside Thailand (Beckerle & Lavin, 2013; Sousa et al., 2005; Wu et al., 2013; Xu et al., 2008) and in Thailand (Borisuth, 2010; Chaikwang, 2005; Koatdok, 2009; Wattanakul, 2012; Wuttisela, 2010). Moreover, self-efficacy was a significant predictor of diabetes self-management in regression

analyses (Gao et al., 2013; Wu et al., 2013; Xu et al., 2008). This study added to the evidence that self-efficacy relates significantly to diabetes self-management. Thai older adults with T2DM in the study who had higher self-efficacy had better diabetes self-management. Moreover, this study found that self-efficacy was a significant predictor of diabetes self-management, which is consistent with Wattanakul's study (2012) of Thai older adults with T2DM. Gao et al. (2013) and Xu et al. (2008) reported that self-efficacy had a direct positive relationship with diabetes self-management. Therefore, this study reinforces the evidence that self-efficacy influences how people perform and maintain their diabetes self-management behaviors such as diet behaviors, exercise, and taking medication to control their diabetes throughout life.

Health Literacy and Diabetes Self-Management

Health literacy had a significant bivariate correlation with diabetes self-management in the present study but the association became non-significant when health literacy was combined with other modifiable factors such as diabetes related numeracy, diabetes knowledge, and self-efficacy to predict diabetes self-management. Similarly, health literacy did not demonstrate a significant relationship with overall diabetes self-management in five previous studies regardless of the health literacy questionnaire, including two studies using a form of TOFHLA (Kim et al., 2004; Mancuso, 2010), two studies using a form of REALM (Bains & Egede, 2011; McCleary-Jones, 2011), and one using the Diabetes-Specific Health Literacy scale (Yamashita & Kart, 2011). This present study used the Three Levels of Health Literacy Scale and found that people who reported higher health literacy also reported better diabetes self-management but also that health

literacy was not a significant predictor in diabetes self-management in multiple regressions. Heath literacy seems relevant to the participants' perceptions of their abilities to receive health information. Patients who did not understand the instructions could not apply information to their practice in daily life (Eknithiset, 2009).

This study found that health literacy was not directly related to diabetes self-management. Rather, the effects of health literacy might have an indirect impact through other variables. Osborn et al. (2010a) found that social support is a mechanism linking health literacy and diabetes self-management behaviors in that health literacy has a direct relationship with social support and through social support, health literacy had an indirect relationship on diabetes self-management. However, The results of this study suggested that health literacy may have an indirect effect through self-efficacy or diabetes knowledge to diabetes self-management.

Diabetes-Related Numeracy and Diabetes self-Management

Diabetes-related numeracy was unrelated to diabetes self-management. The DNT score of Thai older adults with T2DM in the study was low but did not account for variance in diabetes self-management. This is somewhat surprising because the abilities to calculate and interpret numbers in daily life are thought to be necessary for diabetes self-management. However, it is possible that the questions in Thai DNT used in the present study may not cover enough of the context needed for diabetes self-management or that the content of the items may not have a close relationship to behaviors measured by the diabetes self-management questionnaire (SDSCA). These findings do not support the conceptual framework of the study that was derived from the findings of previous

studies that showed that higher diabetes-related numeracy related to better SMBG (Huizinga et al., 2008), better adjustment of insulin for carbohydrate intake and blood glucose level (Cavanaugh, et al., 2008; Huizinga et al., 2008). However, Cavanaugh, et al. (2008) and Huizinga et al. (2008) included samples with T1DM and T2DM in which 60% of the participants received insulin treatment while this study included people with only T2DM and just 9% of the participants received insulin treatment. In addition, the present study did not evaluate SMBG because it is not common for Thai older adults with T2DM to practice SMBG Diabetes-related numeracy did not have a significant relationship with overall diabetes self-management, which is consistent with previous studies (Cavanaugh et al., 2008; Osborn et al., 2011; White et al., 2011).

Although diabetes-related numeracy did not predict diabetes self-management, diabetes-related numeracy is one of the modifiable factors that was expected to predict diabetes control in the conceptual framework of the study. The overall regression models significantly predicted diabetes self-management. In addition, this study found a significant positive interrelationship at a moderate level between diabetes-related numeracy and the other modifiable factors such as health literacy, diabetes knowledge, and self-efficacy. Thai older adults with T2DM in the study who had higher diabetes-related numeracy had higher health literacy, greater diabetes knowledge, and greater self-efficacy. The results were consistent with previous studies. DNT scores have been associated with other factors that might impact diabetes control such as diabetes knowledge (Huizinga et al., 2008), diabetes self-efficacy (Osborn, et al., 2010b), health literacy and mathematical skills (Huizinga et al., 2008; White, et al., 2011). It is possible

that diabetes-related numeracy truly might not have a direct effect on diabetes outcomes like diabetes self-management and glycemic control but diabetes-related numeracy might have a relationship with another factor and then through that other factor affect diabetes self-management and glycemic control. Osborn et al. (2009) reported that diabetes-related numeracy explained the relationship between African American race and poor glycemic control, and they hypothesized that this might be part of the relationship of diabetes-related numeracy to diabetes self-management.

Age, Diabetes Knowledge and Diabetes Self-Management

In bivariate correlations, age has a negative relationship with diabetes knowledge; Thai older adults with T2DM who were older had lower diabetes knowledge. Whereas in multiple correlational analyses, age has a positive relationship with diabetes self-management; Thai older adults with T2DM who were older had better diabetes self-management. There are three factors that may explain this result. First, the relationships among independent factors and outcomes in multiple regressions may be different from relationships between independent factors and outcomes from bivariate analysis because in multiple correlations the third variable in the analysis changes the relationship between the two variables. For example, the third variable might suppresses irrelevant variance in the relationship between predictor and outcome variables. Second, as per the ADA recommendation (2014), patients with diabetes need ongoing diabetes self-management that consists of multiple domains such as diet behavior, exercise, taking medication adherence, self-monitoring blood glucose, and foot care. The questions in the diabetes knowledge questionnaire used in the present study may not cover enough information

needed for self-management or the content of the items may not have a close relationship to behaviors measured by the diabetes self-management questionnaire (SDSCA). Thai older adults with T2DM in this study could be engaged in good self-management behaviors without knowing the correct answers to every question on the diabetes knowledge test. Third, the participants in this study are older adults with an average of duration of diabetes of 9 years, with much of the sample having diabetes for more than two years. These older adult may have learned from their experiences using trial and error to control their diabetes.

Predicting Glycemic Control (A1C)

Diabetes knowledge demonstrated a significant relationship and contributed to the prediction of A1C but the relationship was *positive*, meaning more knowledge was associated with higher (worse) A1C. In contrast, diabetes knowledge has also been shown to have a negative relationship with A1C (McPherson, et al., 2008; Nguyen et al., 2010; Srichana, 2005). This study used a cross-sectional design and collected data at one point in time to explore the relationships among variables at fixed time (Polit & Beck, 2004). The cross-sectional design does not allow investigation of the sequence of events in the relationships. It is possible that the patients with poor glycemic control might have received extensive attention from health care providers and received explanations about diabetes and glycemic control that helped them improve their self-management and glucose control. Therefore, they might have high scores on diabetes knowledge. Or, the patients who had poor glycemic control may have sought out more health information to

decrease their glycemic levels. Therefore, it is unknown whether high A1C is the cause or effect of diabetes knowledge in this study.

Duration of Diabetes and Glycemic Control (A1C)

Three previous studies demonstrated that duration of diabetes was significantly positively correlated with glycemic control as measured by A1C (Osborn et al., 2009; Osborn et al., 2010b; Wattanakul, 2012). The hierarchical multiple regression analysis results in this study demonstrated that duration of diabetes was not related to any modifiable factors or to diabetes self-management although duration of diabetes was significantly related to A1C. Thai older adults with T2DM in the study who had longer diabetes duration had worse A1C. In the first model, non-modifiable personal factors such as age, gender, education, and duration of diabetes accounted for just 7% of the total variance in A1C and only duration of diabetes was a significant predictor of A1C. In the second model, modifiable factors were added in the equation, and in the final model, diabetes self-management was added in the equation; however, the R^2 change of adding the modifiable factors and the R^2 change of adding diabetes self-management in each model were small and non-significant. Diabetes knowledge was a significant predictor and a stronger predictor than duration of diabetes. Modifiable factors and diabetes self-management in this present study show no strong effect on A1C perhaps because this study included only older adults. Older adults face multifaceted changes (Ferraro, 2013). For example, some older adults experience deteriorative changes that result in physical impairment, reduced functional abilities, and decreased in hormone secretion (Eliopoulos, 2014) especially, in older adults with diabetes. People with diabetes who do not have

good diabetes control have chronic hyperglycemia which leads to chronic blood vessel dysfunction, which damages cells and tissues throughout the body (Michel, 2011). Therefore, longer duration of diabetes may contribute physiological changes and also, reflect glycemic level.

One concern is that outliers in the data might exert undue influence on the relationship between duration of diabetes and A1C. This study collected data from older adults who had been diagnosed with diabetes since adult age. This present study found five extreme values in duration of diabetes; five participants had diabetes for 30 years and three extremely high values of A1C including 13.8% for two participants and 19.1% for one participant were identified by the boxplot check. As Field (2009) suggested, one option is to remove outlier cases if they are not from the population that study intent to explore.

After examining each participant who had extremely high values of either duration of diabetes or A1C, it was found that all of them belonged in the study's population. The score of outliers were changed to the next highest score plus one or the mean plus two standard deviations (Field, 2009). However, including the outliers in the analysis after changing the scores via the two options did not make a difference in the prediction of diabetes self-management and A1C compared to analysis when the five participants who had extreme values of duration of diabetes or three participants who had extremely high values of A1C were included in the analysis with their original values.

Diabetes Self-Management and Glycemic Control (A1C)

Diabetes self-management was not a significant predictor of A1C in Thai older adults with T2DM in this study, which does not support the conceptual framework of the study. Osborn, et al. (2010a) found that patients who had better diabetes self-management had better glycemic control but the correlation was small. In Thailand, studies conducted with all age groups reported that the relationship between diabetes self-management and glycemic control was ambiguous. In addition, most studies used FPG to evaluate glycemic control instead of A1C. FPG is a blood glucose test that reports the blood glucose level in the moment and is fairly easy for patients to manipulate while A1C indicates the amount of blood glucose that is attached to hemoglobin molecules in red blood cells over the red blood cell's life span (Michel, 2011). Therefore, A1C is a more accurate evaluation of blood sugar level over the course of months. However, Wattanakul's study (2012) found that diabetes self-management was not significantly related to A1C in Thai older adults with T2DM. It is possible that the measurement of diabetes self-management may not capture the self-management activities that affect A1C for older adults such as exercise domain. Older adults may have the difficult in exercise but they might be better in diet behavior. In addition, the target population in this study is older adults. Older adults are often faced with aged-related changes of degeneration that leads to physical and cognitive impairments such as decline in sensory-perceptual abilities, less selective orienting of attention, learning deficits related to speed and some memory function, (Stine-Morrow & Miller, 1999). Therefore, older adults with diabetes may have more difficulty performing certain behaviors than younger adults. Finding the relationship between the separated behaviors of diabetes self-management and diabetes

outcomes may be more appropriate. For instance, older adults might have difficulty exercising but might practice better diet behaviors. In this study, most older adults had good practice in medication adherence but just fair levels for diet and exercise behaviors. This study did not measure physical or cognitive impairments or life experiences, social support, or motivation that might have impacted self-management behaviors for better or worse.

Health Literacy and Glycemic Control (A1C)

Health literacy was not a significant predictor of A1C after controlling for age, gender, education, duration of diabetes, diabetes-related numeracy, diabetes knowledge, self-efficacy, and diabetes self-management in the present study. Overall, evidence for the relationship between health literacy and glycemic control has been inconsistent across studies. A number of studies reported a non-significant relationship between health literacy and glycemic control (Bains & Egede, 2011; DeWalt et al., 2007; Kim et al., 2004; Mancuso, 2010; Morris, et al., 2006; Yamashita & Kart, 2011) and others reported a significant relationship (Powell et al., 2007; Schillinger et al., 2002; Schillinger et al., 2006; Tang et al., 2008). Although this study demonstrated that health literacy was significantly related to diabetes self-management, health literacy did not seem to have a direct effect on biophysical measurements such as A1C that indicate glycemic control.

Diabetes-Related Numeracy and Glycemic Control (A1C)

Diabetes-related numeracy did not show a significant relationship with A1C in this study. This finding was inconsistent with previous studies that found diabetes-related numeracy had a moderate to strong significant relationship with and ability to predict

glycemic control (Cavanaugh et al., 2008; Osborn et al., 2009). However, these studies included participants from all adult age groups with both T1DM and T2DM while this study focused only older adults with T2DM. In the studies by Cavanaugh et al. (2008) and Osborn et al. (2009), 96% of the A1C values from the participants were obtained over a 6 month period, with a range of 0-323 days ,whereas this study obtained A1C data within just three months of survey data collection. A1C indicates the amount of blood glucose that is attached to hemoglobin molecules in red blood cells over the red blood cell's life span (Michel, 2011) that normally was evaluated for three months. Therefore, after three months, patients might not have the same A1C.

The Correlation of Education and Factors in the Study

This present study found that education was related to modifiable factors such as health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy, which is consistent with the conceptual framework. Thai older adults with T2DM who had higher education had higher health literacy, higher diabetes-related numeracy, greater diabetes knowledge, and greater self-efficacy. In bivariate analyses, education did not show a significant relationship with diabetes self-management but in hieratical multiple regression education was a significant predictor of diabetes self-management. However, the significant relationship between education and diabetes self-management became non-significant when modifiable factors were added in the final model to predict diabetes self-management.

The study of Schillinger et al. (2006) found that education was significantly associated with A1C but in path analysis, after health literacy was included in the model,

the relationship between education and A1C became non-significant. Therefore, health literacy mediated the relationship between education and A1C. However, the present study did not investigate the mediator or moderator relationship among the independent variables and diabetes outcomes.

Factors other than the selected non-modifiable personal factors and modifiable factors in this study might have impacted glycemic control. For example, Tang et al. (2008) measured the variables that were similar to those in the present study, except for patient awareness score. Tang et al. found that in an adjusted model that included gender, duration of diabetes, having insurance, patient awareness in complication score, medication adherence subscale of the C-SDSCA and health literacy, that being male, less duration of diabetes, increased patient awareness score, higher health literacy, and higher scores on the medication adherence subscale of the C-SDSCA significantly predicted lower A1C, accounting for an impressive 98.6% of the variance in A1C. The predictors in Tang et al.'s study were similar to the variables measured in the current study and account for a huge amount of variance in A1C. Therefore, patient awareness score should be considered for measurement in future studies.

It is notable that the amount of variance accounted for was much higher in the equation to predict diabetes self-management than in the equation to predict A1C in multiple analyses. Beyond the factors that were investigated for their relationship with A1C in this study, there may be other factors that affected A1C levels that were not measured in this present study or included as predictors such as comorbidities, smoking, and diabetes medication treatment. In this study participants had comorbidities such as

hypertension (76%), high cholesterol (54%), and neurological problem (24%). In addition, 16% of the participants smoked. For diabetes medication treatment, most participants received oral medication for diabetes treatment while some participants received insulin treatment. These variables were not included in the analyses because they were not included in the conceptual model.

Limitations

Three limitations are noted in this study:

1. This study is a correlation study. Findings of the study about factors contributing the predictions in diabetes self-management and glycemic control cannot suggest a causal relationship. In addition, the cross-sectional design also observes the relationship between factors and health outcome at a single point of time and does not examine how the relationship between health behaviors and health outcomes may change over time.
2. This study recruited the participants from primary care units, and a community hospital. It is unclear if findings from this study would generalize to Thai older adults with T2DM in other parts of Thailand or who do not visit primary care clinics.
3. The original DNT was developed for a Western culture. Although the process of translating the DNT to the Thai language focused on a symmetrical approach and kept conceptual equivalence, many items were

modified from the original DNT to fit with Thai older with T2DM. Therefore, the context of Thai DNT may not be exactly equivalent with the original DNT, and it is not possible to compare the diabetes-related numeracy with other samples.

Conclusions

1. Thai older adults with T2DM in this study who were older demonstrated higher diabetes knowledge, and higher self-efficacy which predicts better diabetes self-management after controlling gender, education, duration of diabetes, health literacy, and diabetes related numeracy.
2. Duration of diabetes and diabetes knowledge predict glycemic control in older adults with T2DM in the study. Older adults who had longer duration of diabetes had worse glycemic control while those who had more diabetes knowledge had worse glycemic control.
3. In Thai older adults with T2DM, people who had higher health literacy tended to have higher diabetes related numeracy, greater diabetes knowledge, and greater self-efficacy.
4. Self-monitoring blood glucose remains impractical for Thai older adults with T2DM in the communities participating in this study. Only a few participants tested their blood glucose themselves.
5. Thai older adults with T2DM in the community had knowledge deficits in aspects of diabetes-related numeracy such as using food labels, food

proportion, and increasing of blood sugar after carbohydrate intake.

Implications and Recommendations

This section includes the implications for theory, research, practice, education, and policy in Thailand.

IMPLICATIONS FOR THEORY

The conceptual framework for this study combined the cultural component of health literacy (Zarcadoolas et al., 2005) and Nutbeam's (2000) three levels of health literacy. In addition, this study included concepts related to diabetes control drawn from the scientific literature including diabetes related numeracy, diabetes knowledge, and self-efficacy (see Figure 1). The results of the study partially support the conceptual framework in the prediction of diabetes outcomes. Age, diabetes knowledge, and self-efficacy were predictors of diabetes self-management while duration of diabetes and diabetes knowledge were predictors of glycemic control. However, the overall amounts of predicted variance in diabetes self-management and glycemic control were small suggesting that other variables influence diabetes self-management and glycemic control. For instance, social support, patients' awareness of complications and complication screening reports, functional impairment, health policy, body mass index (BMI), medication treatment for diabetes, and comorbidity might explain variance in self-management and glycemic control. Generally, Thai families are composed of more than one generation in the house. Therefore, other family members may help older adults to

prepare meals and take older adults to exercise. Patients with high complication awareness in medical records and complication screening reports and good diabetes management of treatment can affect glycemic control in Chinese patients with diabetes (Tang et al., 2008). Functional impairment might affect older adults' self-management (Blaum et al., 2010; Bruce et al., 2003) and received fewer opportunities to receive health care services such as diabetes education, diet consulting (Bruce, Davis, Cull, & Davis, 2003), and exercise counseling (Forjuoh et al., 2011). Therefore, older adults may lack opportunities to learn how to improve their diabetes self-management. Health policy also affects diabetes care. For example, most Thai older adults with T2DM in this study did not practice self-monitoring blood glucose. Public health policies did not cover the cost. Self-monitoring blood glucose is important for patients with diabetes to check their glycemic condition. When patients with diabetes know their glycemic condition that it is low, high, or in control level, they can make a decision about how to manage their diabetes and achieve glycemic control.

