The associations between dry mouth and oral health-related quality of life in diabetic patients in Songkhla, Thailand

Arisa Srikong, 190188090

Supervisors: Professor Sarah R Baker and Professor Barry J Gibson

A thesis submitted in the fulfilment of the requirement for the Degree of Doctor of Philosophy

Unit of Oral Health, Dentistry and Society
School of Clinical Dentistry
The University of Sheffield
United Kingdom

2023

COVID-19 statement

In 2019, I arrived in the UK to commence my PhD. Towards the end of that year, news emerged of a novel virus causing an infectious disease in Asia. At that time, little did I anticipate that it would escalate into a global pandemic with profound effects on daily life. During the pandemic and ensuring lockdown measures, it became evident that the challenges extended beyond physical health; mental health issues also emerged as a significant concern.

For my research project, my initial plan was to collect data at Hatyai hospital. Participant recruitment and data collection were scheduled to occur there, involving salivary flow collection and face- to-face interviews at two time points: baseline and six-month follow-up. However, after receiving ethical approval in May 2021, the hospital, due to the ongoing and indefinite nature of the outbreak, decided not to allow non-emergency face-to-face data collection. Initially, my team and I chose to wait, hoping for an improvement in the situation. Unfortunately, after a month, no signs of improvement were evident. Consequently, we had to reconfigure our study. Recruitment and data collection had to be conducted via phone, and salivary flow collection had to be cancelled. Given the time constraints and the potentially more time-consuming nature of remote data collection compared to face-to-face methods, we shortened the follow-up period from six to three months.

As a result, the study was able to recruit only 11% of Type 1 diabetic patients. However, this figure aligns with the nature of distribution of diabetes types, where it is estimated that Type 1 diabetes comprises around 10% of all cases (Banday et al., 2020). Consequently, the present study focused primarily on Type 2 diabetic patients, as the two types of diabetes could not be compared, nor collapsed into one group due to substantial differences in the disease profile. In addition, the data collected at baseline and the three-month follow up were, perhaps unsurprisingly, fairly similar. Therefore, I decided not to assess changes over time but rather concentrate solely on the baseline dataset.

Now, in 2023, life has returned to a semblance of normalcy, and the memories of life during the pandemic have begun to fade. My PhD project may not have unfolded as originally planned, yet it has taught me valuable lessons in adaptability, patience, and managing unexpected challenges. Eventually, COVID-19 receded into history, and I'm submitting my thesis to you.

Abstract

Objective: To examine the associations between dry mouth and oral health-related quality of life (OHRQoL) in diabetic patients in Songkhla, Thailand utilising the Wilson and Cleary model as the guiding framework.

Background: Dry mouth is a condition in which the individual experiences a dryness sensation (xerostomia) and/or salivary gland hypofunction. Dry mouth is a common oral health problem for patients with diabetes, which can lead to a range of impacts in daily life which, in turn, may lead to a lower quality of life (QoL). To date, there have been few studies that have examined the associations between dry mouth and OHRQoL in diabetic patients.

Methods: Two hundred and ten diabetic patients were included in the study. Data collection was by self-reported questionnaires collected via telephone interview including symptom and functional status, general health perceptions, psychological distress (depression and anxiety), sense of coherence, health locus of control and self-esteem. Clinical data retrieved from medical records included underlying diseases, medications, blood sugar levels and duration of diabetes, alongside demographic characteristics (age, sex, income, education level). Structural equation modelling (SEM) was used to analyse the direct and indirect pathways between the variables according to the Wilson and Cleary model.

Results: The main results were that worse dry mouth symptoms status were associated with worse OHRQoL. This association was mediated by functioning and health perceptions. However, an association was not found between clinical status and symptoms. The psychological variables (sense of coherence and self-esteem) played a key role at each stage of the model. Furthermore, polypharmacy and multimorbidity impacted on clinical status, health perceptions, and OHRQoL.

Conclusions: The findings support Wilson and Cleary model, indicating that dry mouth impacted on daily lives of diabetic patients in a range of ways including eating, drinking, and socialising. Interventions targeted at reducing multi-morbidity, managing polypharmacy, and improving psychological adaptation were also found to be important suggesting potential avenues to minimise impact of dry mouth and improve QoL.