Duration of diabetes and diabetes knowledge were the only predictors from the conceptual framework of the study that predicted diabetes control. Age, gender, education, health literacy, diabetes related numeracy, self-efficacy, and diabetes self-management were not significant predictors. The overall amounts of predicted variance in glycemic control was low. Other variables that impact physiological changes may influence individual’s glycemic level of patients with diabetes such as medication treatment for diabetes and comorbidity because those variables affect directly to glycemic levels.

The conceptual framework suggests age, diabetes knowledge, and self-efficacy would contribute to diabetes self-management while duration of diabetes contributes glycemic control. Therefore, these variables should be included in testing of future model. Although gender, education, health literacy, and diabetes related numeracy were not significant predictors of either diabetes self-management or glycemic control in the final model, the significant relationships between factors and between factors and diabetes outcomes were found in correlation analysis. Therefore, these variables should stay in the model. Lastly, the Thai DNT did not contribute significantly to the predictive models; the Thai DNT may need further revisions.

IMPLICATIONS FOR RESEARCH

This study fills a large gap in the professional knowledge of diabetes self-management in Thai older adults with T2DM. Several studies of relationships pertaining to diabetes control and intervention studies to improve diabetes outcomes have been performed but there are few studies with older adults and fewer in Thailand. From a review of experimental and quasi-experimental nursing research studies in patients with diabetes conducted during 1982-2005 in Thailand, only 6.4% focused on older adults with diabetes (Playrahan, 2008).

This study suggests the following opportunities for advanced research. As diabetes self-management is concerned with ongoing behaviors to control the disease, the cross-sectional design of this study can only measure the relationships among factors at one point in time. A longitudinal study is needed to monitor changes in behaviors and

diabetes outcomes over time. Findings in this study demonstrated that the measured factors predict diabetes outcomes but the amount of explained variance is small in the predictions of both diabetes self-management and glycemic control. Other factors not included in this study must have a relationship with these two diabetes outcomes. Previous studies found social support and belief in the treatment might also be important to explore among Thai older adults.

Although this study provides information about diabetes knowledge and self-efficacy as predictors for diabetes self-management in Thai older adults, the correlation study does not assume causation. A path analysis study or structural equation modeling analysis may help the researcher to better understand the relationship between factors and diabetes outcomes. In addition, an intervention study to enhance diabetes knowledge and diabetes related numeracy based on health literacy level might be advantageous to older adults with T2DM to improve their diabetes self-management. One such intervention study might involve the creation of an educational program using materials and strategies appropriate for older adults with T2DM to address issues of low education or low health literacy.

Diabetes related numeracy is a relatively new concept in Thailand. A qualitative study is needed to better understand the ways in which Thai older adults with T2DM use numbers in their daily self-management. Although diabetes related numeracy did not show a significant relationship with diabetes self-management, diabetes related numeracy demonstrated a relationship with other factors (health literacy, diabetes knowledge, and self-efficacy), which do relate to diabetes self-management.

IMPLICATIONS FOR PRACTICE

In Thailand, nurses work with T2DM patients to help them maintain healthy self-management behaviors and achieve glycemic control. As witnessed during data collection in the communities, nurses who work in the communities took on numerous responsibilities to promote self management among older adults with T2DM in the communities such as giving health information to individuals and groups while running a diabetes clinic or during a patient's visit to a clinic, creating health projects to promote health for older adults, and participating in older adults' organizations once a month as a consultant about health. Findings from the study can be shared with nurses to improve understanding about which factors relate significantly to diabetes self-management and glycemic control. The nurses can then apply that information to their self-management efforts with older adults with T2DM.

This study established a valid and reliable version of the DNT for the Thai language and culture to measure diabetes-related numeracy skills for older adults with T2DM. Nurse-scholars and clinicians now have an instrument to screen the numeracy skills of Thai older adults with T2DM and then provide the information in areas of deficient knowledge.

The present study found a relationship among health literacy, diabetes related-numeracy, diabetes knowledge, and self-efficacy, and a relationship between diabetes knowledge and self-efficacy to diabetes glycemic control. With this information, nurses can provide lifelong learning opportunities for older adults with diabetes by creating diabetes education programs, interventions, and teaching materials to use in teaching

numeracy skills to older adults with diabetes to more effectively improve their self-management knowledge and behaviors, promote self-efficacy and better health, and decrease and prevent chronic disease-related complications.

IMPLICATIONS FOR NURSING EDUCATION

Thailand has become an aging society. Older people account for 14.5% of the Thai population (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2013). Older people are particularly affected by diabetes. The population of older adults with diabetes is growing in Thailand. Among all Thai adults with diabetes, older adults with diabetes have a higher risk of diabetes-related complications than younger adults with diabetes. However, there are gaps of knowledge about factors to related diabetes self-management and glycemic control in the older adult population. It is necessary to prepare nursing students to better understand how to care for older adults in their self-management efforts to control the disease and prevent diabetes related complications.

Findings from the study showed a relationship among health literacy, diabetes-related numeracy, diabetes knowledge, and self-efficacy to diabetes self-management and diabetes control that is beneficial to integrate into the curriculum of gerontology nursing. Most information in textbooks and documents in nursing education rely on Western knowledge. Although factors in the study contributed a small amount to predict diabetes outcomes, this information is based on data from Thai older adults with T2DM, which increases evidence in support of knowledge regarding Thai older adults.

IMPLICATIONS FOR POLICY IN THAILAND

The Thai Eleventh National Economic and Social Development Plan (2012-2016) focuses on developing the potential of every individual at all levels to reach health policy goals (National Economic and Social Development Board, 2012). Thai public health policies support the use of diabetes self-management by older adults to prevent the development or worsening of diabetes-related complications (National Economic and Social Development Board, 2012). This study provides knowledge about diabetes self-management and glycemic control in Thai older adults with T2DM, thereby contributing evidence policy makers can use when planning health policy, such as making lifelong learning opportunities available about diabetes self-management for every Thai older adult with T2DM to promote better health, and decrease and prevent diabetes-related complications. Based on the results of the present study, public health policy should recommend an assessment for health literacy, diabetes knowledge, and diabetes-related numeracy then provide the diabetes education that include information about food label, and food proportion for older adults with T2DM. Diabetes education should also be modified to build on an individual's health literacy, and diabetes-related numeracy level. Especially for older adults who had low health literacy and diabetes-related numeracy, specific diabetes education classes that use readable materials and effective teaching methods appropriate for this population.

In addition, only a few of Thai older adults with T2DM in this study tested their blood glucose levels themselves. SMBG supplies and equipment are available but are expensive and are not covered by health insurance or reimbursed by the government.

Many Thai people with diabetes do not have access to or cannot afford to perform SMBG. Therefore, SMBG remains impractical in the communities. However, SMBG is important for patients with diabetes. SMBG helps patients to know their current blood glucose levels and prompt them to manage hyper- and hypoglycemia. Therefore, SMBG should be included in health policy change of Thailand.

APPENDICES

Appendix A: Framework for Considering Treatment Goals for Glycemia, Blood Pressure, and Dyslipidemia in Older Adults with Diabetes

A Framework for Considering Treatment Goals for Glycemia, Blood Pressure, and Dyslipidemia in Older Adults with Diabetes

Patient Characteristics/ Health Status	Rationale	Reasonable A1C Goal (A Lower Goal May Be Set for an Individual if Achievable without Recurrent or Severe Hypoglycemia or Undue Treatment Burden)	Fasting or Preprandial Glucose (mg/dL)	Bedtime Glucose (mg/dL)	Blood Pressure (mmHg)	Lipids
Healthy (Few coexisting chronic illnesses, intact cognitive and functional status)	Longer remaining life expectancy	<7.5%	90–130	90–150	<140/80	Statin unless contraindicated or not tolerated
Complex/intermediate (Multiple coexisting chronic illnessesa or 2+ instrumental ADL impairments or mild to moderate cognitive impairment)	Intermediate remaining life expectancy, high treatment burden, hypoglycemia vulnerability, fall risk	<8.0%	90–150	100–180	<140/80	Statin unless contraindicated or not tolerated
Very complex/poor health (Long-term care or end-stage chronic illnessesb or moderate to severe cognitive impairment or 2+ ADL dependencies)	Limited remaining life expectancy makes benefit uncertain	<8.5%c	100–180	110–200	<150/90	Consider likelihood of benefit with statin (secondary prevention more so than primary)

This represents a consensus framework for considering treatment goals for glycemia, blood pressure, and dyslipidemia in older adults with diabetes. The patient characteristic categories are general concepts. Not every patient will clearly fall into a particular category. Consideration of patient/caregiver preferences is an important aspect of treatment individualization. Additionally, a patient's health status and preferences may change over time. ADL = activities of daily living.

a Coexisting chronic illnesses are conditions serious enough to require medications or lifestyle management and may include arthritis, cancer, congestive heart failure, depression, emphysema, falls, hypertension, incontinence, stage III or worse chronic kidney disease, MI, and stroke. By

multiple we mean at least three, but many patients may have five or more.132

b The presence of a single end-stage chronic illness such as stage III–IV congestive heart failure or oxygen-dependent lung disease, chronic kidney disease requiring dialysis, or uncontrolled metastatic cancer may cause significant symptoms or impairment of functional status and significantly reduce lift expectancy.

c A1C of 8.5% equates to an estimated average glucose of ~200 mg/dL. Looser glycemic targets than this may expose patients to acute risks from glycosuria, dehydration, hyperglycemic hyperosmolar syndrome, and poor wound healing.

Copy from Sue Kirkman et al., 2012, p.10

Appendix B: Psychometric properties of the Instrument Used in the Study

Variables	Measurement	Score Items	Validity	Reliability
Personal factors	Age, Gender, Education level, Duration of diabetes			
Health literacy (HL)	Three Level of Health Literacy Scale-Thai version (Thai-TLHLS, Chontichachalalauk, 2014)	14 items measured with a four-point response scale (1 = never to 4 = often) - Possible scores from 14 to 56 5 items, functional; 4 items, critical; and 5 items, communication HL	In original version of Ishikawa et al. (2008) reported that content validity was supported by exploratory factor analysis and construct validity was supported by correlations between health literacy and other measures. Correlations between HL scales and other measures include diabetes knowledge r = 0.37, p <.001. Translated to Thai language with cultural appropriate methods by researcher, cognitive interview, back-translated was checked by health literacy expert	In original of Ishikawa et al. (2008) reported that Functional α = .84, Critical α = .77, and Communication α = .65 for subscale of the health literacy. Cronbach's of the total HL scale = 0.78. In Thai version of TLHLS, Functional α = .933, Critical α = .899, and Communication α = .871 for subscale of the health literacy
Diabetes-related Numeracy	The Diabetes Numeracy Test (Huizinga et al. ,2008)	43 items -9 items of nutrition; 4 items of exercise; 4 items of SMBG; 5 items of oral medication use; 21 items of insulin used Items are scored as binary outcomes. -correct or incorrect – with no partial credit	Construct validity from the prior construct model and expected correlations from expert panel. The DNT was correlated with education (ϱ = 0. 52), income (ϱ = 0. 51), literacy (REALM, ϱ = 0.54), Numeracy (WRAT, ϱ = 0.62), and diabetes knowledge (DKT, ϱ = 0.71) indication construct validity.	Internal consistency (KR-20 = 0.95), indication high reliable

Variables	Measurement	Score Items	Validity	Reliability
Diabetes Knowledge	The General Knowledge of Patients with Diabetes-Thai scale (Wongwiwatthananukit, Krittiyanumt, & Wannapinyo, 2004)	21 items -5 items, general knowledge of diabetes and diagnosis; -5 item, diabetes related complications; -6 items, self-care on daily basis and on sick day; 5 items, taking medication to control diabetes Items are scored as true, false, and do not know	Content validity by an expert panel. The difficulty index of items ranged from 0.18 to 0.87. In Thai version of DMSES, Wattanakul (2012) reported the difficult index of the items range from 0.31-0.88.	Kruder-Richardson 20 of 0.81 In Thai version of DMSES, Wattanakul (2012) reported the Cronbach's alpha was 0.848.
Self-efficacy	The Diabetes Management Self-Efficacy Scale (Thai DMSES, Iamsumang, 2009)	20 items with 5-choice Likert response scales (1 = definitely not; 2 = probably not; 3 = maybe yes/maybe no; 4 = probably yes; and 5 = definitely yes) and possible scores range from 20 to 100	Semantic equivalence between the original English version and Thai version with an Intra-class Correlation Coefficient (ICC) of 0.88. The scale-level CVI was 0.96 and the item-level CVI was 0.80 and higher, indicating acceptable content validity. Exploratory and confirmatory factor analysis suggested the T-DMSES has three subscales using 19 items. The convergent validity of the Thai-DMSES with a moderate correlation with the Thai-General Self-Efficacy-Scale ($r = 0.36$, $p < 0.01$).	Cronbach's alpha of 0.95 Test-retest reliability with ICC of 0.69.

Variables	Measurement	Score Items	Validity	Reliability
Diabetes self-management behaviors	The Summary Diabetes Self-Care Activities-Thai (SDSCA-Thai, Wattanakul, 2012)	17 items 5 items, healthy eating activities;2 items, physical activities; 3 items, medication adherence; 2 items, blood glucose monitoring test; 5 items (foot care)		In Toobert et al., 2000) reported test-retest correlations over 3-4 months were moderate, with mean r = 0.40, ranging from r = -0.05 (for medications) to 0.78 (for glucose testing. In Thai-SDSCA, Wattanakul (2012) reported that the Cronbach's alpha of the SDSCA-Thai was .752. The Cronbach's alpha of each scale was 0.952 for general diet, 0.588 for specific diet, 0.624 for exercise, 0.459 for blood glucose testing, 0.947 for medication adherence, and 0.547 for foot care.
Glycemic control	Glycosylated hemoglobin A1C	Patients' profile at primary care units and a primary based hospital		

Appendix C: Permission Letters to Use the Instrument in the Study

UTmail Mail - Ask a permission to use the Functional, Commu... https://mail.google.com/mail/u/0/?ui=2&ik=5668a5c3f8&view...

Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Ask a permission to use the Functional, Communicative, and Critical Health literacy
4 messages

Jiraporn Chontichachalala <chonjira@utexas.edu> Wed, Nov 7, 2012 at 8:14 PM
To: hirono-tky@umin.ac.jp

Dear Assoc.Prof.Dr.Hirono Ishikawa

I am Thai people. Now, I am a doctoral nursing at The University of Texas at Austin, school of nursing. I will do the dissertation about health literacy for patients with diabetes in Thailand. Therefore, I would like to ask a permission to use the Functional, Communicative, and Critical Health literacy. It will be useful for my patients with diabetes, if my research may help to fullfill a gap of knowledge in diabetes care. In addition, if I need to do some process about ask a permission, please let me know.

I found in BiomedExperts website that u have network in Thailand. If you work with some person about health literacy in Thailand, would you please suggest me to contact them. I think health literacy is a new concept inThailand, If we have network, it will be better to develop the knowlege. Thank you very much.

I am not sure that can I contact in person or pass your department, so, if it is duplicated, I am apologized in advance.
Kind regard,
Jiraporn Chontichachalalauk

Hirono Ishikawa <hirono-tky@umin.ac.jp> Wed, Nov 7, 2012 at 10:28 PM
To: Jiraporn Chontichachalala <chonjira@utexas.edu>

Dear Jiraporn Chontichachalala

Thank you for your interest in our scale.
Please find attached the English translation of the HL scale.
You can adopt it into Thai for your study.
I would appreciate if you could cite our paper in Diabetes Care
when you publish your study.

Best wishes,
Hirono Ishikawa

-
Hirono Ishikawa, PhD
Department of Health Communication
School of Public Health, The University of Tokyo
Address: 7-3-1 Hongo, Bunkyo-ku, Tokyo
113-8655, Japan
Phone: +81-3-5800-8781
Fax: +81-3-5689-0726
email: hirono-tky@umin.ac.jp

UT MAIL

Jiraporn Chontichachalalauk <chonjira@utexas.edu>

would like to ask a permission to use the DNT_Jiraporn

2 messages

Jiraporn Chontichachalalauk <chonjira@utexas.edu> Mon, Jun 23, 2014 at 11:08 AM
To: mary.margaret.huizinga@vanderbilt.edu

Dear Professor Huizinga

I am a doctoral nursing student at the University of Texas at Austin, School of Nursing. My research of interest is Thai older adults with diabetes. I am interested to evaluate and investigate diabetes-related numeracy and relationship with other factor in Thai people.

I would like to ask a permission to translate the Diabetes Numeracy Test. However, one concern is the different of language and culture between Western and Thai people that make it difficult to translate and use the Diabetes Numeracy Test without adaptation.

Therefore, I would like to ask a permission to modify of the translated DNT for culture equivalence for Thai people in my dissertation. The number of items of Thai-DNT might be different from original. The findings of the study will be published in my dissertation and within the journals derived from the study.

Please let me know if you allow me to use your instrument. Upon your email confirmation I will forward a permission letter for you signature.

Thank you in advance.

Best regards,

--
Jiraporn Chontichachalalauk
Ph.D. Candidate, RN
The University of Texas at Austin
School of Nursing
1700 Red River
Austin, TX 78701
Tel.512-426-9092
Email: chonjira@utexas.edu

Huizinga, Mary Margaret <mary.margaret.huizinga@vanderbilt.edu> Mon, Jun 23, 2014 at 11:26 AM
To: Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Hi Jiraporn,
Please do use and modify the DNT as needed - no permission letter needed.
Best,
Mimi Huizinga

Sent from my iPhone
[Quoted text hidden]

UT MAIL

Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Ask a permission to use the General Knowledge of Diabetic Patients_Jiraporn

2 messages

Jiraporn Chontichachalalauk <chonjira@utexas.edu> Wed, Jul 2, 2014 at 2:14 AM
To: supakit@hawaii.edu

Dear Assoc.Pro. Dr. Supakit Wongwiwatthananukit

I am a nurse instructor at Ramathibodi School of Nursing, Ramathibodi Hospital, Mahidol University. Now, I am studying in doctoral degree in nursing at the University of Texas at Austin, School of Nursing. My research of interest is Thai older adults with diabetes. My purposes of the study is to explore the relationships among selected personal factors, health literacy, diabetes-related numeracy, diabetes knowledge, diabetes self-efficacy, diabetes self-management, and glycemic control in Thai older adults with T2DM.

I would like to ask a permission to use and get reprint of the general knowledge of diabetic patients that published from reference below;

Wongwiwatthananukit, S., Krittiyanunt, S, & Wannapinyo, A. (2004). Development and validation of an instrument to assess the general knowledge of patients with diabetes.

The Thai Journal of Pharmaceutical Sciences. 28(1-2), 17-29.

The findings of the study will be published in my dissertation and within the journals derived from the study. One concern is that the general knowledge of patients with diabetes in Thai version will be translated into English language. Both Thai and English version of the general knowledge of patients with diabetes will document in my dissertation.

Please let me know if you allow me to use your instrument. Upon your email confirmation I will forward a permission letter for you signature.

Thank you in advance.

Best regards,

--
Jiraporn Chontichachalalauk
Ph.D. Candidate, RN
The University of Texas at Austin
School of Nursing

1700 Red River
Austin, TX 78701
Tel.512-426-9092
Email: chonjira@utexas.edu

Supakit Wongwiwatthananukit <supakit@hawaii.edu> Wed, Jul 2, 2014 at 6:23 AM
To: Jiraporn Chontichachalalauk <chonjira@utexas.edu>

สวัสดีครับคุณจิราพร

ด้วยความยินดีครับ ผมอนุญาตให้ใช้แบบสอบถามตามที่ขอครับ หากมีอะไรให้ผมช่วย

บอกมาได้เลยนะครับไม่ต้องเกรงใจ พอดีช่วงนี้ผมไม่ได้อยู่อเมริกา เลยไม่สามารถจัดส่งreprintให้ได้ครับ ผมจะกลับช่วงกลางเดือนสิงหาคมครับ ผมคิดว่าหากคุณจิราพรรู้จักใครที่เมืองไทยก็ขอให้เค้าcopy และscan ส่งให้เลยจะดีกว่ารอผมส่งให้นะครับ

ขออวยพรให้ประสบผลสำเร็จนะครับ

ศุภกิจ

UT MAIL

Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Ask a permission to use the T-DMSES_Jiraporn

2 messages

Jiraporn Chontichachalalauk <chonjira@utexas.edu> Tue, Jul 1, 2014 at 3:10 PM
To: towipa@gmail.com

Dear Professor Dr. Wipa Iamsumang

I am a nurse instructor at Ramathibodi School of Nursing, Ramathibodi Hospital, Mahidol University. Now, I am studying in doctoral degree in nursing at the University of Texas at Austin, School of Nursing. My research of interest is Thai older adults with diabetes. One of my purposes of the dissertation is to explore the relationships among selected personal factors, health literacy, diabetes-related numeracy, diabetes knowledge, diabetes self-efficacy, diabetes self-management, and glycemic control in Thai older adults with T2DM.

I would like to ask a permission to use and get reprint of the Thai version of the Diabetes Management Self-Efficacy Scale (T-DMSES) for older adults with T2DM. that published in your doctoral dissertation at the State University of New York at Buffalo, Department of the School of Nursing.

The T-DMSES will be used in original Thai language. The findings of the study will be published in my dissertation and within the journals derived from the study. One concern is that the T-DMSES might be adjusted some items or format to appropriately use for study population. Both Thai and English version of the T-DMSES will document in my dissertation.

Please let me know if you allow me to use your instrument. Upon your email confirmation I will forward a permission letter for you signature.

Thank you in advance.

Best regards,

--
Jiraporn Chontichachalalauk
Ph.D. Candidate, RN
The University of Texas at Austin
School of Nursing
1700 Red River
Austin, TX 78701
Tel.512-426-9092
Email: chonjira@utexas.edu

Wipa Iamsumang Jaramillo <towipa@gmail.com> Thu, Jul 3, 2014 at 12:56 AM
To: Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Yes, you can use my tool. Please let me know if you need my hand.
Wipa Iamsumang Jaramillo

Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Ask a permission to use the SDSCA_Jiraporn

4 messages

Jiraporn Chontichachalalauk <chonjira@utexas.edu> Thu, Aug 14, 2014 at 5:47 PM
To: deborah@ori.org

Dear Dr.Toobert

I am a doctoral nursing student at the University of Texas at Austin, School of Nursing. I come from Thailand. My purpose of the dissertation is to explore the relationships among selected personal factors, health literacy, diabetes-related numeracy, diabetes knowledge, diabetes self-efficacy, diabetes self-management, and glycemic control in Thai older adults with T2DM.

I would like to ask a permission to use and get reprint of the Summary of Diabetes Self-Care Activities (SDSCA). According to the SDSCA was already translated into Thai language by Thai investigators. So, I will use the SDSCA in Thai language from those investigators.

However, the SDSCA was translated into Thai versions and was adapt. My target population is older adults with T2DM and they do not perform self-monitoring blood glucose (SMBG). So, I might not able to measure the subscale of SMBG. I am looking for Thai version of SDSCA from Dr. Boontuan Wattanakul in her doctoral dissertation at University of Chicago, College of Nursing. If you have the appropriate Thai version of SDSCA for my studying, Please let me know.

The findings of the study will be published in my dissertation and within the journals derived from the study. Both Thai and English version of the Summary of Diabetes Self-Care Activities will document in my dissertation.

Please let me know if you allow me to use your instrument. Upon your email confirmation I will forward a permission letter for you signature.

Thank you in advance.

Best regards,

--
Jiraporn Chontichachalalauk
Ph.D. Candidate, RN
The University of Texas at Austin

School of Nursing
1700 Red River
Austin, TX 78701
Tel.512-426-9092
Email: chonjira@utexas.edu

Deborah Toobert <Deborah@ori.org> Fri, Aug 15, 2014 at 12:40 PM
To: Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Dear Jiraporn,

You have our permission to use the Summary of Diabetes Self-Care Activities Questionnaire in your research project. The instrument is in the public domain, and permission is not required. (But you have it anyway). Attached is the 2000 Diabetes Care article with the SDSCA psychometric information. At the end of the article, there is an appendix with the questionnaire, and the scoring information. I have also attached a user-friendly copy of the SDSCA instrument.

Thai translation. I do not have the Thai translation in my possession but have contact information for three investigators to refer you to for a Thai translation. Do I have permission from you to forward your request to them?

Blood Glucose Self Monitoring: Please feel free to omit any section of the SDSCA that is not relevant for your study sample.

Best of luck with your research,

Deborah

From: Jiraporn Chontichachalalauk [mailto:chonjira@utexas.edu]
Sent: Thursday, August 14, 2014 3:47 PM
To: Deborah Toobert
Subject: Ask a permission to use the SDSCA_Jiraporn

[Quoted text hidden]

2 attachments

SDSC-7studies-measure-rev.scale.pdf
57K

Summary of Diabetes Self-DiabetesCare2000.doc
64K

Jiraporn Chontichachalalauk <chonjira@utexas.edu> Fri, Aug 15, 2014 at 9:26 PM
To: Deborah Toobert <Deborah@ori.org>

Dear Dr.Toobert
Thank you very much to give me a permission. Could you please forward my email to those three Thai investigators who translate SDSCA into Thai language.
Best regards,
[Quoted text hidden]

Deborah Toobert <Deborah@ori.org> Sat, Aug 16, 2014 at 2:55 PM
To: Jiraporn Chontichachalalauk <chonjira@utexas.edu>

Jiraporn, I have sent an email to the investigators who may have Thai translations of the SDSCA, and asked them to contact you directly. I hope it works out.

Deborah

Deborah J. Toobert, PhD
Senior Research Scientist
Oregon Research Institute
1776 Millrace Drive
Eugene, Oregon 97403

http://www.ori.org/

Phone:(541) 485-2123
Home office (541) 338-8037
Fax: (541) 434-1505
email: deborah@ori.org

From: Jiraporn Chontichachalalauk [mailto:chonjira@utexas.edu]
Sent: Friday, August 15, 2014 7:26 PM
To: Deborah Toobert
Subject: Re: Ask a permission to use the SDSCA_Jiraporn

[Quoted text hidden]

Appendix D: Permission Letter from Research Setting

October 10, 2014

Dr. James Wilson, Ph.D.
Chair, Institutional Review Board
P.O. Box 7426
Austin, TX 78713
irbchair@austin.utexas.edu

Dear Dr. Wilson:

The purpose of this letter is to grant Ms. Jiraporn Chontichachalalauk, a graduate student at the University of Texas at Austin permission to conduct research at Klong Yong I Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, Ban Salawan Tambon Health Promoting Hospital, and Mahasawat Tambon Health Promoting Hospital, Putthamoltol District, Nakhon Pathom Province.

We understand that the project, "Translation and Evaluation of the Thai Version of Diabetes Numeracy Test-DNT for Older Adults with Type 2 Diabetes" will be conducted in two phases and the purpose of Phase I is to develop the Diabetes Numeracy Test for use with Thai patients and the purpose of Phase II is to explore the relationships among factors affecting diabetes control in older adults with type 2 diabetes. We will allow our government officers at Tambon Health Promotion Hospitals to cooperate 10 Thai older adults with type 2 diabetes for Phase I and an additional 195 patients for Phase II participated in the study. We will be appreciated that the researcher will explain the study's purpose and more information in order to obtain written informed consent and access hemoglobin A1C level for her research.

We are pleased that Tambon Health Promoting Hospitals of Putthamoltol District were selected as sites for this study because diabetes is an important problem in this district and we hope that this study will help us to care diabetes.

I, Mr. Sarot Limpipusana do hereby grant permission for Ms. Jiraporn Chontichachalalauk to conduct Translation and Evaluation of the Thai Version of Diabetes Numeracy Test-DNT for Older Adults with Type 2 Diabetes at Klong Yong I Tambon Health Promoting Hospital, Klong Yong II Tambon Health Promoting Hospital, Ban Salawan Tambon Health Promoting Hospital, and Mahasawat Tambon Health Promoting Hospital, Putthamoltol District, Nakhon Pathom Province.

Sincerely,

[Mr. Sarot Limpipusana]
Putthamoltol District Public Health Chief Officer

Appendix E: Human Subject Approval Document

(IRB, the University of Texas at Austin)

OFFICE OF RESEARCH SUPPORT

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date: 12/02/14

PI: Jiraporn Chontichachalala

Dept: Nursing

Title: Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes

Re: IRB Expedited Approval for Protocol Number 2014-08-0071

Dear Jiraporn Chontichachalala:

In accordance with the Federal Regulations the Institutional Review Board (IRB) reviewed the above referenced research study and found it met the requirements for approval under the Expedited category noted below for the following period of time: 12/02/2014 to 12/01/2015 . *Expires 12 a.m. [midnight] of this date.* If the research will be conducted at more than one site, you may initiate research at any site from which you have a letter granting you permission to conduct the research. You should retain a copy of the letter in your files.

Expedited category of approval:

☐ 1) Clinical studies of drugs and medical devices only when condition (a) or (b) is met. (a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (Note: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review). (b) Research on medical devices for which (i) an investigational device exemption application (21 CFR Part 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

☐ 2) Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows: (a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and children2, considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

☐ 3) Prospective collection of biological specimens for research purposes by non-invasive means. Examples:
(a) Hair and nail clippings in a non-disfiguring manner.

(b) Deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction;
(c) Permanent teeth if routine patient care indicates a need for extraction.
(d) Excreta and external secretions (including sweat).
(e) Uncannulated saliva collected either in an un-stimulated fashion or stimulated by chewing gumbase or wax or by applying a dilute citric solution to the tongue.
(f) Placenta removed at delivery.
(g) Amniotic fluid obtained at the time of rupture of the membrane prior to or during labor.
(h) Supra- and subgingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylactic scaling of the teeth and the process is accomplished in accordance with accepted prophylactic techniques.
(i) Mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings.
(j) Sputum collected after saline mist nebulization.

☐ 4) Collection of data through non-invasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications).
Examples:
(a) Physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy.
(b) Weighing or testing sensory acuity.
(c) Magnetic resonance imaging.
(d) Electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography.
(e) Moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

☒ 5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis).
Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(4). This listing refers only to research that is not exempt.

☐ 6) Collection of data from voice, video, digital, or image recordings made for research purposes.

☒ 7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.
Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b)(3). This listing refers only to research that is not exempt.

☒ Use the attached approved informed consent document(s).

☐ You have been granted a Waiver of Documentation of Consent according to 45 CFR 46.117 and/or 21 CFR 56.109(c)(1).

☐ You have been granted a Waiver of Informed Consent according to 45 CFR 46.116(d).

Responsibilities of the Principal Investigator:

1. Report immediately to the IRB any unanticipated problems.

2. Submit for review and approval by the IRB all modifications to the protocol or consent form(s). Ensure the proposed changes in the approved research are not applied without prior IRB review and approval, except when necessary to eliminate apparent immediate hazards to the subject. Changes in approved research implemented without IRB review and approval initiated to eliminate apparent immediate hazards to the subject must be promptly reported to the IRB, and will be reviewed under the unanticipated problems policy to determine whether the change was consistent with ensuring the subjects continued welfare.

3. Report any significant findings that become known in the course of the research that might affect the willingness of subjects to continue to participate.

4. Ensure that only persons formally approved by the IRB enroll subjects.

5. Use only a currently approved consent form, if applicable.
   Note: Approval periods are for 12 months or less.

6. Protect the confidentiality of all persons and personally identifiable data, and train your staff and collaborators on policies and procedures for ensuring the privacy and confidentiality of subjects and their information.

7. Submit a Continuing Review Application for continuing review by the IRB. Federal regulations require IRB review of on-going projects no less than once a year a reminder letter will be sent to you two months before your expiration date. If a reminder is not received from Office of Research Support (ORS) about your upcoming continuing review, it is still the primary responsibility of the Principal Investigator not to conduct research activities on or after the expiration date. The Continuing Review Application must be submitted, reviewed and approved, before the expiration date.

8. Upon completion of the research study, a Closure Report must be submitted to the ORS.

9. Include the IRB study number on all future correspondence relating to this protocol.

If you have any questions contact the ORS by phone at (512) 471-8871 or via e-mail at orsc@uts.cc.utexas.edu.

Sincerely,

James P. Wilson

James Wilson, Ph.D.
Institutional Review Board Chair

OFFICE OF RESEARCH SUPPORT

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date: 02/11/15

PI: Jiraporn Chontichachalala

Dept: Nursing

Title: Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes

Re: IRB Amendment Approval for Protocol Number 2014-08-0071

Dear Jiraporn Chontichachalala:

In accordance with the Federal Regulations for review of research studies, the Institutional Review Board (IRB) reviewed your requested amendment to the above referenced protocol and found that it met the requirements for approval.

Approval for your study expires on 12/01/2015. *Expires 12 a.m. [midnight] of this date.*

The following requested changes were approved:

Revised Protocol: Add Putthamonthon Community Hospital as a recruitment site, Add Chulalongkorn University graduate students as research assistants; Update the Consent Form

- ☐ Continue to use the original approved consent form(s).
- ☒ Use the attached approved informed consent document(s).
- ☐ You have been granted a Waiver of Documentation of Consent according to 45 CFR 46.117 and/or 21 CFR 56.109(c)(1).
- ☐ You have been granted a Waiver of Informed Consent according to 45 CFR 46.116(d).

Responsibilities of the Principal Investigator:

1. Report immediately to the IRB any unanticipated problems.

2. Submit for review and approval by the IRB all modifications to the protocol or consent form(s). Ensure the proposed changes in the approved research are not applied without prior IRB review and approval, except when necessary to eliminate apparent immediate hazards to the subject. Changes in approved research implemented without IRB review and approval initiated to eliminate apparent immediate hazards to the subject must be promptly reported to the IRB, and will be reviewed under the unanticipated problems policy to determine whether the change was consistent with ensuring the subjects continued welfare.

3. Report any significant findings that become known in the course of the research that might affect the willingness of subjects to continue to participate.

4. Ensure that only persons formally approved by the IRB enroll subjects.

5. Use only a currently approved consent form, if applicable.
   Note: Approval periods are for 12 months or less.

6. Protect the confidentiality of all persons and personally identifiable data, and train your staff and collaborators on policies and procedures for ensuring the privacy and confidentiality of subjects and their information.

7. Submit a Continuing Review Application for continuing review by the IRB. Federal regulations require IRB review of on-going projects no less than once a year a reminder letter will be sent to you two months before your expiration date. If a reminder is not received from Office of Research Support (ORS) about your upcoming continuing review, it is still the primary responsibility of the Principal Investigator not to conduct research activities on or after the expiration date. The Continuing Review Application must be submitted, reviewed and approved, before the expiration date.

8. Upon completion of the research study, a Closure Report must be submitted to the ORS.

9. Include the IRB study number on all future correspondence relating to this protocol.

If you have any questions contact the ORS by phone at (512) 471-8871 or via email at orsc@uts.cc.utexas.edu.

Sincerely,

James P. Wilson

James Wilson, Ph.D.
Institutional Review Board Chair

Appendix F: Human Subject Approval Document (in Thailand)

คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล
๒๗๐ ถนนพระราม ๖ แขวงทุ่งพญาไท เขตราชเทวี กทม. ๑๐๔๐๐
โทร. (๐๒) ๒๐๑-๑๐๐๐

Faculty of Medicine Ramathibodi Hospital, Mahidol University.
270 Rama VI Road, Ratchathewi, Bangkok 10400, Thailand
Tel. (662) 201-1000

Documentary Proof of Ethical Clearance
Committee on Human Rights Related to Research Involving Human Subjects
Faculty of Medicine Ramathibodi Hospital, Mahidol University

MURA2014/667

Title of Project	Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes
Protocol Number	ID 11-57-65
Principal Investigator	Miss. Jiraporn Chontichachalaluak
Official Address	Ramathibodi School of Nursing Faculty of Medicine Ramathibodi Hospital Mahidol University

The aforementioned project has been reviewed and approved by the Committee on Human Rights Related to Research Involving Human Subjects, based on the Declaration of Helsinki.