Keywords: Dry mouth, oral health-related quality of life, diabetes mellitus

Acknowledgements

There is a quote that says, “After every storm, there is a rainbow”. I consider myself incredibly fortunate to have finally seen that rainbow. During the heaviest of storms, I was blessed with a warm home to shelter in.

First and foremost, I want to extend my deepest gratitude to those who have consistently supported and encouraged me, especially, my family and friends. Your unwavering support and strength have lifted me through the darkness moments. “Thank you” never seems sufficient to express my feelings; I love you all from the bottom of my heart.

Next, I want to acknowledge the two most pivotal figures who have always had my back: my super-duper supervisors, Prof. Sarah R. Baker and Prof. Barry J. Gibson. Words cannot adequately convey how incredibly kind you both are and how much your belief in me means. Whenever I questioned myself, I reminded myself that there are persons who believe in me, and that is you. Thank you profoundly for your guidance, support, and unwavering faith in me. Four years under your supervision have flown by, and I deeply appreciate every moment. I truly believe it was destiny that brought me to you, and I consider myself incredibly fortunate to have found such remarkable role models. I hope you understand the depth of my appreciation, even though it is difficult to express in words.

Moreover, I extend my thanks to Prince of Songkla university, my colleagues, and my research assistant for their funding, valuable advice, and assistance during the data collection process. I am also grateful to Hatyai hospital for permitting contact with patients for project invitations and for providing essential tools to remote work. My heartfelt thanks go out to all the participants who joined the study. Your involvement is greatly appreciated.

Lastly, I want to express my gratitude to the University of Sheffield for providing a conducive environment. It was here that I made wonderful new friends and encountered friendly staffs.

And, finally, I want to thank myself for not giving up during these hard times. It may not be excellent, but I have done my best. I love you, Arisa.

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

List of tables

List of tables

List of figures

List of abbreviations

Audit of Diabetes-Dependent Quality of Life	ADDQoL-19
Diabetes mellitus	DM
Fasting blood sugar	FBS
Fasting plasma glucose	FPG
Geriatric Oral Health Assessment Index	GOHAI
Haemoglobin A1c	HbA1c
Hospital and Anxiety Depression Scale	HADS
Health locus of control	HLOC
Health-related quality of life	HRQoL
International Classification of Functioning, Disability and Health	ICF
International Classification of Impairment, Disability and Handicap	ICIDH
Magnetic resonance imaging	MRI
Modified Schirmer test	MST
Multidimensional Health Locus of Control scale form C	MHLC-C
Non-communicable diseases	NCD
Oral glucose tolerance test	OGTT
The short form Oral Health Impact Profile	OHIP-14
Oral health-related quality of life	OHRQoL
Quality of life	QoL
Rosenberg Self-Esteem Scale	RSES
Salivary gland hypofunction	SGH
Sense of coherence	SOC
Stimulated salivary flow rate	SSFR
Structural equation modelling	SEM
Type 1 Diabetic patients	T1DM
Type 2 Diabetic patients	T2DM
Universal health coverage	UHC
Visual Analogue Scale	VAS
Xerostomia Inventory	XI

Chapter One

Introduction

Dry mouth is the condition in which an individual experiences a sensation of mouth dryness (xerostomia) or salivary gland hypofunction (SGH) (Liu et al., 2012). To date, there is no general consensus on the terminology of xerostomia and SGH, and both terms are commonly used interchangeably (Orellana et al., 2006; Bultzingslowen et al., 2007; Mortazavi et al., 2014). For example, Bertram (1967) used xerostomia and SGH to describe different salivary flow levels (Nederfors, 2000) or used xerostomia as both subjective symptoms of oral dryness and reduction in salivary secretion (Fox et al., 1987). For the present PhD research project, xerostomia is described as an individual's subjective sensation or their perception of dry mouth (Orellana et al., 2006; Khovidhunkit et al., 2009; Thomson, 2015; Villa et al., 2016). SGH is defined as a decrease in saliva produced by the salivary gland which leads to a salivary flow rate reduction (Nederfors, 2000; Khovidhunkit et al., 2009; Hopcraft and Tan, 2010).

It is worthy of note that xerostomia and SGH can occur within the same individual, but this is not always the case (Joanna and Thomson, 2015; Agostini et al., 2018; Sonpanao et al., 2023). For example, Fox et al. (1987) found that almost 90% of dry mouth patients had self-reported dry mouth problems during the day and night. However, there was no significant difference in either unstimulated or stimulated salivary flow rates between those who reported dry mouth issues during both periods and those who did not.