Signature of Secretary Committee on Human Rights Related to Research Involving Human Subjects	..... Prof. Duangrurdee Wattanasirichaigoon, M.D.
Signature of Chairman Committee on Human Rights Related to Research Involving Human Subjects	..... Prof. Pratak O-Prasertsawat, M.D.
Date of Approval	December 12, 2014
Duration of Study	4 Months

คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล
๒๗๐ ถนนพระราม ๖ แขวงทุ่งพญาไท เขตราชเทวี กทม. ๑๐๔๐๐
โทร. (๐๒) ๒๐๑-๑๐๐๐

Faculty of Medicine Ramathibodi Hospital, Mahidol University.
270 Rama VI Road, Ratchathewi, Bangkok 10400, Thailand
Tel. (662) 201-1000

เอกสารรับรองโดยคณะกรรมการจริยธรรมการวิจัยในคน
คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี
มหาวิทยาลัยมหิดล

เลขที่ ๒๕๕๗/๖๖๗

ชื่อโครงการ	การแปลและประเมินแบบทดสอบความสามารถในการคำนวณที่เกี่ยวกับการจัดการดูแลตนเองของผู้ป่วยเบาหวานสำหรับผู้สูงอายุที่เป็นเบาหวานชนิดไม่พึ่งอินซูลินฉบับภาษาไทย
เลขที่โครงการ/รหัส	ID ๑๑-๕๗-๖๕ ย
ชื่อหัวหน้าโครงการ	นางสาวจิราพร ชลธิชาชลาลักษณ์
ที่ทำงาน	โรงเรียนพยาบาลรามาธิบดี คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล

ขอรับรองว่าโครงการดังกล่าวข้างต้นได้ผ่านการพิจารณาเห็นชอบโดยสอดคล้องกับแนวปฏิญญา เฮลซิงกิ จากคณะกรรมการจริยธรรมการวิจัยในคน คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี

ลงนาม	
กรรมการและเลขานุการจริยธรรมการวิจัยในคน	(ศาสตราจารย์ แพทย์หญิงดวงฤดี วัฒนศิริชัยกุล)
ลงนาม	
ประธานกรรมการจริยธรรมการวิจัยในคน	(ศาสตราจารย์ นายแพทย์ประทักษ์ โอประเสริฐสวัสดิ์)
วันที่รับรอง	๑๒ ธันวาคม ๒๕๕๗
ระยะเวลาในการศึกษา	๔ เดือน

คณะกรรมการจริยธรรมการวิจัยในคน
โทรศัพท์ 1544 โทรสาร 2772

ที่ จวค 9/2558
วันที่ 8 มกราคม 2558
เรื่อง อนุญาตให้มีผู้ช่วยวิจัยในการเก็บข้อมูล

เรียน นางสาวจิราพร ชลธิชาชลาลักษณ์

อ้างถึงเอกสารลงวันที่ 23 ธันวาคม 2557 คณะกรรมการจริยธรรมการวิจัยในคนได้พิจารณาโครงการวิจัย เรื่อง การแปลและประเมินแบบทดสอบความสามารถในการคำนวณที่เกี่ยวกับการจัดการดูแลตนเองของผู้ป่วยเบาหวาน สำหรับผู้สูงอายุที่เป็นเบาหวานชนิดไม่พึ่งอินซูลินฉบับภาษาไทย (Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes) (ID 11-57-65 ย) ของ นางสาวจิราพร ชลธิชาชลาลักษณ์ โรงเรียนพยาบาลรามาธิบดี หัวหน้าโครงการได้ส่งเอกสารขอมีผู้ช่วยวิจัยในการเก็บข้อมูล ให้คณะกรรมการจริยธรรมการวิจัยในคนรับทราบ

โดยมีรายละเอียดที่ขอเพิ่มดังนี้

1. การเก็บข้อมูลจะทำในคลินิกโรคเรื้อรังซึ่งจะมีเดือนละครั้งดังนั้นผู้ป่วยเบาหวานจะมานัดในช่วงเวลาเดียวกันมาก จึงจำเป็นต้องมีผู้ช่วยวิจัยมาช่วยเก็บข้อมูล
2. ผู้ช่วยวิจัยจะเป็นนักศึกษาพยาบาลหรือสาขาวิชาชีพทางสุขภาพ โดยผู้วิจัยจะฝึกผู้ช่วยวิจัยถึงวิธีการเก็บข้อมูลและรักษาจริยธรรมคุณธรรมทางวิทยาศาสตร์ เพื่อให้มีมาตราฐานในการเก็บข้อมูล

คณะกรรมการจริยธรรมการวิจัยในคนรับทราบและอนุมัติเรื่องดังกล่าว ณ วันที่ 30 ธันวาคม 2557

ประทักษ์ โอประเสริฐสวัสดิ์

(ศาสตราจารย์นายแพทย์ประทักษ์ โอประเสริฐสวัสดิ์)
ประธานกรรมการจริยธรรมการวิจัยในคน

มุ่งเรียนรู้ คู่คุณธรรม นำสู่คุณภาพ

คณะกรรมการจริยธรรมการวิจัยในคน
โทร. ๑๕๔๔ โทรสาร ๒๗๗๒

ที่ จวค ๒๘๓๓/๒๕๕๗
วันที่ ๒๗ พฤศจิกายน ๒๕๕๗
เรื่อง แจ้งผลการพิจารณาโครงการ

เรียน นางสาวจิราพร ชลธิชาชลาลักษณ์

ตามที่ท่านได้ส่งโครงการวิจัยเรื่อง การแปลและประเมินแบบทดสอบความสามารถในการคำนวนที่เกี่ยวกับการจัดการดูแลตนเองของผู้ป่วยเบาหวาน สำหรับผู้สูงอายุที่เป็นเบาหวานชนิดไม่พึ่งอินสุลินฉบับภาษาไทย (Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes) (ID 11-57-65 ย) ของ นางสาวจิราพร ชลธิชาชลาลักษณ์
โรงเรียนพยาบาลรามาธิบดี
เพื่อพิจารณาจริยธรรมนั้น
<u>คณะกรรมการฯ</u> ได้พิจารณาแล้วมีข้อเสนอแนะให้เพิ่มเติมและแก้ไขดังนี้

ต้องมี permission เป็นลายลักษณ์อักษรจากเจ้าของ Test (Diabetes Numeracy Test) มี copyright

จึงเรียนมาเพื่อดำเนินการโดยทำบันทึกส่งมายังหน่วย จริยธรรมการวิจัยในคน ชั้น ๓ อาคารวิจัยและสวัสดิการ โทร ๐๒-๒๐๑-๑๕๔๔

(ศาสตราจารย์นายแพทย์ประทักษ์ โอประเสริฐสวัสดิ์)
ประธานกรรมการจริยธรรมการวิจัยในคน

<u>หมายเหตุ</u> กรุณาดำเนินการ โดยทำบันทึกข้อความ แก้ไขตามข้อเสนอแนะ 1 ชุด พร้อม ซีดีฉบับแก้ไขแล้ว 1 แผ่น ส่งมายังหน่วยจริยธรรมการวิจัยในคน ภายใน 90 วัน นับจากวันที่ได้รับบันทึกแจ้งผลการพิจารณาโครงการ
มิฉะนั้น ต้องดำเนินการ ยื่นเข้าสู่กระบวนการ การพิจาณาใหม่

มุ่งเรียนรู้ คู่คุณธรรม นำสู่คุณภาพ

Appendix G: Expert Invitation Letters

SCHOOL OF NURSING

1710 Red River • Austin, Texas 78701-1412

December 10, 2014

Dean of Faculty of Medicine
Ramathibodi Hospital
Mahidol University

Dear Dean of the Faculty of Medicine:

Miss Jiraporn Chontichachalalauk, RN, MS is a graduate student at The University of Texas at Austin School of Nursing in the doctoral degree program, studying to earn a PhD. Her dissertation is called "Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes" and I am the faculty supervising her dissertation.

As part of her dissertation process, Miss Chontichachalalauk will adapt a research instrument called the Diabetes Numeracy Test to make it culturally appropriate for use with Thai older adults with type 2 diabetes.

We invite Assistant Professor Dr. Porntip Malathum, a faculty member in Ramathibodi Nursing School, to be a member of an expert panel and to provide her opinion of the validity of the revised research instrument.

Please kindly consider the request. You may contact Miss Chontichachalalauk at chonjira@yahoo.com or me at agarcia@mail.nur.utexas.edu if you have any questions.

Yours sincerely,

Alexandra García

Alexandra A. Garcia, PhD, RN, FAAN
Associate Professor

Copy to Assistant Professor Dr. Porntip Malathum

SCHOOL OF NURSING

1710 Red River • Austin, Texas 78701-1412

December 10, 2014

Dean of Faculty of Medicine
Ramathibodi Hospital
Mahidol University

Dear Dean of the Faculty of Medicine:

Miss Jiraporn Chontichachalalauk, RN, MS is a graduate student at The University of Texas at Austin School of Nursing in the doctoral degree program, studying to earn a PhD. Her dissertation is called "Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes" and I am the faculty supervising her dissertation.

As part of her dissertation process, Miss Chontichachalalauk will adapt a research instrument called the Diabetes Numeracy Test to make it culturally appropriate for use with Thai older adults with type 2 diabetes.

We invite Assistant Professor Dr. Sangthong Therathongkum, a faculty member in Ramathibodi Nursing School, to be a member of an expert panel and to provide her opinion of the validity of the revised research instrument.

Please kindly consider the request. You may contact Miss Chontichachalalauk at chonjira@yahoo.com or me at agarcia@mail.nur.utexas.edu if you have any questions.

Yours sincerely,

Alexandra Garcia

Alexandra A. Garcia, PhD, RN, FAAN
Associate Professor

Copy to Assistant Professor Dr. Sangthong Therathongkum

SCHOOL OF NURSING

1710 Red River • Austin, Texas 78701-1412

December 10, 2014

Dean of Faculty of Medicine
Ramathibodi Hospital
Mahidol University

Dear Dean of the Faculty of Medicine:

Miss Jiraporn Chontichachalalauk, RN, MS is a graduate student at The University of Texas at Austin School of Nursing in the doctoral degree program, studying to earn a PhD. Her dissertation is called "Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes" and I am the faculty supervising her dissertation.

As part of her dissertation process, Miss Chontichachalalauk will adapt a research instrument called the Diabetes Numeracy Test to make it culturally appropriate for use with Thai older adults with type 2 diabetes.

We invite Associate Professor Dr. Noppawan Piaseu, a faculty member in Ramathibodi Nursing School, to be a member of an expert panel and to provide her opinion of the validity of the revised research instrument.

Please kindly consider the request. You may contact Miss Chontichachalalauk at chonjira@yahoo.com or me at agarcia@mail.nur.utexas.edu if you have any questions.

Yours sincerely,

Alexandra García

Alexandra A. Garcia, PhD, RN, FAAN
Associate Professor

Copy to Associate Professor Dr. Noppawan Piaseu

SCHOOL OF NURSING

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As part of her dissertation process, Miss Chontichachalalauk will adapt a research instrument called the Diabetes Numeracy Test to make it culturally appropriate for use with Thai older adults with type 2 diabetes.

We invite Assistant Professor Dr. Apinya Siripitayakunkit, a faculty member in Ramathibodi Nursing School, to be a member of an expert panel and to provide her opinion of the validity of the revised research instrument.

Please kindly consider the request. You may contact Miss Chontichachalalauk at chonjira@yahoo.com or me at agarcia@mail.nur.utexas.edu if you have any questions.

Yours sincerely,

Alexandra Garcia

Alexandra A. Garcia, PhD, RN, FAAN
Associate Professor

Copy to Assistant Professor Dr. Apinya Siripitayakunkit

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As part of her dissertation process, Miss Chontichachalalauk will adapt a research instrument called the Diabetes Numeracy Test to make it culturally appropriate for use with Thai older adults with type 2 diabetes.

We invite Numpeth Saibuathong, from the Department of Nursing in the Division of Medicine, to be a member of an expert panel and to provide her opinion of the validity of the revised research instrument.

Please kindly consider the request. You may contact Miss Chontichachalalauk at chonjira@yahoo.com or me at agarcia@mail.nur.utexas.edu if you have any questions.

Yours sincerely,

Alexandra Garcia

Alexandra A. Garcia, PhD, RN, FAAN
Associate Professor

Copy to Numpeth Saibuathong

Appendix H: The Participant Screening Sheet

Participant Screening Sheet

Project: Translation and Evaluation the Thai Version of Diabetes Numeracy Test for Older Adults with Type 2 Diabetes (T2DM)

Instruction: This Participant Screening Sheet will use to screen and recruit the potential participants for the study. The researcher will interview each potential participant by checklists below. If the potential participant meet all checklists of inclusion criteria and do not fall into any checklist of exclusion criteria, the researcher will invite the potential participant to participate in the study. Some participants who do not meet all checklists of inclusion criteria or fall into at any exclusion criteria will be excluded.

The researcher will check at each item if the potential participant meets these criteria.

Checklist

Yes	No	Inclusion criteria
□	□	1. Are you Thai nationality?
□	□	2. Are you 60 years or older?
□	□	3. Are you diagnosed with T2DM for at least one year?
□	□	4. Check yes, if the potential participant is able to hear and speak Thai language.

Yes	No	Exclusion criteria
□	□	1. Has a doctor ever told you that you have a problem with your memory?
□	□	2. Check yes, if the potential participant is the hospital inpatients, the residents of a skilled nursing home, assisted living facility, or prison?

The researcher say to the potential participant "I really appreciate your time to cooperate"

The result from checklist

□ Invite to participate in the study

□ Exclude from the study

Researcher: Jiraporn Chontichachalalauk
Contact: 6698-267-5992 (Thai phone number)
Office in Thailand: Ramathibodi Nursing of School, Faculty of Medicine Ramathibodi Hospital, Mahidol University. Address: 270 Rama 6 Road, Phayathai, Rachathewi, Bangkok, 10400, Thailand.
Tel: +66-2-201-1240 http://nursing.mahidol.ac.th

Appendix I: The Personal Information Sheet

(English and Thai Versions)

Personal Questionnaire

1. Sex: 1. Male 2. Female

2. Age:_____ or Birthday Date/Month/Years_____

3. Your highest educational level is

   1. No formal education and unable to read and/or write

   2. No formal education but able to read/write

   3. Primary school

   4. Middle school

   5. High school/Vocational training

   6. Bachelor's degree or above

4. Number of years you spend time in the school is_____ years

5. Marital Status:

   1. Never married 2. Married/ Living together

   3. Separated/Divorced 4. Widowed

6. What is your living arrangement?

   1. Living alone

   2. Living with spouse/significant other/children/grandchildren/other

   3. Other, please identify_____

7. Number of people living at your house (not including yourself) _____ persons

8. What is your current job status?

1. Employed for wages 2. Merchandizer or own business

3. Retired 4. Housework

5. Farmer/Agriculture 6. Other, please identify_____

9. What is family income/month?

1. < 5,000 Baht 2. 5,000-10,000 Baht

3. >10,000-15,000 Baht 4. >10,000-15,000 Baht

10. What is your health care cost payment?

1. Universal coverage scheme

2. Reimbursement from the government welfare scheme

3. Self-paid

4. Other, please identify_____

11. How long have you had diabetes?_____years and_____months

12. Other medical conditions (can answer more than one answer)

□ Hypertension □High cholesterol □ Coronary hearth disease

□Thyroid problems □ Overweight □ Renal dysfunction/failure

□ Stroke ie paralysis □ Eye problems, identify_____

□ Osteoarthritis □ Osteoporosis □ Neurological problems ie numbness

□ Cancer □ Depression □ Surgery during last year, identify_____

□ Other, please identify_____

13. Do you know about food label?

1. No 2. Yes

if yes, how much do you understand in using food label?

Not at all understand	1	2	3	4	5	6	7	8	9	10	Totally understand

If yes, how often do you decide to buy food with determining the food label?

□ Never □ Seldom □ Sometime □ Often □ Always

14. Do you have difficultly reading due to vision problem?

1. No 2. Yes

If yes, do you wear glasses when you read?

1. No 2. Yes

15. Do you have any difficulty hearing?

1. No 2. Yes

If yes, do you wear a hearing aid?

1. No 2. Yes

16. Has a doctor ever told you that you have a problem with your memory?

1. No 2. Yes, please identify_____

For researcher

Recent HbA1c date/month/year_____HbA1c level =_____%

Personal Questionnaire (Thai version)

แบบสอบถามข้อมูลส่วนบุคคล

1. เพศ: 1. ชาย 2. หญิง

2. อายุ:_____ หรือ วัน/เดือน/ปีเกิด _____

3. ระดับการศึกษาสูงสุดของท่านคือ

1. ไม่ได้เรียนหนังสือและอ่านไม่ออกเขียนไม่ได้

2. ไม่ได้เรียนหนังสือแต่อ่านออกเขียนได้

3. ประถมศึกษา

4. มัธยมต้น (ม1-ม3)

5. มัธยมปลาย (ม4-ม6)/สายอาชีพ

6. ปริญญาตรีหรือสูงกว่าขึ้นไป

4. ระยะเวลาที่ท่านศึกษาในโรงเรียนทั้งหมด_____ ปี

5. สถานภาพสมรส:

1. ไม่เคยแต่งงาน 2. สมรส/อยู่ด้วยกัน

3. แยกกันอยู่/หย่า 4. หม้าย

6. ลักษณะความเป็นอยู่อาศัยของท่านคืออะไร

1. อยู่คนเดียว

2. อยู่กับคู่สมรส/ย/ลูก/หลาน

3. อื่นๆ โปรดระบุ_____

7. จำนวนสมาชิกที่อาศัยอยู่ร่วมบ้านเดียวกับท่าน (ไม่รวมตัวท่าน) _____ คน

8. ท่านทำงานอะไรในปัจจุบัน

1. รับจ้าง 2. ขายของหรือมีกิจการของตัวเอง

3. เกษียณจากงาน 4. ทำงานบ้านหรืออยู่บ้านเฉยๆ

5. ทำนาหรือเกษตรกรรม 6. อื่นๆ โปรดระบุ_____

9. ท่านมีรายได้ครอบครัวต่อเดือนเท่าไหร่

1. < 5,000 บาท 2. 5,000-10,000 บาท

3. >10,000-15,000 บาท 4. >10,000-15,000 บาท

10. ท่านจ่ายค่ารักษาพยาบาลของท่านอย่างไร

1. ใช้สิทธิโครงการประกันสุขภาพถ้วนหน้า

2. เบิกต้นสังกัดจากราชการ

3. จ่ายค่ารักษาพยาบาลเอง

4. อื่นๆ โปรดระบุ_____

11. ท่านได้รับการวินิจฉัยว่าเป็นเบาหวานมานานเท่าไร_____ปีและ_____เดือน

12. ภาวะการเจ็บป่วยทางการแพทย์อื่นๆ (สามารถตอบได้มากกว่า 1 ข้อ)

□ ความดันโลหิตสูง	□ ไขมันในเลือดสูง	□ โรคหลอดเลือดหัวใจตีบหรือตัน
□ ธัยรอยด์	□ น้ำหนักเกิน	□ การทำงานของไตเสื่อมหรือไตวาย
□ โรคหลอดเลือดสมอง	เช่น อัมพาต อัมพฤกษ์	□ ปัญหาทางตา ระบุ_____
□ ข้อเข่าเสื่อม	□ โรคกระดูกพรุน	□ ปัญหาทางระบบประสาท เช่น ชาปลายมือปลายเท้า
□ มะเร็ง	□ ภาวะซึมเศร้า	□ ได้รับการผ่าตัดในปีที่ผ่านมา ระบุ_____

□ อื่นๆ โปรดระบุ_____

13. ท่านรู้จักฉลากอาหารหรือฉลากโภชนาการหรือไม่

1. ไม่รู้จัก 2. ใช่ รู้จัก

ถ้าท่านรู้จัก ท่านเข้าใจการใช้ฉลากอาหารหรือฉลากโภชนาการมากน้อยเพียงใด

ไม่เข้าใจเลย	1	2	3	4	5	6	7	8	9	10	เข้าใจมากที่สุด

ถ้าท่านรู้จัก ท่านตัดสินใจซื้ออาหารโดยดูฉลากโภชนาการหรือฉลากอาหารบ่อยครั้งเพียงใด

□ ไม่เคย □ นานครั้ง □ บางครั้ง □ บ่อยครั้ง □ สม่ำเสมอ

14. ท่านมีปัญหาในการอ่านหนังสือเนื่องจากปัญหาทางสายตาหรือไม่

1. ไม่มี 2. มีปัญหา

ถ้าท่านมีปัญหาทางสายตา ท่านใส่แว่นสายตาเมื่ออ่านหนังสือหรือไม่

1. ไม่ใส่ 2. ใส่แว่นสายตา

15. ท่านมีปัญหาในการได้ยินหรือไม่

1. ไม่มี 2. มีปัญหา

ถ้าท่านมีปัญหาทางการได้ยิน ท่านใส่เครื่องช่วยฟังหรือไม่

1. ไม่ได้ใส่ 2. ใส่เครื่องช่วยฟัง

16. แพทย์เคยบอกท่านว่า ท่านมีปัญหาทางด้านความจำหรือไม่

1. ไม่เคย 2. เคย โปรดระบุ_____

สำหรับผู้วิจัย

ค่า HbA1c ล่าสุด วัน/เดือน/ปี_____HbA1c level =_____%

Appendix J: The Thai-The Three Level of Health Literacy Scale

(English and Thai Versions)