As the definitions of xerostomia and SGH are often not clear; this has meant that the measurement methods used in previous studies have often varied. This has led to the epidemiology of the condition varying greatly in the published literature (Joanna and Thomson, 2015; Villa et al., 2016). The range in the prevalence of xerostomia has been reported as between 0.4% to 46% (Orellana et al., 2006; Hopcraft and Tan, 2010), whilst the prevalence of unstimulated hyposalivation ranges between 14.9% to 39.8% (Osterberg et al., 1984; Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Flink et al., 2008). The prevalence of stimulated hyposalivation ranged from 2.3% to 31.7% (Osterberg et al., 1984; Anttila et al., 1998; Ikebe et al., 2007; Flink et al., 2008). The prevalence of the combination of the two conditions has been reported as between 2.0% to 5.7% (Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Ikebe et al., 2007).

As noted earlier, inconsistencies in prevalence may be due to differences in both the definitions and measurement tools used. To date, these have been measured in a variety of ways as both xerostomia and hyposalivation. Xerostomia can be assessed by asking an individual directly either through self-report questionnaires or through interviews. For example, the Xerostomia Inventory (XI) developed by Thomson et al. (1999) is a questionnaire that covers experiences and behaviour change due to xerostomia, and the participant can rate the severity of their symptoms. To date, the XI has been utilised to examine xerostomia in many studies across the world.

For SGH, the condition can be examined by salivary flow measurement, also known as sialometry. There are several methods of salivary flow assessments. In general, the assessment can be divided into four methods; passive (drain), active (spit), suction, and swab (Thomson, 2005; Falcão et al., 2013; Thomson, 2015). Measurement can examine both unstimulated and stimulated salivary flow. There have been factors that have been shown to influence the salivary flow rate, including state of hydration, body position, circadian rhythm, and smoking.

Dry mouth can be influenced by systemic diseases, medications, age, sex, radiation, and health-related behaviours. Serious conditions, diseases, and injuries that cause nervous system problems, or damage to salivary glands can result in decreased salivary production. Moreover, medications are the most common cause of dry mouth (Porter et al., 2004; Shirlaw and Khan, 2017). There are numerous drugs that have been reported to cause dry mouth, for example, antidepressants, anticholinergics, antispasmodics, antihistamines, antihypertensives, sedatives, bronchodilators, diuretics, and analgesics (Guggenheimer and Moore, 2003; Liu et al., 2012; Millsop et al., 2017).

Age and sex are factors that can influence dry mouth with numerous reports of a higher prevalence of dry mouth in the older adults and women (Nederfors et al., 1997). However, it is important to take into account systemic diseases and medications as confounding variables in these associations as both increase with age.

Furthermore, radiation and some treatments, for example, stapedectomy can cause damage to the nerve supply to salivary glands, in turn, leading to diminished salivary secretion and chronic dry mouth symptoms (Tanasiewicz et al., 2016; Jensen et al., 2019). Apart from these, there have also been reports that smoking, alcohol, and caffeine use affect both salivary secretion and xerostomia (Pedersen et al., 2002; Tanasiewicz et al., 2016; Millsop et al., 2017; Shirlaw and Khan, 2017).

Dry mouth has been reported to have various negative effects on the oral cavity, which increases the susceptibility to oral diseases, for example, dental caries, periodontitis, and oral infection, such as denture stomatitis (Locker, 1993; Guggenheimer and Moore, 2003; Folke et al., 2009; Gueiros et al., 2009; Tanasiewicz et al., 2016; Millsop et al., 2017). All of these effects impair the ability of the oral cavity to function. For example, there have been reports of difficulty in eating, swallowing, speaking, taste alteration, walking, running, singing, tooth brushing and sleeping in patients with dry mouth (Locker, 2003; Gerdin et al., 2005; Ikebe et al., 2005; Folke et al., 2009; Niklander et al., 2017; Gibson et al., 2020).

In addition, there have been a number of psychological and social impacts as a result of dry mouth which have been reported in the literature. These have included being anxious, annoyed, agitated, angry, confused, depressed, despairing, disgusted, embarrassed, forlorn, fearful, frightened, frustrated, gnawing, grumpy, helpless, irritated, melancholic, mad, nervous, nerve-wracking, panicked, regretful, sad, shameful, stressed, struggling, self-conscious, self-aware, tense, upset, uneasy, and worried (Locker, 2003; Gerdin et al., 2005; Thomson et al., 2006; Ikebe et al., 2007; Folke et al., 2009; Gibson et al., 2020).

Various signs, symptoms, functional limitations, and psychological impacts can lead individuals to also experience negative social consequences of dry mouth. Such impacts include difficulty speaking to others and interacting in groups, reluctance to eat with others as ashamed of their eating habits, feeling different, enjoying kissing, and sexual intercourse, having trouble enjoying time off, having work difficulties, less life satisfaction, avoiding activities such as fitness programmes due to the need to drink frequently, or chorus singing and lack of saliva leading to poor retention of dentures resulting in less confidence in various social settings (Thomson et al., 2006; Ikebe et al., 2007; Folke et al., 2009; Gibson et al., 2020).

Diabetes mellitus is a chronic systemic disease which has been increasing in prevalence around the world. Diabetes impacts oral health, including dry mouth (Ship, 2003; Deshpande et al., 2008; Mauri-Obradors et al., 2017; Rohani, 2019). This is because diabetes can have a deleterious effect on the salivary gland resulting in SGH and xerostomia (Chávez et al., 2001; Lamster et al., 2008; Busato et al., 2012; Ivanovski et al., 2012).

To date, previous studies have reported that diabetic patients had a higher prevalence of xerostomia (Ben-Aryeh et al., 1993; Moore et al., 2001; Khovidhunkit et al., 2009; Malicka et al., 2014) and SGH than healthy individuals (Moore et al., 2001; Khovidhunkit et al., 2009; Borges et al., 2010; Lone et al., 2017). The prevalence of xerostomia in diabetic patients ranged from 20% to 76.4% (Sreebny et al., 1992; Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Busato et al., 2009; Khovidhunkit et al., 2009; Borges et al., 2010; Malicka et al., 2014). For SGH, the prevalence of unstimulated hyposalivation ranged 14.9% to 39.8% (Osterberg et al., 1984; Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Flink et al., 2008). For stimulated saliva, the prevalence of hyposalivation ranged 2.3% to 31.7% (Osterberg et al., 1984; Anttila et al., 1998; Ikebe et al., 2007; Flink et al., 2008).

Dry mouth is seemingly a common oral health problem in diabetes, which can lead patients to encounter numerous difficulties in daily life, including both clinical and social problems. All of these can lead to poorer quality of life (QoL) (Busato et al., 2009; Molania et al., 2017). Further, numerous factors have been shown to influence the QoL of diabetic patients, for example, patient’s demographic characteristics (e.g. age, sex), socioeconomic status, and disease status.

In Thailand, there have been few studies that have explored dry mouth in the population, and even fewer studies with diabetic patients. Furthermore, most studies conducted to date – in Thailand or worldwide - on dry mouth have focused primarily on clinical aspects, treatment, and clinical management. Very few that have investigated the impact of dry mouth on oral health-related quality of life (OHRQoL) and well-being.

Therefore, this PhD research study aims to examine associations between dry mouth and OHRQoL in diabetic patients in Songkhla province, Thailand. The study uses the Wilson and Cleary model (1995) as its conceptual framework, which hypothesises the relationship between a clinical condition (in this case dry mouth), symptom status, functional status, general health perceptions and well-being. It also hypothesises the importance of individual and environmental variables in the inter-relationships between clinical conditions, symptoms, functioning and well-being. The model has been utilised in various chronic diseases (Ojelabi et al., 2017), including oral health conditions, including xerostomia (Baker et al., 2007; Baker et al., 2008).

The PhD thesis is structured as follows:

Chapter Two reviews the literature related to dry mouth, diabetic mellitus, OHRQoL, as well as the Wilson and Cleary model. This chapter also outlines the rationale, aim and research questions.

Chapter Three describes the methodology, methods, measurements, and materials used.

Chapter Four reports the results which overview the characteristics of the participants, clinical status as well as patient-reported outcomes. This chapter also reports the associations among variables and the relationships of variables based on the Wilson and Cleary model. The overview reports data from all participants at baseline and at three-month follow-up. The correlations and the resulting model, however, focuses only on Type 2 diabetic patients at baseline. This is because the number of Type 1 diabetic patients was low, and there was little difference (for either Type 1 or 2 patients) in results between baseline and three-month follow-up.