The Three Levels of Health Literacy Scale

Direction: This questionnaire asks your experience and opinion about health information that you receive and your decision making in health care. Please answer each question by checking the answer that is most relevant to you

1 = Never

2 = Seldom

3 = Sometime

4 = Often

Functional Health Literacy

In reading instructions or leaflets from hospitals or pharmacies, how often have you...	Never	Seldom	Sometime	Often
1. found that the print was too small to read	1	2	3	4
2. found characters and words that you did not know	1	2	3	4
3. found that the content was too difficult	1	2	3	4
4. needed a long time to read and understand them	1	2	3	4
5. needed someone to help you read them	1	2	3	4

Communicative Health Literacy

Since being diagnosed with diabetes, how often have you...	Never	Seldom	Sometime	Often
6. collected information from various sources	1	2	3	4
7. extracted the information from you wanted	1	2	3	4
8. understood the obtained information	1	2	3	4
9. communicated your thoughts about your illness to someone	1	2	3	4
10. applied the obtained information to your daily life	1	2	3	4

Critical Health Literacy

Since being diagnosed with diabetes, how often have you...	Never	Seldom	Sometime	Often
11. considered whether the information was applicable to your situation	1	2	3	4
12. considered the credibility of the information	1	2	3	4
13. checked whether the information was valid and reliable	1	2	3	4
14. collected information to make health-related decisions	1	2	3	4

The Three Levels of Health Literacy Scale (Thai version)

แบบสอบถามความแตกฉานความรู้ความเข้าใจทางด้านสุขภาพ

คำชี้แจง แบบสอบถามนี้ถามท่านเกี่ยวกับการรับรู้ของตัวท่านเอง ต่อความรู้และความเข้าใจทางด้านสุขภาพที่ท่านได้รับ และการตัดสินใจในการดูแลสุขภาพ กรุณาเลือกหมายเลขที่ตรงกับตัวท่านมากที่สุด ดังต่อไปนี้

1 = ไม่เคย

2 = นานครั้ง

3 = บางครั้ง

4 = บ่อยครั้ง

ความแตกฉานทางด้านการอ่านและการเขียนทางด้านสุขภาพ (Functional health literacy)

ในการอ่านข้อมูลหรือคำแนะนำทางด้านสุขภาพจากแหล่งต่างๆ เช่น หนังสือ วารสาร แผ่นพับหรือฉลากยาจากโรงพยาบาลหรือ สถานีอนามัย ท่านเคยมีปัญหาดังต่อไปนี้หรือไม่และบ่อยครั้งเพียงใด	ไม่เคย	นานครั้ง	บางครั้ง	บ่อยครั้ง
1. พบตัวหนังสือที่เล็กเกินไป	1	2	3	4
2. พบตัวหนังสือหรือคำที่ไม่เข้าใจ	1	2	3	4
3. พบว่าเนื้อหาเหล่านั้นยากเกินไป	1	2	3	4
4. ต้องใช้เวลาอ่านและทำความเข้าใจเนื้อหาเหล่านั้นนาน	1	2	3	4
5. ต้องมีคนช่วยท่านอ่านเนื้อหาเหล่านั้น	1	2	3	4

ความแตกฉานทางด้านการติดต่อสื่อสารทางด้านสุขภาพ (Communicative health literacy)

ตั้งแต่ที่ท่านรับรู้ว่าเป็นโรคเบาหวาน ท่านได้ทำตามดังข้อต่อไปนี้หรือไม่และบ่อยครั้งเพียงใด	ไม่เคย	นานครั้ง	บางครั้ง	บ่อยครั้ง
6. รวบรวมหรือหาข้อมูลจากที่ต่างๆ เช่น แผ่นพับ เอกสาร หรือถามจากผู้อื่น เช่น หมอ พยาบาล เจ้าหน้าที่สาธารณสุข	1	2	3	4
7.สามารถเลือกเฉพาะข้อมูลที่ท่านต้องการจะใช้จากเอกสารที่ท่านอ่านหรือจากข้อมูลที่ท่านได้รับฟังมา	1	2	3	4
8. เข้าใจข้อมูลหรือเนื้อหาที่ท่านได้อ่านหรือรับฟังมาเหล่านั้น	1	2	3	4
9.สามารถติดต่อสื่อสารโดยบอกเล่าความคิดเกี่ยวกับความเจ็บป่วยของตัวท่านเองให้ผู้อื่นเข้าใจได้	1	2	3	4
10. นำข้อมูลที่ได้รับเหล่านั้นมาใช้ในชีวิตประจำวันได้	1	2	3	4

ความแตกฉานทางด้านการคิดและวิเคราะห์ทางด้านสุขภาพ (Critical health literacy)

ตั้งแต่ที่ท่านรับรู้ว่าเป็นโรคเบาหวาน ท่านได้ทำตามดังข้อต่อไปนี้หรือไม่และบ่อยครั้งเพียงใด	ไม่เคย	นานครั้ง	บางครั้ง	บ่อยครั้ง
11. คิดถึงว่าข้อมูลที่ท่านได้อ่านหรือรับฟังมาเหล่านั้นใช้ก้บตนเองได้หรือไม่	1	2	3	4
12. คิดถึงความน่าเชื่อถือของข้อมูลเหล่านั้น	1	2	3	4
13. ตรวจสอบว่าข้อมูลเหล่านั้นมีความถูกต้องและแม่นยำหรือไม่	1	2	3	4
14. รวบรวมข้อมูลที่ได้รับเหล่านั้นมาตัดสินใจเกี่ยวกับสุขภาพของตนเอง	1	2	3	4

Appendix K: The Thai Diabetes Numeracy Test

(English and Thai Versions)

Calculating skills of diabetes patients on numbers related to self-management assessment form (Thai DNT)

Instructions: This questionnaire is used to assess the ability of diabetes patients to calculate numbers related to self-management.

For researchers, please

- prepare calculators, pencils, and blank papers for calculation for participants
- allow participants to wear glasses or hearing-aid devices, if applicable.
- read the questionnaire for participants. Repeat the questions again, if needed.
- do not limit the time for answering each question.
- move to the next question at once after a question has been answered and the answer has been recorded.

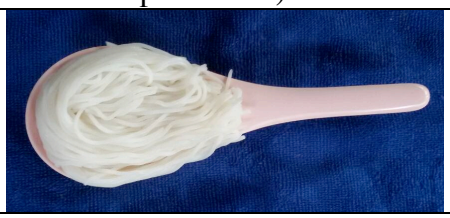
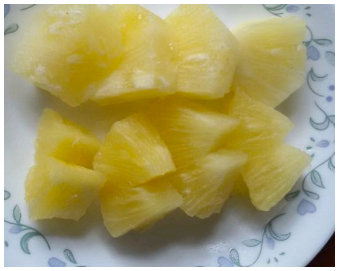
1. If a ladle of cooked rice is equal to a portion of flour, how many portions of flour are equal to two ladles of cooked rice?
   answer _____portions.
2. A medium sized ripe mango is equal to 2 portions of flour. If you want 1 portion of flour, how many mangoes do you have to eat?
   answer _____ mangoes
3. The recommended intake of foods in the rice and flour group is 8-12 ladles a day. If you have 3 ladles for breakfast, 3 ladles for lunch, how many ladles would you have for dinner to make it 8 ladles in total a day?
   answer _____ ladles
4. If a gram of cooked rice can increase 3 units of blood sugar level, how many units of blood sugar level can be increased by a ladle of cooked rice? (If a ladle of cooked rice is 55 gram)
   answer _____ units
5. The suggested intake of vegetables is 6 ladles per day, divided into 3 meals equally. How many ladles of vegetable per meal will you have?
   answer _____ ladles

6. The table below represents the proportions of vegetables and fruits.
(Read the table in order from left to right and then from top to bottom.)

1 portion of fruit equals	 1 portion of fruit = 1 orange or	 1 portion of fruit = Half medium-sized guava
1 portion of vegetable equals	 1 portion of vegetable= 2 ladle scoop of raw vegetable or	 1 portion of vegetable= 1 ladle scoop of cooked vegetable

Today, you have
half of a medium sized guava,
1 orange and
2 ladles of fresh vegetable.
If you want to have 5 portions of vegetable and fruit a day, how many ladles of cooked vegetable should you have?
answer:_____ladles

7. The table below represents the proportions of food and 1 portion of flour.
(Read the table in order from left to right and then from up to down.)

1 piece of Thai rice noodles = 1 portion of flour	
8 pieces of pineapple of suitable sizes = 1 portion of flour	

You have 2.5 portions of Thai rice noodles and 8 pieces of pineapple of suitable sizes. How many portions of flour will you get?
answer _____ portions

8. From the nutrition information label of fruit juice below, how many grams of sugar will you get if you drink half a box of the fruit juice?
answer _____ grams

Fruit juice

Nutrition Facts		
Serving Size : 1 glass (200 ml.) Servings Per Container: 1		
Amount Per Serving Calories 110 kilocalories (Carories from Fat 0)		
	% Daily Value*	
Total Fat	0 g	0%
Saturated	0 g	0%
Cholesterol	0 mg	0%
Protein less than	1 g	
Total Carbohydrate	25 g	8%
Dietary Fiber	2 g	8%
Sugars	6 g	
Sodium	10 mg	0%
Potassium	200 mg	6%

9. From the nutrition information label of low sugar soymilk below, if you drink half a box of this soymilk, how many grams of carbohydrates (which is in the group of fiber, flour and sugar) will you get?
   answer _____ grams

low sugar soymilk

Nutrition Facts		
Serving Size : 1 box (250 cm.^{3})		
Servings Per Container : 1		
Amount Per Serving		
Calories 180 kilocalories (Carories from Fat 70)		
	% Daily Value*	
Total Fat	8 g	12%
Saturated Fat	4 g	20%
Cholesterol	0 mg	0%
Protein	9 g	
Total Carbohydrate	20 g	6%
Dietary Fiber	<1 g	3%
Sugars	15 g	
Sodium	135 mg	6%

10. After a walk for exercise, you have to have food in the rice and flour group such as cooked corn within 15 minutes. If you finish your walk at 2 pm., by what time should you have the cooked corn?
    answer: _____ o'clock
11. When you take a walk, you will have food in rice and flour group such as crackers for energy. You have to have crackers containing 5 grams of flour every half an hour during your walk. If you take a one hour walk, how many pieces of crackers do you have to have? (a piece of cracker of 2.5 inches in size contains 5 grams of flour.)
    answer: _____ pieces

12. If your goal is to control your blood sugar level to be between 60 and 120. Circle a number below that is in the range of your goal.

55
145
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13. If you want to self-monitor your blood sugar level 4 times a day for 30 days, how many test strips do you need?
answer_____ strips

14. In the table below, the left column is the average cumulative amount of blood sugar in the last 3 months (A1C) compared with the right column, which is the value of blood sugar level. For example, as shown in the table, 6 % of the average cumulative amount of blood sugar is equal to the blood sugar level at 120.

Average cumulative amount of blood sugar %	**blood - sugar value**
13 %	330
12 %	300
11 %	270
10 %	240
9%	210
8%	180
7%	150
6%	120
5%	90
4%	60

From the table above, if your blood sugar level is 240, how much is your average cumulative amount of blood sugar ?
answer: _____%

15. A doctor asks you to test your blood sugar level 3 times a day. On March 5th, you have 50 test strips. When do you have to buy some more test strips? Please circle a date below.

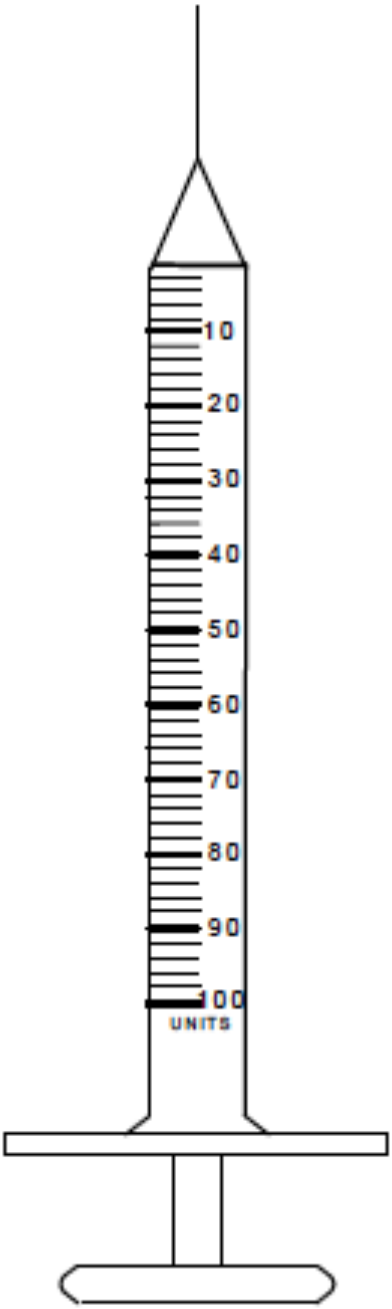
March, 15th
April, 15th
May, 15th
June, 15th

16. You have to take a tablet of a drug lowering blood sugar half an hour before your breakfast. If you have breakfast at 8.00 am, when should you take this drug?
    answer: _____o'clock
17. You have to take half a tablet of a drug lowering blood sugar before your breakfast everyday. If you will be away for 2 weeks, how many tablets, at least, should you prepare?
    answer: _____tablets
18. You have to take 1 tablet of a drug lowering blood sugar after breakfast and dinner. You see your doctor once a month and get the pills that are enough for a month. How many tablets of this drug should you get? (There is 30 days in a month.)
    answer: _____tablets
19. If you have several underlying diseases and need to take the following drugs;
    half a tablet of a drug lowering blood sugar before breakfast
    a tablet of a drug lowering blood sugar after breakfast and dinner
    a tablet of hypertensive drug after breakfast
    a tablet of a drug lowering fat before bedtime
    Only after breakfast, how many tablets do you have to take?
    answer: _____tablets

20. If you take a tablet for diabetes twice a day, how many days will you spend for taking 60 tablets?
    answer: _____days

Insulin injection (only for those who use insulin injection)

21. If you have to inject 54 units of insulin by using a 100 units syringe, please underline the number representing 54 units in the syringe below.



22. Before breakfast, you have to inject two types of insulin, 10 units for type 1 and 16 units for type 2. How many units of insulin do you have to inject in total?
    answer: _____units
23. When you have a portion of food in the rice and flour group, a doctor advises you to inject 2 units of insulin. If you have 6 portions of food in the rice and flour group, how many units of insulin do you have to inject?
    answer: _____units
24. You usually inject 42 units of insulin. When you have your colon checked, a doctor tells you to reduce its amount to half of this number. Therefore, if you have your colon checked, how many units of insulin will you inject?
    answer: _____units

Please use the information below to answer question 25. A doctor tells you to inject insulin with the amount as shown in the table. The left column is the value of blood sugar. The right column is the amount of insulin to be injected.

If blood sugar level is	amount of insulin to be injected (units)
130-180	0
181-230	1
231-280	2
281-330	3
331-380	4

25. If your blood sugar level is 295, how many units of insulin will you inject?
    answer: _____units

แบบประเมินทักษะการคำนวณตัวเลขที่เกี่ยวข้องกับการบริหารจัดการตนเองสำหรับผู้ที่เป็นเบาหวาน

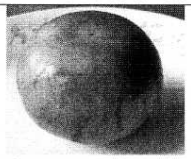
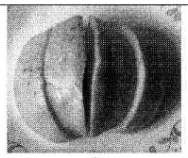
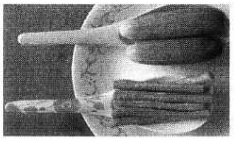
คำแนะนำ แบบสอบถามนี้วัดความสามารถในการคิดเลขที่เกี่ยวข้องกับการดูแลตนเองของผู้ป่วยเบาหวาน

สำหรับผู้วิจัย ให้ปฏิบัติดังนี้

- เตรียมเครื่องคิดเลข ดินสอ และกระดาษทดเลข ให้ผู้ตอบแบบสอบถาม
- ให้ผู้ตอบแบบสอบถามใส่แว่นสายตาหรือเครื่องช่วยฟัง ถ้ามี
- อ่านแบบสอบถามให้ผู้ตอบฟัง อ่านคำถามซ้ำได้ถ้าผู้ตอบต้องการ
- ไม่จำกัดเวลาในการตอบคำถามในแต่ละข้อ
- เมื่อผู้ตอบแบบสอบถามตอบคำถามแล้ว บันทึกคำตอบแล้วให้ข้ามไปทำข้อถัดไปทันที

1. ข้าวสวย 1 ทัพพีเท่ากับแป้ง 1 ส่วน ข้าวสวย 2 ทัพพีเท่ากับแป้งกี่ส่วน
   ตอบ _____ส่วน
2. มะม่วงสุกขนาดกลาง 1 ลูก เท่ากับแป้ง 2 ส่วน ถ้าท่านต้องการแป้ง 1 ส่วน ท่านต้องกินมะม่วงสุกนี้กี่ลูก
   ตอบ _____ลูก
3. อาหารในหมวดข้าว-แป้ง ควรกินวันละ 8-12 ทัพพี ถ้าท่านกินมื้อเช้า 3 ทัพพี มื้อกลางวัน 3 ทัพพี ท่านจะกินข้าว-แป้งอีกกี่ทัพพีในมื้อเย็น เพื่อให้ครบ 8 ทัพพี
   ตอบ _____ทัพพี
4. ข้าวสวย 1 กรัมเพิ่มน้ำตาลในเลือดได้ 3 หน่วย ข้าวสวย 1 ทัพพี เพิ่มน้ำตาลในเลือดได้กี่หน่วย (ถ้าข้าวสวย 1 ทัพพี เท่ากับ 55 กรัม)
   ตอบ _____หน่วย
5. ท่านได้รับคำแนะนำให้กินผักวันละ 6 ทัพพี ท่านแบ่งกินเป็น 3 มื้อ เท่าๆกัน ท่านจะกินผักมื้อละกี่ทัพพี
   ตอบ _____ทัพพี

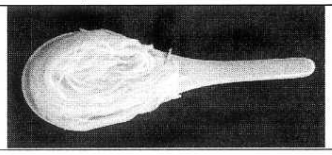
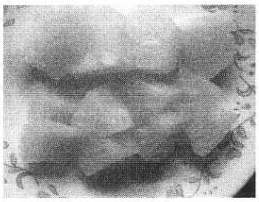
6. จากตารางแสดงปริมาณสัดส่วนของหมวดผักและผลไม้ด้านล่าง
(อ่านตารางตามลำดับจากด้านซ้ายไปขวา และจากด้านบนไปล่าง)