Chapter Five discusses the findings of the study. This chapter also considers the limitations of the study.

Chapter Six provides a summary of the study and offers recommendations for clinicians, health promotion efforts, and future research.

Chapter Two

Literature Review

2.1. Introduction

In recent years, there have been various studies on dry mouth, and many have investigated the association between dry mouth and oral health-related quality of life (OHRQoL) and well-being. However, there have been few studies in diabetic patients. In Thailand, there have been only a few studies on dry mouth, and none investigating the link between dry mouth and OHRQoL and well-being in diabetic patients.

This chapter aims to present a comprehensive review of existing literature on dry mouth, diabetes mellitus, and OHRQoL. It also seeks to identify gaps in literature. The review will commence with dry mouth, followed by diabetes mellitus, and then OHRQoL.

2.2 Dry mouth

The first section will review the literature on dry mouth, beginning with definitions, followed by a discussion of its prevalence and measurement. This will lead on to the causes of dry mouth, which encompass diseases, medications, treatments, and behaviours. The final section will consider the impacts of dry mouth, including physiological, functional, psychological, and social consequences.

2.2.1 Definitions of dry mouth

A reduction or alteration in salivary flow can lead to the common oral health condition, known as dry mouth, which can generally be categorised into two states: xerostomia and salivary gland hypofunction (SGH), also referred to as hyposalivation (Liu et al., 2012). There is no general consensus on the terminology for xerostomia and SGH, and both terms are commonly used interchangeably (Orellana et al., 2006; Bultzingslowen et al., 2007; Mortazavi et al., 2014). For instance, in the diagnosis of Sjogren’s syndrome, the Copenhagen criteria denote xerostomia as an abnormal salivary gland function which leads to a reduction in salivary flow rate (Manthrope et al., 1986), while the European classification assesses xerostomia both as a subjective dry mouth perception and as abnormal salivary gland involvement (Vitali et al., 1996; Vitali et al., 2002).

Other examples of ambiguous definitions include the use of xerostomia and SGH to describe varying salivary flow levels (Bertram 1967, cited in Nederfors, 2000). Fox et al. (1987) employed xerostomia to refer to both the subjective symptom of oral dryness and decreased salivary secretion. In addition, Nederfors et al. (1997) defined xerostomia as the subjective symptom of oral dryness, while SGH denoted a decreased salivary flow rate.

As evident from the discussion above, there exist numerous definitions of dry mouth, many of which share similarities. To ensure simplicity and clarity, the accepted clinical definition of xerostomia is an individual's subjective sensation or perception of having a dry mouth (Orellana et al., 2006; Khovidhunkit et al., 2009; Thomson, 2015; Villa et al., 2016). The subjective symptom or perception can then be assessed by directly asking individuals, either through self-report questionnaires or interviews. For example, the perception of dry mouth can be assessed with questions such as: "How often does your mouth feel dry?" (Thomson et al., 1999), "Do you feel dry in the morning, periodically during the day, in the evening, or at night?" (Narhi, 1994), or "Does your mouth feel distinctly dry?" (Osterberg et al., 1984).

For SGH, the agreed definition can be defined as a substantial reduction in saliva production by the salivary gland, resulting in a decrease in salivary flow rate (Nederfors, 2000; Khovidhunkit et al., 2009; Hopcraft and Tan, 2010). This objective indicator of SGH can be determined by salivary flow measurement, also known as sialometry.

In Thailand, many studies have denoted xerostomia as the subjective feeling or symptoms of dry mouth (Nittayananta et al., 2010; Nittayananta et al., 2013; Thatreenaranon, 2018; Vathanophas, 2019), and SGH as a reduced salivary flow rate (Nittayananta et al., 2010; Nittayananta et al., 2013; Samnieng, 2015).

It is noteworthy that xerostomia and SGH can coexist within the same individual, although this is not always the case (Joanna and Thomson, 2015; Agostini et al., 2018; Sonpanao et al., 2023). Indeed, the relationship between the two has been examined in many studies (Fox et al., 1987; Anttila et al., 1998; Thomson et al., 1999; Putten et al., 2011; Hahnel et al., 2014; Sonpanao et al., 2023).

For example, a study conducted by Fox et al. (1987) in the USA examined a sample of 100 patients with dry mouth symptoms. At the first visit, patients were asked to complete a series of questions related to oral dryness perception and oral functions. This included inquiries about experiencing dry mouth sensations at night or upon awakening, difficulties in swallowing, and any behavioural changes adopted to alleviate the symptoms. Additionally, the study investigated unstimulated and 2% citric acid solution stimulated salivary flow.

To ensure standardised conditions, patients were instructed to avoid eating, drinking, smoking, and performing oral hygiene for a period of 2 hours before salivary collection. Appointments were scheduled between 9 and 11 am. Saliva samples were directly collected from the major salivary glands. The parotid secretion sample was collected using a modified Carlson-Crittenden collector, and the submandibular/sublingual secretion sample was directly obtained from salivary glands using a micropipette at the glandular orifices. Secretion samples were collected into pre-weighed plastic tubes, and the gravimetric method was used to investigate salivary flow rate.

The findings of this study showed that almost 90% of the patients self-reported experiencing dry mouth problems throughout the day and night. In spite of this, there were no significant differences observed in unstimulated and stimulated salivary flow rate between those who reported dry mouth during day and night, and those who did not. Similarly, the results from questions regarding behaviours aimed at alleviating dry mouth (e.g., keeping a glass of water by the bedside, chewing gum, or using candies for relief) showed non-significant differences. However, a significant association was found between decreased salivary flow rate and eating-related functions. For instance, difficulties in swallowing dry foods and the need to sip liquids to aid in swallowing were associated.

These findings indicated that subjective dryness symptoms and objective signs of hyposalivation do not always coexist; rather, the relationship between the two appears more complicated. Of note, the study collected salivary flow rate data directly from each gland using a modified Carlson-Crittenden collector and micropipette. As a result, the findings could identify which gland exhibited hypofunction. However, the authors did not provide details about the analysis process or the laboratory conditions. Consequently, little can be concluded about the validity, reliability, and accuracy of measurement methods used.

In support of this, Ikebe et al. (2007) conducted a study to investigate the prevalence of dry mouth symptoms and hyposalivation among 278 active older adult participants (aged 60 - 81 years) in Japan. By employing the question “Does your mouth feel dry when eating a meal?” to evaluate xerostomia, they found that 8.3% experienced a subjective feeling of dry mouth during eating. Stimulated whole saliva was evaluated by chewing and collected between 10 am and 3 pm by five calibrated dentists. The findings indicated that 19% of participants were diagnosed with hyposalivation (with a cut-off value set at 0.5 mL/min). Yet, the coexistence of both conditions was observed in only 3.3% of cases. Interestingly, the study also found that those without dry mouth symptoms exhibited a significantly higher salivary flow rate.

Furthermore, the researchers examined dental status, finding that 4.3% of participants were edentulous, and 60% had at least 24 teeth. The study also investigated OHRQoL using the short-form of the oral health impact profile (OHIP-14). Poorer OHRQoL was associated with lower general health satisfaction, lower financial position, fewer remaining teeth, experiencing dry mouth while eating, and hyposalivation. Participants with xerostomia and hyposalivation also reported significantly higher taste alteration, psychological impacts, and disruptions in daily life compared to other groups. The study demonstrated no significant association between xerostomia and hyposalivation, aligning with the findings of Fox et al. (1987).

Notably, the Ikebe et al. (2007) study specifically assessed dry mouth during eating, whereas Fox et al. (1987) used the question without specifying a particular time or activity. This difference might account for the higher prevalence of xerostomia in the Fox et al. (1987) study compared to Ikebe et al. (2007). Similar results were found in salivary flow, despite the varying methods and collection times used in the studies.

Moreover, many studies have failed to find significant relationships between xerostomia and SGH. Hopcraft and Tan (2010) reviewed 11 studies undertaken in Northern Europe, USA, Canada, and Australia. Of these, seven examined the prevalence of xerostomia and SGH in the general population within the same sample of participants. The study found a prevalence of both conditions ranging from 2% to 5.7%. The prevalence of xerostomia varied from 8.3% to 42%, while hyposalivation prevalence ranged from 11.5% to 47%. Hopcraft and Tan (2010) suggested that this discrepancy might be attributed to the different definitions and methodologies. Further details of prevalence and methods are provided in the section below.