ผลไม้ 1 ส่วน เท่ากับ	 **ผลไม้ 1 ส่วน = ส้ม 1 ผล** **หรือ**	 **ผลไม้ 1 ส่วน = ฝรั่งขนาดกลางครึ่งลูก**
ผัก 1 ส่วน เท่ากับ	 **ผัก 1 ส่วน = ผักดิบ 2 ทัพพี** **หรือ**	 **ผัก 1 ส่วน = ผักสุก 1 ทัพพี**

วันนี้ท่านกิน ฝรั่งขนาดกลางครึ่งลูก
ส้ม 1 ผล และ
ผักดิบ 2 ทัพพี

ถ้าท่านต้องการกินผักและผลไม้ให้ครบวันละ 5 ส่วน ท่านควรจะกินผักสุกอีกกี่ทัพพี
ตอบ _____ทัพพี

7. จากตารางแสดงปริมาณสัดส่วนอาหารต่อแป้ง 1 ส่วนด้านล่าง
(อ่านตารางตามลำดับจากด้านซ้ายไปขวา และจากด้านบนไปล่าง)

ขนมจีน 1 จับ = แป้ง 1 ส่วน	
สับปะรดชิ้นพอคำรวม 8 ชิ้น = แป้ง 1 ส่วน	

มื้อกลางวันท่านกิน ขนมจีนจำนวน 2 จับครึ่ง และสับปะรดชิ้นพอคำรวม 8 ชิ้น ท่านได้รับแป้งกี่ส่วน
ตอบ _____ส่วน

8. จากฉลากโภชนาการของน้ำผลไม้ด้านล่าง ถ้าท่านดื่มน้ำผลไม้ครึ่งกล่องท่านได้รับน้ำตาลกี่กรัม
ตอบ _____กรัม

น้ำผลไม้กล่อง

ข้อมูลโภชนาการ		
หนึ่งหน่วยบริโภค : 1 แก้ว (200 มล.) จำนวนหน่วยบริโภคต่อกล่อง: 1		
คุณค่าทางโภชนาการต่อหนึ่งหน่วยบริโภค พลังงานทั้งหมด 110 กิโลแคลอรี่ (พลังงานจากไขมัน 0)		
ร้อยละของปริมาณที่แนะนำต่อวัน*		
ไขมันทั้งหมด	0 ก.	0%
ไขมันอิ่มตัว	0 ก.	0%
โคเลสเตอรอล	0 มก.	0%
โปรตีน น้อยกว่า	1 ก.	
คาร์โบไฮเดรตทั้งหมด	25 ก.	8%
ใยอาหาร	2 ก.	8%
→ **น้ำตาล**	6 ก.	
โซเดียม	10 มก.	0%
โพแทสเซียม	200 มก.	6%

9. จากฉลากโภชนาการของนมถั่วเหลืองน้ำตาลต่ำด้านล่าง ถ้าท่านดื่มนมถั่วเหลืองนี้ครึ่งกล่อง ท่านจะได้รับคาร์โบไฮเดรตซึ่งเป็นกลุ่มใยอาหาร แป้ง และน้ำตาล กี่กรัม
ตอบ _____กรัม

นมถั่วเหลืองน้ำตาลต่ำ

ข้อมูลโภชนาการ		
หนึ่งหน่วยบริโภค : 1 กล่อง (250 ซม.^{3})		
จำนวนหน่วยบริโภคต่อกล่อง: 1		
คุณค่าทางโภชนาการต่อหนึ่งหน่วยบริโภค		
พลังงานทั้งหมด 180 กิโลแคลอรี่		
(พลังงานจากไขมัน 70)		
ร้อยละของปริมาณที่แนะนำต่อวัน*		
ไขมันทั้งหมด	8 ก.	12%
ไขมันอิ่มตัว	4 ก.	20%
โคเลสเตอรอล	0 มก.	0%
โปรตีน	9 ก.	
คาร์โบไฮเดรตทั้งหมด	20 ก.	6%
ใยอาหาร	<1 ก.	3%
น้ำตาล	15 ก.	
โซเดียม	135 มก.	6%

10. หลังเดินออกกำลังกายเสร็จ ท่านต้องกินอาหารในหมวดข้าว-แป้ง เช่น ข้าวโพดต้ม ภายใน 15 นาที ถ้าท่านเดินออกกำลังกายเสร็จ ตอนบ่าย 2 โมง ท่านควรกินข้าวโพดต้มภายในเวลาไม่เกินกี่โมง
ตอบ _____ โมง

11. เวลาท่านไปเดินออกกำลังกาย ท่านจะกินอาหารในหมวดข้าว-แป้ง เช่น ขนมปังกรอบ เพื่อให้พลังงาน ท่านต้องกินขนมปังกรอบที่มีแป้ง 5 กรัมเมื่อเดินออกกำลังกายทุกครึ่งชั่วโมง ถ้าท่านเดินออกกำลังกาย 1 ชั่วโมง ท่านจะต้องกินขนมปังกรอบกี่ชิ้น (ถ้าขนมปังกรอบ 1 ชิ้น ขนาด 2 นิ้วครึ่ง มีแป้ง 5 กรัม)
ตอบ _____ชิ้น

12. ถ้าท่านมีเป้าหมายในการควบคุมน้ำตาลในเลือด อยู่ระหว่าง 60 ถึง 120
จงวงกลมตัวเลขด้านล่างซึ่งเป็นค่าน้ำตาลในเลือดที่อยู่ในเป้าหมายการควบคุมน้ำตาลในเลือดของท่าน

55
145
118

13. ถ้าท่านต้องตรวจน้ำตาลในเลือดด้วยตนเองวันละ 4 ครั้ง เป็นเวลา 30 วัน
ท่านต้องใช้แผ่นวัดน้ำตาลจำนวนทั้งหมดกี่แผ่น
ตอบ _____แผ่น

14. จากตารางด้านล่าง ด้านซ้ายเป็นค่าน้ำตาลเฉลี่ยสะสมในเลือด 3 เดือนที่ผ่านมา (เอ วัน ซี)เปรียบเทียบกับด้านขวาเป็นค่าน้ำตาลในเลือด เช่น น้ำตาลเฉลี่ยสะสมในเลือด 6 % เท่ากับน้ำตาลในเลือด 120 (ดังรูป)

ค่าน้ำตาลเฉลี่ยสะสมในเลือด %	ค่าน้ำตาลในเลือด
13 %	330
12 %	300
11 %	270
10 %	240
9%	210
8%	180
7%	150
6%	120
5%	90
4%	60

จากตารางด้านบน หากท่านมีน้ำตาลในเลือด 240 จะเท่ากับค่าน้ำตาลเฉลี่ยสะสมในเลือดเท่าไร
ตอบ _____%

15. หมอให้ท่านตรวจน้ำตาลในเลือดวันละ 3 ครั้ง ท่านมีแผ่นวัดน้ำตาลทั้งหมด 30 แผ่นในวันที่ 5 มีนาคม ท่านต้องซื้อแผ่นวัดน้ำตาลอีกเมื่อไหร่ ให้วงกลมจากวันที่ให้ด้านล่าง

15 มีนาคม
15 เมษายน
15 พฤษภาคม
15 มิถุนายน

16. ท่านต้องกินยาเม็ดลดน้ำตาลในเลือด 1 เม็ดก่อนอาหารเช้าครึ่งชั่วโมง ถ้าท่านกินข้าวเวลา 8.00 โมงเช้า ท่านควรกินยากี่โมง

    ตอบ_____โมง

17. ท่านต้องกินยาเม็ดลดน้ำตาลในเลือดวันละครึ่งเม็ด ก่อนอาหารเช้าทุกวัน ถ้าท่านจะไปต่างจังหวัดเป็นเวลา 2 สัปดาห์ ท่านควรเตรียมยานี้ไปอย่างน้อยกี่เม็ด

    ตอบ _____เม็ด

18. ท่านต้องกินยาเม็ดลดน้ำตาลในเลือดครั้งละ 1 เม็ดหลังอาหารเช้าและเย็น ท่านพบแพทย์เดือนละ 1 ครั้ง และได้รับยาสำหรับ 1 เดือน ท่านควรได้รับยานี้จำนวนทั้งหมดเท่าไหร่ (1 เดือนมี 30 วัน)

    ตอบ _____เม็ด

19. ถ้าท่านมีโรคประจำตัวหลายโรคและต้องกินยาดังนี้

    ยาเม็ดลดน้ำตาลในเลือด ครึ่งเม็ด ก่อนอาหารเช้า
    ยาเม็ดลดน้ำตาลในเลือด 1 เม็ด หลังอาหารเช้าและเย็น
    ยาเม็ดลดความดันโลหิต 1 เม็ด หลังอาหารเช้า
    ยาเม็ดลดไขมัน 1 เม็ด ก่อนนอน

    เฉพาะหลังอาหารเช้าท่านต้องกินยารวมทั้งหมดกี่เม็ด

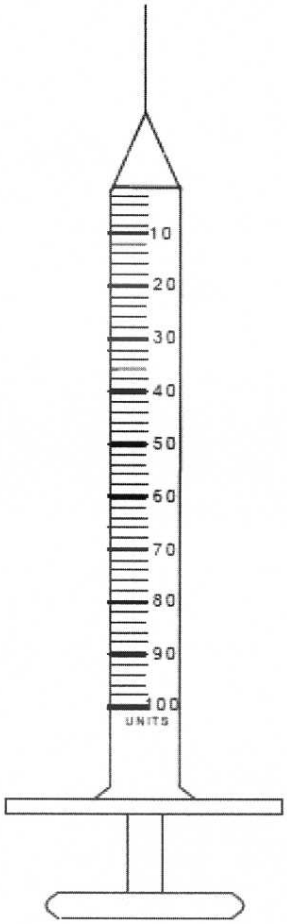
    ตอบ _____เม็ด

20. ถ้าท่านกินยารักษาโรคเบาหวาน ครั้งละ 1 เม็ด วันละ 2 ครั้ง ท่านมียานี้อยู่จำนวน 60 เม็ด จะเพียงพอสำหรับกี่วัน

    ตอบ _____วัน

ด้านการใช้ยาฉีดลดน้ำตาลในเลือด (เฉพาะผู้ใช้ยาฉีดลดน้ำตาลในเลือดเท่านั้น)

21. ถ้าท่านต้องฉีดอินซูลิน 54 ยูนิต โดยใช้กระบอกฉีดยาขนาด 100 ยูนิต จากกระบอกฉีดยาด้านล่าง โปรดขีดเส้นตัวเลขที่แสดงว่าเป็น 54 ยูนิต



22. ก่อนอาหารเช้า ท่านต้องฉีดยาอินซูลิน 2 ชนิด ชนิดที่ 1 จำนวน 10 ยูนิต ชนิดที่ 2 จำนวน 16 ยูนิต ท่านต้องฉีดอินซูลินรวมทั้งหมดกี่ยูนิต
    ตอบ _____ยูนิต
23. เมื่อท่านกินอาหารในหมวดข้าว-แป้งทุก 1 ส่วน หมอแนะนำท่านให้ฉีดอินซูลิน 2 ยูนิต ถ้าท่านกินอาหารในหมวดข้าว-แป้ง 6 ส่วน ท่านต้องฉีดอินซูลินกี่ยูนิต
    ตอบ _____ยูนิต
24. ปกติท่านฉีดอินซูลิน 42 ยูนิต หมอบอกท่านให้ฉีดอินซูลินลดลงครึ่งหนึ่ง เมื่อต้องไปตรวจลำไส้ ดังนั้นถ้าท่านต้องไปตรวจลำไส้ท่านจะฉีดอินซูลินกี่ยูนิต
    ตอบ _____ยูนิต

โปรดใช้ข้อมูลด้านล่างตอบคำถามข้อ 25 หมอบอกท่านให้ฉีดอินซูลินดังตาราง ด้านซ้ายเป็นค่าน้ำตาลในเลือด ด้านขวาเป็นจำนวนอินซูลินที่ฉีด

ถ้าน้ำตาลในเลือด เท่ากับ	จำนวนอินซูลินที่ฉีด (ยูนิต)
130-180	0
181-230	1
231-280	2
281-330	3
331-380	4

25. ถ้าน้ำตาลในเลือด 295 ท่านจะฉีดอินซูลินกี่ยูนิต
    ตอบ _____ยูนิต

Appendix L: The General Diabetes Knowledge

(English and Thai Versions)

General Diabetes Knowledge

Direction: This questionnaire asks about your understanding of diabetes information

Please answer each question by checking your best answer.

Questions	Yes	No	Do not know
1. Diabetes mellitus is likely to be cured by treatment.	□	□	□
2. Insulin is produced by kidney.	□	□	□
3. Normally, blood sugar levels should be 90 – 130 mg/dl.	□	□	□
4. Stress causes blood sugar levels to increase.	□	□	□
5. Genetic problems are one of the causes of diabetes mellitus.	□	□	□
6. If you are beginning to have a low blood sugar reaction, you may feel sweating, shaking, and faint.	□	□	□
7. You are at greater risk of heart disease than people that do not have diabetes.	□	□	□
8. Poor blood sugar control can cause numbness in the hands and feet.	□	□	□
9. Poor blood sugar control can result in kidney failure.	□	□	□
10. Good blood sugar control usually reduces or delays occurrence of diabetes complications.	□	□	□
11. Drinking alcohol can affect blood sugar levels.	□	□	□

Questions	Yes	No	Do not know
12. You should continue to exercise if you have chest pain or severe illness.	□	□	□
13. You should check your feet every day.	□	□	□
14. In patients with diabetes, infections can cause high sugar levels.	□	□	□
15. If you are sick, you should drink more liquids and eat meals.	□	□	□
16. In a sick period, you do not need to take medications since your blood sugar levels are usually low.	□	□	□
17. You should do not take your medications or insulin twice if you realize that you forgot your medication or insulin.	□	□	□
18. When you begin having signs of low blood sugar, you should take sweetened food or drink.	□	□	□
19. When you take diabetes drugs before meal and do not eat your meal, your blood sugar usually decreases.	□	□	□
20. Alcohol is likely to cause diabetes drugs not to work.	□	□	□
21. While you are receiving diabetes drugs and you continue eating sweet desserts, this may result in poor blood sugar control.	□	□	□

General Diabetes Knowledge (Thai version)

แบบทดสอบความรู้เรื่องโรคเบาหวาน

คำชี้แจง แบบสอบถามนี้ถามท่านเกี่ยวกับความรู้ทางด้านเบาหวาน

กรุณาตอบคำถามแต่ละข้อโดยเลือกคำตอบที่ถูกต้องมากที่สุด

คำถาม	ถูก	ผิด	ไม่รู้
1. โรคเบาหวานสามารถรักษาให้หายขาดได้*	☐	☐	☐
2. อินซูลินสร้างมาจากไต*	☐	☐	☐
3. ค่าปกติของระดับน้ำตาลในเลือดเมื่ออดอาหารตลอดคืน คือ 90-130 มิลลิกรัม/เดซิลิตร	☐	☐	☐
4. ความเครียดเป็นสาเหตุที่ทำให้ระดับน้ำตาลในเลือดเพิ่มสูงขึ้นได้	☐	☐	☐
5. สาเหตุหนึ่งของโรคเบาหวานเกิดจากความผิดปกติทางกรรมพันธุ์	☐	☐	☐
6. เมื่อร่างกายมีระดับน้ำตาลในเลือดต่ำจะมีอาการแสดง คือ เหงื่อออก ใจสั่น หน้ามืด	☐	☐	☐
7. ผู้ป่วยโรคเบาหวานมีโอกาสเป็นโรคหลอดเลือดหัวใจตีบได้มากกว่าผู้ที่ไม่เป็นโรคเบาหวาน	☐	☐	☐
8. การควบคุมระดับน้ำตาลในเลือดได้ไม่ดีสามารถทำให้เกิดอาการชาโดยเฉพาะปลายมือและเท้าได้	☐	☐	☐
9. การควบคุมระดับน้ำตาลในเลือดได้ไม่ดีสามารถก่อให้เกิดภาวะไตวายได้	☐	☐	☐
10. การควบคุมระดับน้ำตาลในเลือดให้อยู่ในเกณฑ์ปกติจะลดอาการแทรกซ้อนหรือทำให้อาการแทรกซ้อนเกิดได้ช้าลง	☐	☐	☐
11. การดื่มเครื่องดื่มแอลกอฮอล์เช่น เหล้า ไวน์ ยาดอง มีผลเปลี่ยนแปลงระดับน้ำตาลในเลือดได้	☐	☐	☐

คำถาม	ถูก	ผิด	ไม่รู้
12. ผู้ป่วยโรคเบาหวานที่ป่วยมากหรือมีอาการเจ็บหน้าอกไม่ควรหยุดออกกำลังกาย*	☐	☐	☐
13. ผู้ป่วยโรคเบาหวานควรตรวจเท้าทุกวัน	☐	☐	☐
14. ผู้ป่วยโรคเบาหวานเมื่อเกิดภาวะการติดเชื้อจะทำให้ระดับน้ำตาลในเลือดอยู่ในระดับสูงได้มากกว่าช่วงเวลาปกติ	☐	☐	☐
15. ผู้ป่วยโรคเบาหวานเมื่อไม่สบายควรดื่มน้ำมากๆ และไม่ควรงดอาหาร	☐	☐	☐
16. ในช่วงเวลาที่ไม่สบายผู้ป่วยโรคเบาหวานไม่จำเป็นต้องรับประทานยาลดระดับน้ำตาลเนื่องจากระดับน้ำตาลในเลือดต่ำอยู่แล้ว*	☐	☐	☐
17. การกินยาเม็ดลดระดับน้ำตาลในเลือด ถ้าลืมกินยาให้รีบกินทันทีที่นึกได้แต่ถ้าท่านนึกได้ในเวลาที่ใกล้ถึงเวลากินยาของมื้อถัดไปแล้วก็ให้งดมื้อที่ลืมไปแล้วกินยาในมื้อต่อไปตามปกติไม่ต้องเพิ่มขนาดยาเป็น 2 เท่า	☐	☐	☐
18. ขณะที่ใช้ยาถ้าท่านมีอาการของภาวะน้ำตาลในเลือดลดต่ำกว่า ปกติ ให้กินของหวานๆเช่นน้ำหวานเพื่อบรรเทาอาการและควรแจ้งให้แพทย์ทราบเพื่อปรับขนาดยาให้เหมาะสม	☐	☐	☐
19. ถ้าท่านต้องกินยาเม็ดลดระดับน้ำตาลในเลือดก่อนอาหารแต่ท่านไม่ได้กินอาหารหลังจากกินยาจะมีผลทำให้ระดับน้ำตาลในเลือดของท่านลดลงต่ำกว่าปกติได้	☐	☐	☐
20. การดื่มเครื่องดื่มเช่น เหล้า ยาดอง ไวน์ อาจมีผลต่อยาเม็ดลดระดับน้ำตาลในเลือดที่ท่านรับประทานได้	☐	☐	☐
21. การที่ผู้ป่วยกินยาลดระดับน้ำตาลในเลือดแต่ยังคงกินอาหารที่มีรสหวานเช่นทองหยิบ ทองหยอดอยู่จะมีผลทำให้การควบคุมระดับน้ำตาลในเลือดได้ผลไม่ดีนัก	☐	☐	☐

Appendix M: The Thai Version of the Diabetes Management Self-Efficacy Scale

(English and Thai Versions)

Diabetes Management Self-Efficacy Scale

Direction: please answer each question by checking the answer that describes how confident you are in managing your diabetes**.**

5 = Definitely

4 = Probably Yes

3 = Maybe Yes/Maybe No

2 = Probably No

1 = Definitely Not

Content	Confidence level				
	Definitely Not **1**	Probably No **2**	Maybe Yes /Maybe No **3**	Probably Yes **4**	Definitely **5**
1. I think I can check my blood sugar level if I have to.					
2. I think I can adjust my blood sugar level back to normal when the level of my blood gets too high.					
3. I think I can adjust my blood sugar level back to normal when the level of my blood gets too low.					
4. I think I can choose the right foods to eat.					
5. I think I can control my weight.					

Content	Confidence level				
	Definitely Not	Probably No	Maybe Yes /Maybe No	Probably Yes	Definitely
6. I think I can check to see if there are problems with the skin on my feet, such as the color or if there are bruises, wounds, or inflammations.					
7. I think I can check to see if there are problems with my vision such as a blurred vision.					
8. I think I can get enough exercise by doing things such as walking or riding a bike.					
9. I think I can adjust my diet when I'm ill.					
10. I think I can care of myself and eat suitable food almost of the time.					
11. I think I can increase my level of					

Content	Confidence level				
	Definitely Not	Probably No	Maybe Yes /Maybe No	Probably Yes	Definitely
exercise if the doctor tells me to do.					
12. When I do more exercise than normal, I think I can adjust my food intake suitably.					
13. I think I can adjust my food suitably when I am away from home.					
14. I think I can care for myself by eating suitable food when I am on days off, at festivals, on holidays, or on vacation.					
15. I think I can follow my food when I go to parties.					
16. I think I can adjust my diet suitably when I am under stress or pressure.					

Content	Confidence level				
	Definitely Not	Probably No	Maybe Yes /Maybe No	Probably Yes	Definitely
17. I think I can go to see the doctor every time I have an appointment to check my diabetes.					
18. I think I can take my medicine as prescribed by the doctor.					
19. I think I can adjust my medication when I get sick.					

Diabetes Management Self-Efficacy Scale (Thai version)

แบบวัดการรับรู้สมรรถนะแห่งตนของผู้สูงอายุไทยในการควบคุมและดูแลตนเองสำหรับโรคเบาหวานชนิดไม่พึ่งอินสุลิน

คำชี้แจง

แบบวัดชุดนี้มีวัตถุประสงค์เพื่อต้องการวัดระดับความมั่นใจของท่านในความสามารถที่จะปฏิบัติกิจกรรมในการควบคุมและดูแลตนเองสำหรับโรคเบาหวาน กรุณาเลือกคำตอบที่ตรงกับระดับความมั่นใจของท่านในแต่ละข้อที่เกี่ยวกับการควบคุมและดูแลตนเองในโรคเบาหวาน โดยแต่ละคะแนนมีความหมายดังนี้

5 หมายถึง มีความมั่นใจมากที่สุด

4 หมายถึง มีความมั่นใจมาก

3 หมายถึง มีความมั่นใจปานกลาง

2 หมายถึง มีความมั่นใจน้อย

1 หมายถึง ไม่มีความมั่นใจเลย

สถานการณ์	ระดับความมั่นใจ				
	ไม่เลย 1	น้อย 2	ปานกลาง 3	มาก 4	มากที่สุด 5
1.ท่านคิดว่าท่านสามารถตรวจสอบระดับน้ำตาลในเลือดได้เอง ถ้าจำเป็นต้องทำ					
2.ท่านคิดว่าท่านสามารถทำให้ระดับน้ำตาลในเลือดกลับมาอยู่ในเกณฑ์ปกติได้เมื่อท่านมีอาการของภาวะน้ำตาลในเลือดสูงเกินไป เช่น ปัสสาวะบ่อย กระหายน้ำ อ่อนเพลีย หรือเป็นแผลหายช้า					
3.ท่านคิดว่าท่านสามารถทำให้ระดับน้ำตาลในเลือดกลับมาอยู่ในเกณฑ์ปกติได้เมื่อท่านมีอาการของภาวะน้ำตาลในเลือดต่ำเกินไป เช่น ใจสั่น หน้ามืด หรือเหงื่อออกมาก					
4.ท่านคิดว่าท่านสามารถเลือกกินอาหารที่เหมาะสมกับโรคเบาหวานได้ถูกต้อง					
5.ท่านคิดว่าท่านสามารถควบคุมน้ำหนักตัวเองให้เป็นไปตามเกณฑ์ได้					

สถานการณ์	ระดับความมั่นใจ				
	ไม่เลย 1	น้อย 2	ปานกลาง 3	มาก 4	มากที่สุด 5
6.ท่านคิดว่าท่านสามารถตรวจดูความผิดปกติของผิวหนังบริเวณเท้าด้วยตัวเองได้ เช่น สีผิวซีดเขียวคล้ำ มีรอยช้ำ บาดแผล หรืออาการอักเสบ					
7.ท่านคิดว่าท่านสามารถสังเกตอาการผิดปกติทางการมองเห็น เช่น ตาพร่ามัว					
8.ท่านคิดว่าท่านสามารถออกกำลังกายอย่างเพียงพอที่จะควบคุมระดับน้ำตาลในเลือด เช่น การเดิน หรือการขี่จักรยาน					
9.ท่านคิดว่าท่านสามารถปรับเปลี่ยนการกินอาหารของตัวเองได้อย่างเหมาะสมกับโรคเบาหวานเมื่อท่านเจ็บป่วย					
10.ท่านคิดว่าท่านสามารถที่จะกินอาหารได้ตามแผนการกินที่เหมาะสมกับโรคเบาหวานของท่านได้เป็นส่วนใหญ่					
11.ท่านคิดว่าท่านสามารถออกกำลังกายเพิ่มมากขึ้น ถ้าแพทย์แนะนำให้ท่านทำ					

สถานการณ์	ระดับความมั่นใจ				
	ไม่เลย 1	น้อย 2	ปานกลาง 3	มาก 4	มากที่สุด 5
12.เมื่อท่านออกกำลังกายมากกว่าปกติ ท่านสามารถปรับเปลี่ยนการกินอาหารได้อย่างเหมาะสมกับพลังงานที่สูญเสียไป					
13.ท่านคิดว่าท่านสามารถที่จะกินอาหารได้ตามแผนการกินที่เหมาะสมกับโรคเบาหวานของท่าน แม้ว่าท่านไม่ได้อยู่ที่บ้าน					
14.ท่านคิดว่าในช่วงวันหยุดตามเทศกาลต่างๆหรือช่วงพักร้อนท่านสามารถที่จะกินอาหารได้ตามแผนการกินที่เหมาะสมกับโรคเบาหวานของท่าน					
15.ท่านคิดว่าเมื่อท่านอยู่ในงานเลี้ยงพบปะสังสรรค์ ท่านสามารถที่จะกินอาหารได้ตามแผนการกินที่เหมาะสมกับโรคเบาหวานของท่าน					
16.ท่านคิดว่าท่านสามารถปรับเปลี่ยนการกินอาหารของตัวเองได้เมื่อท่านอยู่ในภาวะเครียดหรือกดดัน					

สถานการณ์	ระดับความมั่นใจ				
	ไม่เลย 1	น้อย 2	ปานกลาง 3	มาก 4	มากที่สุด 5
17.ท่านคิดว่าท่านสามารถไปพบแพทย์เป็นประจำตามที่แพทย์นัดเพื่อตรวจเช็คอาการโรคเบาหวาน					
18.ท่านคิดว่าท่านสามารถกินยาหรือฉีดอินสุลินตามที่แพทย์สั่งได้					
19.ท่านคิดว่าท่านสามารถปรับยาได้เองเมื่อท่านเจ็บป่วย					

Appendix N: The Summary Diabetes self-management Activities (SDSCA)

(English and Thai Versions)

The Revised Summary of Diabetes Self-Care Activities

Directions: The questions below ask you about your diabetes self-care activities during the past 7 days. If you were sick during the past 7 days, please think back to the last 7 days that you were not sick.

Diet

---

1. How many of the last SEVEN DAYS have you followed a healthful eating plan?

   0 1 2 3 4 5 6 7

2. On average, over the past month, how many DAYS PER WEEK have you followed your eating plan?

   0 1 2 3 4 5 6 7

3. On how many of the last SEVEN DAYS did you eat five or more servings of fruits and vegetables?

   0 1 2 3 4 5 6 7

4. On how many of the last SEVEN DAYS did you eat high fat foods such as red meat or full-fat dairy products?

   0 1 2 3 4 5 6 7

Exercise

---

5. On how many of the last SEVEN DAYS did you participate in at least 30 minutes of physical activity? (Total minutes of continuous activity, including walking).

   0 1 2 3 4 5 6 7

6. On how many of the last SEVEN DAYS did you participate in a specific exercise session (such as aerobic dance, jogging, walking, biking) other than what you do around the house or as part of your work?

   0 1 2 3 4 5 6 7

Blood Sugar Testing

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7. On how many of the last SEVEN DAYS did you test your blood sugar?

   0 1 2 3 4 5 6 7

8. On how many of the last SEVEN DAYS did you test your blood sugar the number of times recommended by your health care provider?

   0 1 2 3 4 5 6 7

Foot Care

---

9. On how many of the last SEVEN DAYS did you check your feet?
   0 1 2 3 4 5 6 7
10. On how many of the last SEVEN DAYS did you inspect the inside of your shoes?
   0 1 2 3 4 5 6 7

Smoking

---

11. Have you smoked a cigarette—even one puff—during the past SEVEN DAYS?
   0 No
   1 Yes
   If yes, how many cigarettes did you smoke on an average day?
   Number of cigarettes:_____
12. Which of the following medications for your diabetes has your doctor prescribed? Please check all that apply.
   □[a] An insulin shot 1 or 2 times a day.
   □[b] An insulin shot 3 or more times a day.
   □[c] Diabetes pills to control my blood sugar level.
   □[d] Other (specify):
   □[e] I have not been prescribed either insulin or pills for my diabetes.

Diet

---

13. On how many of the last SEVEN DAYS did you space carbohydrates evenly through the day?

    0 1 2 3 4 5 6 7

Medications

---

14. On how many of the last SEVEN DAYS, did you take your recommended diabetes medication?

    0 1 2 3 4 5 6 7

15. On how many of the last SEVEN DAYS did you take your recommended insulin injections?

    0 1 2 3 4 5 6 7

16. On how many of the last SEVEN DAYS did you take your recommended number of diabetes pills?

    0 1 2 3 4 5 6 7

Foot Care

---

17. On how many of the last SEVEN DAYS did you wash your feet?

    0 1 2 3 4 5 6 7

18. On how many of the last SEVEN DAYS did you soak your feet?

    0 1 2 3 4 5 6 7

19. On how many of the last SEVEN DAYS did you dry between your toes after washing?

    0 1 2 3 4 5 6 7

Smoking

20. At your last doctor's visit, did anyone ask about your smoking status?

    0 No
    1 Yes

21. If you smoke, at your last doctor's visit, did anyone counsel you about stopping smoking or offer to refer you to a stop-smoking program?

    0 No
    1 Yes
    2 Do not smoke

22. When did you last smoke a cigarette?
    □ More than two years ago, or never smoked
    □ One to two years ago
    □ Four to twelve months ago
    □ One to three months ago
    □ One to three weeks ago
    □ Today

The Revised Summary of Diabetes Self-Care Activities (Thai version)
แบบวัดการจัดการตนเองของผู้ป่วยเบาหวาน

คำชี้แจง:คำถามต่อไปนี้ สอบถามเกี่ยวกับกิจกรรมการจัดการตนเองเกี่ยวกับเบาหวานในช่วง 7 วันที่ผ่านมา
ถ้าท่านมีการเจ็บป่วยในช่วง 7 วันที่แล้ว ขอให้ท่านนึกย้อนลงไปภายใน 7 วันที่ท่านไม่ได้มีการเจ็บป่วย

อาหาร

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1. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ทำตามแผนการรับประทานอาหารที่ประโยชน์ต่อสุขภาพของท่าน

   0 1 2 3 4 5 6 7

2. โดยประมาณ ในช่วงเดือนที่ผ่านมา **กี่วันต่อสัปดาห์ ที่**ท่านได้ทำตามแผนการรับประทานอาหารที่ท่านกำหนด

   0 1 2 3 4 5 6 7

3. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ ท่านรับประทานผักและผลไม้ต่างๆ 5 ผลขึ้นไป

   0 1 2 3 4 5 6 7

4. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านรับประทานอาหารที่มีไขมันสูง เช่น เนื้อติดมัน ขาหมู หรือ อาหารที่ปรุงด้วยน้ำมัน

   0 1 2 3 4 5 6 7

การออกกำลังกาย

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5. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ออกกำลังกาย อย่างน้อย 30 นาที (การออกกำลังกายอย่างต่อเนื่อง รวมทั้งการเดิน)

   0 1 2 3 4 5 6 7

6. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ออกกำลังกายประเภทต่างๆ เช่น เต้นแอโรบิค ขี่จักรยาน วิ่ง หรือ เดินช้าๆ เพื่อสุขภาพ นอกเหนือจากการทำงานบ้านหรือที่ทำงาน

   0 1 2 3 4 5 6 7

การตรวจน้ำตาลในเลือด

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7. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ตรวจระดับน้ำตาลในเลือด

0 1 2 3 4 5 6 7

8. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ตรวจระดับน้ำตาลในเลือดตามจำนวนครั้งที่แพทย์สั่ง

0 1 2 3 4 5 6 7

การดูแลเท้า

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9. ในรอบ 7 วันที่ผ่านมา กี่วัน ที่ท่านได้ตรวจดูเท้าของท่าน

0 1 2 3 4 5 6 7

10. ในรอบ 7 วันที่ผ่านมา กี่วัน ที่ท่านได้ตรวจดูด้านในรองเท้าก่อนที่ท่านจะใส่

0 1 2 3 4 5 6 7

การสูบบุหรี่

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11. ท่านสูบบุหรี่ หรือ ยาสูบ บ้างหรือไม่ (แม้แต่สูบเพียง 1 ครั้ง) ในรอบ 7 วันที่ผ่านมา

ไม่เคยสูบบุหรี่

สูบบุหรี่ ท่านสูบบุหรี่ประมาณ วันละ_____มวน

12. การรักษาเบาหวานแบบใดบ้าง ที่แพทย์สั่งเพื่อการรักษาแก่ท่าน
โปรดเลือกทุกข้อที่ท่านได้รับ

ฉีดอินซูลิน วันละ 1 – 2 ครั้ง

ฉีดอินซูลิน วันละ 3 ครั้งหรือมากกว่า

รับประทานยาเพื่อควบคุมระดับน้ำตาลในเลือด

อื่นๆ ระบุ.....

ท่านไม่เคยได้รับการรักษาเบาหวานด้วยการใช้ยารับประทานและการฉีดอินซูลิน

อาหาร

13. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้แบ่งการรับประทานอาหารข้าวหรือแป้ง ให้มีสัดส่วนเท่าๆ กันทุกมื้อ

0 1 2 3 4 5 6 7

การใช้ยา

14. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านรับประทานยาเบาหวานตามที่แพทย์สั่งอย่างเคร่งครัด

0 1 2 3 4 5 6 7

15. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้ฉีดอินซูลินตามที่แพทย์สั่งอย่างเคร่งครัด (สำหรับผู้ที่ฉีดอินซูลิน)

0 1 2 3 4 5 6 7

16. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ ท่านรับประทานยาเบาหวานครบตามจำนวนที่แพทย์สั่ง

0 1 2 3 4 5 6 7

การดูแลเท้า

17. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านล้างเท้าของท่าน

0 1 2 3 4 5 6 7

18. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านแช่เท้า

0 1 2 3 4 5 6 7

19. ในรอบ 7 วันที่ผ่านมา **กี่วัน** ที่ท่านได้เช็ดตามซอกนิ้วเท้าให้แห้งหลังจากการล้างเท้า

0 1 2 3 4 5 6 7

การสูบบุหรี่

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20. การพบแพทย์ครั้งล่าสุด มีใครถามท่านเกี่ยวกับการสูบบุหรี่ บ้างหรือไม่

ไม่มี

มี

21. การพบแพทย์ครั้งล่าสุด ในกรณีที่ท่านสูบบุหรี่ มีใครให้คำปรึกษาเรื่องการเลิกสูบบุหรี่ หรือแนะนำที่จะให้ท่านเข้าร่วมโครงการอดบุหรี่ บ้างหรือไม่

ไม่มี

มี

ไม่ได้สูบบุหรี่

22. ท่านสูบบุหรี่ครั้งล่าสุด เมื่อไหร่

นานกว่าสองปี หรือไม่เคยสูบบุหรี่เลย

1 – 2 ปีที่ แล้ว

4 – 12 เดือน ที่แล้ว

1 – 3 เดือน ที่แล้ว

1 – 3 สัปดาห์ ที่แล้ว

วันนี้

Appendix O: Comparing the Original DNT, Thai DNT (Thai), and Thai DNT (Back- Translation)

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 1. According to the nutrition label, how many grams of total carbohydrate are in ½ cup?	Q 8. จากฉลากโภชนาการของน้ำผลไม้ด้านล่าง ถ้าท่านดื่มน้ำผลไม้ครึ่งกล่องท่านได้รับน้ำตาล กี่กรัม Q 9.จากฉลากโภชนาการของนมถั่วเหลือง น้ำตาลต่ำด้านล่าง ถ้าท่านดื่มนมถั่วเหลือง นี้ครึ่งกล่อง ท่านจะได้รับคาร์โบไฮเดรตซึ่งเป็น กลุ่มใยอาหาร แป้ง และน้ำตาล กี่กรัม	Q 8 From the nutrition information label of fruit juice below, how many grams of sugar will you get if you drink half a box of the fruit juice? Q 9. From the nutrition information label of low sugar soymilk below, if you drink half a box of this soymilk, how many grams of carbohydrates (which is in the group of fiber, flour and sugar) will you get?
Q 2. What is the total amount of carbohydrate eaten if 1 cup of pasta and 1 cup of carrots are eaten together?		
Q 3. If you ate the entire container of pasta, how many calories would you eating?		
Q 4. If you ate the entire bag of chips, how many total grams of carbohydrate would you eat?		

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 5. 1 gram of carbohydrate elevates your blood sugar level 3 points. How much will 20 grams of carbohydrate elevate your blood sugar?	Q 4. ข้าวสวย 1 กรัมเพิ่มน้ำตาลในเลือดได้ 3 หน่วย ข้าวสวย 1 ทัพพี เพิ่มน้ำตาลในเลือดได้กี่หน่วย (ถ้าข้าวสวย 1 ทัพพี เท่ากับ 55 กรัม)	Q 4. If a gram of cooked rice can increase 3 units of blood sugar level, how many units of blood sugar level can be increased by a ladle of cooked rice? (If a ladle of cooked rice is 55 gram)
Q 6. ½ cup of potatoes counts as 1 carbohydrate choice. How many choices does 2 cups of potatoes count s?	Q 1. ข้าวสวย 1 ทัพพีเท่ากับแป้ง 1 ส่วน ข้าวสวย 2 ทัพพีเท่ากับแป้งกี่ส่วน Q 2. มะม่วงสุกขนาดกลาง 1 ลูก เท่ากับแป้ง 2 ส่วน ถ้าท่านต้องการแป้ง 1 ส่วน ท่านต้องกินมะม่วงสุกนี้กี่ลูก Q 3. อาหารในหมวดข้าว-แป้ง ควรกินวันละ 8-12 ทัพพี ถ้าท่านกินมื้อเช้า 3 ทัพพี มื้อกลางวัน 3 ทัพพี ท่านจะกินข้าว-แป้งอีกกี่ทัพพีในมื้อเย็น เพื่อให้ครบ 8 ทัพพี	Q 1. If a ladle of cooked rice is equal to a portion of flour, how many portions of flour are equal to two ladles of cooked rice? Q 2. A medium sized ripe mango is equal to 2 portions of flour. If you want 1 portion of flour, how many mangoes do you have to eat? Q3. The recommended intake of foods in the rice and flour group is 8-12 ladles a day. If you have 3 ladles for breakfast, 3 ladles for lunch, how many ladles would you have for dinner to make it 8 ladles in total a day?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 7. You ate 1 and ½ cups from the food labeled below. How many grams of carbohydrate did you eat?	Q 7. จากตารางแสดงปริมาณสัดส่วนอาหารต่อแป้ง 1 ส่วนด้านล่าง มื้อกลางวันท่านกิน ขนมจีนจำนวน 2 จับครึ่ง และสับปะรดชิ้นพอคำรวม 8 ชิ้น ท่านได้รับแป้งกี่ส่วน	Q7. The table below represents the proportions of food and 1 portion of flour. You have 2.5 portions of Thai rice noodles and 8 pieces of pineapple of suitable sizes. How many portions of flour will you get?
Q 8. Your dietitian recommends you eat **5 servings** of fruits and vegetables, how many cups of cooked vegetables should you eat?	Q 6.จากตารางแสดงปริมาณสัดส่วนของหมวดผักและผลไม้ด้านล่าง วันนี้ท่านกิน ฝรั่งขนาดกลางครึ่งลูก ส้ม 1 ผล และ ผักดิบ 2 ทัพพี ถ้าท่านต้องการกินผักและผลไม้ให้ครบวันละ 5 ส่วน ท่านควรจะกินผักสุกอีกกี่ทัพพี	Q 6. The table below represents the proportions of vegetables and fruits. Today, you have half of a medium sized guava, 1 orange and 2 ladles of fresh vegetable. If you want to have 5 portions of vegetable and fruit a day, how many ladles of cooked vegetable should you have?
Q 9. You ate half the container of carrots. How many carbohydrates did you eat?	Q 5. ท่านได้รับคำแนะนำให้กินผักวันละ 6 ทัพพี ท่านแบ่งกินเป็น 3 มื้อ เท่าๆกัน ท่านจะกินผักมื้อละกี่ทัพพี	Q 5. The suggested intake of vegetables is 6 ladles per day, divided into 3 meals equally. How many ladles of vegetable per meal will you have?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 10. When you lift weights, you need to eat 20 grams of carbohydrate within 15 minutes after you finish. If you finish weight training at 2:00 PM, by when should you eat the carbohydrates?	Q 10. หลังเดินออกกำลังกายเสร็จ ท่านต้องกินอาหารในหมวดข้าว-แป้ง เช่น ข้าวโพดต้ม ภายใน 15 นาที ถ้าท่านเดินออกกำลังกายเสร็จ ตอนบ่าย 2 โมง ท่านควรกินข้าวโพดต้มภายในเวลาไม่เกินกี่โมง	Q 10. After a walk for exercise, you have to have food in the rice and flour group such as cooked corn within 15 minutes. If you finish your walk at 2 pm., by what time should you have the cooked corn?
Q 11. Each cracker has 2 grams of carbohydrate. How many crackers should you eat to get 20 grams?		
Q 12. Before working in the yard you are to decrease your meal insulin by half, if the meal and yard work are two hours or less apart. You usually take 8 units for lunch. If you eat lunch at 12:30 and are going to cut the grass at 2:00 PM, how much insulin should you take?		

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 13. You have to eat 6 grams of carbohydrate for each 30 minutes you plan to walk. You are planning to walk for one hour. You have a bag with 12 crackers. Each cracker contains 10 grams of carbohydrate. How many crackers do you need to eat before your walk?	Q 11. เวลาท่านไปเดินออกกำลังกาย ท่านจะกินอาหารในหมวดข้าว-แป้ง เช่น ขนมปังกรอบ เพื่อให้พลังงาน ท่านต้องกินขนมปังกรอบที่มีแป้ง 5 กรัมเมื่อเดินออกกำลังกาย ทุกครึ่งชั่วโมง ถ้าท่านเดินออกกำลังกาย 1 ชั่วโมง ท่านจะต้องกินขนมปังกรอบกี่ชิ้น (ถ้าขนมปังกรอบ 1 ชิ้น ขนาด 2 นิ้วครึ่ง มีแป้ง 5 กรัม)	Q 11. When you take a walk, you will have food in rice and flour group such as crackers for energy. You have to have crackers containing 5 grams of flour every half an hour during your walk. If you take a one hour walk, how many pieces of crackers do you have to have? (a piece of cracker of 2.5 inches in size contains 5 grams of flour.)
Q 14. Your target blood sugar is between 60 and 120. Please circle the values below that are in the target range (circle all that apply):	Q 12. ถ้าท่านมีเป้าหมายในการควบคุมน้ำตาลในเลือด อยู่ระหว่าง 60 ถึง 120 จงวงกลมตัวเลขด้านล่างซึ่งเป็นค่าน้ำตาลในเลือดที่อยู่ในเป้าหมายการควบคุมน้ำตาลในเลือดของท่าน	Q 12. If your goal is to control your blood sugar level to be between 60 and 120. Circle a number below that is in the range of your goal.

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 15. The hemoglobin A1c (HbA1c) test measures average blood levels for the 2-3 month period before blood is drawn. A HbA1c of 6% is equal to an average blood sugar of about 120. If you average blood sugar in the past 3 months is 240, approximately what is your HbA1c?	Q 14. จากตารางด้านล่าง ด้านซ้ายเป็นค่าน้ำตาลเฉลี่ยสะสมในเลือด 3 เดือนที่ผ่านมา (เอ วัน ซี) เปรียบเทียบกับ ด้านขวาเป็นค่าน้ำตาลในเลือด เช่น น้ำตาลเฉลี่ยสะสมในเลือด 6 % เท่ากับน้ำตาลในเลือด 120 (ดังรูป) จากตารางด้านบน หากท่านมีน้ำตาลในเลือด 240จะเท่ากับค่าน้ำตาลเฉลี่ยสะสมในเลือดเท่าไร	Q 14. In the table below, the left column is the average cumulative amount of blood sugar in the last 3 months (A1C) compared with the right column, which is the value of blood sugar level. For example, as shown in the table, 6 % of the average cumulative amount of blood sugar is equal to the blood sugar level at 120 (see picture). From the table above, if your blood sugar level is 240, how much is your average cumulative amount of blood sugar ?
Q 16.You test your blood sugar 4 times a day. How many strips do you need to take with you on a 2-week vacation?	Q 13.ถ้าท่านต้องตรวจน้ำตาลในเลือดด้วยตนเอง วันละ 4 ครั้ง เป็นเวลา 30 วัน ท่านต้องใช้แผ่นวัดน้ำตาลจำนวนทั้งหมดกี่แผ่น	Q13. If you want to self-monitor your blood sugar level 4 times a day for 30 days, how many test strips do you need?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 17. You test your blood sugar 3 times a day. You purchase a prescription of 50 strips on March 5th . of the dates below, by when will you need to buy new strips?	Q 15. หมอให้ท่านตรวจน้ำตาลในเลือดวันละ 3 ครั้ง ท่านมีแผ่นวัดน้ำตาลทั้งหมด 30 แผ่นในวันที่ 5 มีนาคม ท่านต้องซื้อแผ่นวัดน้ำตาลอีกเมื่อไหร่ ให้วงกลมจากวันที่ให้ด้านล่าง	Q 15. A doctor asks you to test your blood sugar level 3 times a day. On March 5th, you have 30 test strips. When do you have to buy some more test strips? Please circle a date below.
Q 18. You have a prescription for repaglinide 1 mg pills. The label says, " Take 2 mg of repaglinide with breakfast, 1 mg with lunch and 3 mg with supper." How many pills should you take with supper?		
	Q 16. ท่านต้องกินยาเม็ดลดน้ำตาลในเลือด 1 เม็ดก่อนอาหารเช้าครึ่งชั่วโมง ถ้าท่านกินข้าวเวลา 8.00 โมงเช้า ท่านควรกินยากี่โมง	Q 16. You have to take a tablet of a drug lowering blood sugar half an hour before your breakfast. If you have breakfast at 8.00 am, when should you take this drug?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 19. You have a prescription for metformin extended release 500 mg tablets. The label says, "Take 1 tablet with supper each night for the first week. Then, increase by 1 tablet each week for a total of 4 tablets daily with supper." How many tablets should you take with supper each night the **second** week?	Q 19. ถ้าท่านมีโรคประจำตัวหลายโรคและต้องกินยาดังนี้ ยาเม็ดลดน้ำตาลในเลือด ครึ่งเม็ด ก่อนอาหารเช้า ยาเม็ดลดน้ำตาลในเลือด 1 เม็ด หลังอาหารเช้าและเย็น ยาเม็ดลดความดันโลหิต 1 เม็ดหลังอาหารเช้า ยาเม็ดลดไขมัน 1 เม็ด ก่อนนอน **เฉพาะหลังอาหารเช้า**ท่านต้องกินยารวมทั้งหมดกี่เม็ด	Q19. If you have several underlying diseases and need to take the following drugs; -half a tablet of a drug lowering blood sugar before breakfast -a tablet of a drug lowering blood sugar after breakfast and dinner -a tablet of hypertensive drug after breakfast -a tablet of a drug lowering fat before bedtime **Only after breakfast,** how many tablets do you have to take?
Q 20. You have only a few pills left in your pill bottle. Your doctor's office needs 3 days to process a new prescription and your pharmacy needs 2 days to fill it. You take 2 pills a day. What is the **least** amount **of** pills that should be in your prescription bottle when you call for a renewal?	Q 17.ท่านต้องกินยาเม็ดลดน้ำตาลในเลือดวันละครึ่งเม็ด ก่อนอาหารเช้าทุกวัน ถ้าท่านจะไปต่างจังหวัดเป็นเวลา 2 สัปดาห์ ท่านควรเตรียมยานี้ไปอย่างน้อยกี่เม็ด	Q17. You have to take half a tablet of a drug lowering blood sugar before your breakfast everyday. If you will be away for 2 weeks, how many tablets, at least, should you prepare?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 21. For your diabetes, you take 1 pill two times per day. When you get your refill, the bottle has 60 pills. How many days supply do you have?	Q 18. ท่านต้องกินยาเม็ดลดน้ำตาลในเลือด ครั้งละ 1 เม็ดหลังอาหารเช้าและเย็น ท่านพบแพทย์เดือนละ 1 ครั้ง และได้รับยา สำหรับ 1 เดือนท่านควรได้รับยานี้จำนวนทั้งหมด เท่าไหร่ (1 เดือนมี 30 วัน)	Q 18. You have to take 1 tablet of a drug lowering blood sugar after breakfast and dinner. You see your doctor once a month and get the pills that are enough for a month. How many tablets of this drug should you get? (There is 30 days in a month.)
Q 22. You fill your prescription on July 15th. You get a 90 day supply. You must mail in a renewal 10 days before your supply runs out. When do you need to mail in a renewal?	Q 20. ถ้าท่านกินยารักษาโรคเบาหวาน ครั้งละ 1 เม็ด วันละ 2 ครั้ง ท่านมียานี้อยู่จำนวน 60 เม็ด จะเพียงพอสำหรับกี่วัน	Q 20. If you take a tablet for diabetes twice a day, how many days will you spend for taking 60 tablets?
Q 23. You take 46 units of insulin at bedtime. On the syringe below, circle the line/marking that shows you have drawn 46 units.		
Q 24. Your insulin dose is increased to 54 units and you begin using a larger syringe that holds 100 units. On the syringe below, circle the line/marking that shows you have drawn 54 units.	Q 21. ถ้าท่านต้องฉีดอินซูลิน 54 ยูนิต โดยใช้กระบอกฉีดยาขนาด 100 ยูนิต จากกระบอกฉีดยาด้านล่าง โปรดขีดเส้นตัวเลขที่แสดงว่าเป็น 54 ยูนิต	Q 21. If you have to inject 54 units of insulin by using a 100 units syringe, please underline the number representing 54 units in the syringe below.

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Q 25. You take 10 units of insulin lispro and 16 units of insulin glargine before breakfast. What is the total number of units of insulin you take before breakfast?	Q 22. ก่อนอาหารเช้า ท่านต้องฉีดยาอินซูลิน 2 ชนิด ชนิดที่ 1 จำนวน 10 ยูนิต ชนิดที่ 2 จำนวน 16 ยูนิต ท่านต้องฉีดอินซูลินรวมทั้งหมดกี่ยูนิต	Q 22. Before breakfast, you have to inject two types of insulin, 10 units for type I and 16 units for type 2. How many units of insulin do you have to inject in total?
Q 26. The doctor tells you to take 2 units of insulin for every 1 serving of carbohydrate you eat. How many units of insulin do you take for 6 servings of carbohydrate?	Q 23. เมื่อท่านกินอาหารในหมวดข้าว-แป้งทุก 1 ส่วน หมอแนะนำท่านให้ฉีดอินซูลิน 2 ยูนิต ถ้าท่านกินอาหารในหมวดข้าว-แป้ง 6 ส่วน ท่านต้องฉีดอินซูลินกี่ยูนิต	Q 23. When you have a portion of food in the rice and flour group, a doctor advises you to inject 2 units of insulin. If you have 6 portions of food in the rice and flour group, how many units of insulin do you have to inject?
Q 27. 1 unit of insulin lowered your blood sugar by 30 points. How much does 4 units of insulin lower your blood sugar?		

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Use the following information for questions 28, 29, 30 **Please <u>round down</u> to the nearest whole number** You are given the following instructions: "Take 1 unit of insulin for every 7 grams of carbohydrate you eat." How much insulin do you take:		
Q 28. **When you eat 49 grams at Breakfast?**		
Q 29. **When you eat 60 grams at Lunch?**		
Q 30. When you eat 98 grams at Supper?		
Q 31. You have been told to cut you insulin in half for a colon test. Your usual dose is 41 units. What amount should you take for the colon test?	Q 24. ปกติท่านฉีดอินซูลิน 42 ยูนิต หมอบอกท่านให้ฉีดอินซูลินลดลงครึ่งหนึ่ง เมื่อต้องไปตรวจลำไส้ ดังนั้นถ้าท่านต้องไปตรวจสำไส้ท่านจะฉีดอินซูลินกี่ยูนิต	Q 24. You usually inject 42 units of insulin. When you have your colon checked, a doctor tells you to reduce its amount to half of this number. Therefore, if you have your colon checked, how many units of insulin will you inject?

DNT 43 Original Full Version	DNT 25 (Thai Version)	DNT 25 (Back-translated to English)
Use the following information for question 32, 33, 34; You are told to follow the sliding scale shown here. The sliding scale indicates the amount of insulin you take based upon your blood sugar levels…		Please use the information below to answer question 25. A doctor tells you to inject insulin with the amount as shown in the table. The left column is the value of blood sugar. The right column is the amount of insulin to be injected.
Q 32. How much insulin would you take for a blood sugar of 191?		
Q 33. How much insulin would you take for a blood sugar of 134?		
Q 34. How much insulin would you take for a blood sugar of 295?	Q 25. ถ้าน้ำตาลในเลือด 295 ท่านจะฉีดอินซูลินกี่ยูนิต	Q 25. If your blood sugar level is 295, how many units of insulin will you inject?
These question 35 to 43 in original version of DNT were not included in the Thai DNT Use the following information for questions 35, 36, and 37 You check your blood sugar just before eating. You take 1 unit of insulin for every 10 grams of carbohydrates you eat. You are also given the sliding scale shown below. The sliding scale indicates the amount of insulin you should add to your usual dose based upon your blood sugar levels: If your blood sugar is greater than 120 points at breakfast, lunch or supper, add 2 units of insulin. If your blood sugar is greater than 150 points at breakfast, lunch or supper, add 4 units of insulin. If your blood sugar is greater than 180 points at breakfast, lunch or supper, add 6 units of insulin.		
Q 35. Your blood sugar is 284 and you ate 40 grams of carbohydrate at breakfast. How much total insulin do you need to take?		

Q 36. Your blood sugar is 140 and you will eat 50 grams of carbohydrate at lunch. How much total insulin do you need to take?

Q 37. Your blood sugar is 380 and you will eat 60 grams of carbohydrate at supper. How much total insulin do you need to take?

Questions 38-42

You have been asked to start taking 32 units of NPH insulin tonight at bedtime. This insulin will work during the night and will lower your blood sugar first thing in the morning. You were given the following instructions:

- Your goal is to have the morning (fasting) blood sugar below 120.
- Check your blood sugar every morning before breakfast.
- Start with 32 units of NPH tonight. Increase the dose by 2 units **every other** day until your blood sugar is at or below 120.
- Your fasting blood sugar **must** be above 120 for 2 mornings in a row in order for you to increase the insulin dose by 2 units.
- Once your blood sugar is staying below 120, stop increasing the nighttime insulin.

You begin with 32 units of NPH insulin last night. How much NPH insulin will you take on each of the following nights?

Q 38. Morning of day 1, your blood sugar is 164. How much insulin will you take that night?
Q 39. Morning of day 2, your blood sugar is 136. How much insulin will you take that night?
Q 40. Morning of day 3, your blood sugar is 102. How much insulin will you take that night?

Q 41. Morning of day 4, your blood sugar is 140. How much insulin will you take that night?
Q 42. Morning of day 5, your blood sugar is 132. How much insulin will you take that night?
Q 43. After seeing the Doctor, you are given the following instruction to lower a high blood sugar level before a meal:
"Starting with a blood sugar of 120, take 1 unit of insulin lispro for each 50points of blood sugar."
How much insulin should you take for a blood sugar of 375?

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