In summary, dry mouth encompasses to two conditions: xerostomia and SGH, although a clear consensus on the meanings of these terms is lacking. Xerostomia is generally understood as a subjective symptom or feeling of oral dryness, while SGH is defined by decreased salivary flow rate. While the two conditions can coexist, this is not always the case.

2.2.2 Prevalence of dry mouth

Given that the definitions of xerostomia and SGH are often unclear, measurement methods used in previous studies have often varied. Consequently, as mentioned earlier, this has led to significant disparities in the epidemiology of the condition (Joanna and Thomson, 2015; Villa et al., 2016).

Orellana et al. (2006) conducted a systematic review in which they examined the prevalence of xerostomia. The review included 13 studies, all of which examined its prevalence in population-based samples. The sample sizes ranged from 259 to 3,313 participants, and mostly aged 50 years and older. The prevalence across the 13 studies ranged from 0.4% to 46%. The xerostomia assessments were collected via mail, telephone, oral interview, or written interview. An interesting observation was that six of the studies were conducted in Nordic countries, with the remainder based in Germany, Spain, Canada, the USA, Australia, Israel, and Chile. Consequently, further research is needed in non-western countries and with younger adults.

The review suggested the need for consensus on the definitions of xerostomia and SGH, along with the development of standardised measurement tools. These would facilitate easier comparison of prevalence rates across different studies. Table 1 shows xerostomia and SGH prevalence across the world, some studies were reported in Orellana et al. (2006).

Table 1: International xerostomia and salivary gland hypofunction prevalence (Osterberg et al., 1984; Locker, 1993; Narhi, 1994; Nederfors et al., 1997; Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Reichart, 2000; Field et al., 2001; Jansson et al., 2003; Orellana et al., 2006; Ikebe et al., 2007; Flink et al., 2008; Hopcraft and Tan, 2010)

Author	Year	Sample					Assessment		Prevalence (%)		
		Country	Population	Age	Total	Sex	Xerostomia	SGH	Xerostomia	SGH	Both
Osterberg et al.	1984	Sweden	Community	Only 70	451 522	Male Female	Personal interview: “Does your mouth feel distinctly dry?”.	Unstimulated and stimulated whole saliva (subsample)	16.0 25.0	33[a]/7[b] 30[a]/28[b]	N/A
Ben-Aryeh et al.	1985	Israel	Community	Over 60	259	Male Female	Self-administered questionnaire containing a short explanation of xerostomia.	Unstimulated and stimulated whole saliva	27.7 (Total)	N/A	N/A
Locker	1993	Canada	Community	50 and over	907	Male Female	Personal interview as part of the inventory in oral symptoms and complaints (symptoms within 4 weeks before the interview).	N/A	13.8 20.7	N/A	N/A
Narhi	1994	Finland	Community	75-87	98 243	Male Female	Personal Interview: “Does your mouth feel dry?”.	Unstimulated and stimulated whole saliva	46.0 (Total)	N/A	N/A
Nederfors et al.	1997	Sweden	Community	20 30 40 50 60 70 80	441 475 499 474 509 489 426	Male Female	Self-administered questionnaire: “Does your mouth usually feel dry?”. And dryness related symptoms and behaviours.	N/A	19.3 17.7 20.4 22.1 32.2 33.3 35.7	N/A	N/A
Anttila et al.	1998	Finland	Community	Only 55	345 435	Male Female	Self-administered questionnaire, and interview.	Unstimulated and stimulated whole saliva	25.8 33.3	39.8[a] 31.7[b]	N/A

[*] WHO: Recording of data based on World Health Organization, [**] ICD-DA: International Classification of Disease in Dentistry
[a]: the prevalence of unstimulated SGH, [b]: the prevalence of stimulated SGH

Table 1: Continued

Author	Year	Sample					Assessment		Prevalence (%)		
		Country	Population	Age	Total	Sex	Xerostomia	SGH	Xeros-tomia	SGH	Both
Hochberg et al.	1998	USA	Community	65-84	2482	Male Female	Personal interview. - "Does your mouth usually feel dry?" - "Do you wake up at night feeling so dry in your mouth that you need to drink fluid?"	Stimulated whole saliva	13.2 20.1	14.8[b]	4.0
Pujol et al.	1998	Spain	Community	18-65	268	Male Female	Telephone interview.	N/A	6.2 13.0	N/A	N/A
Thomson et al.	1999	Australia	Community	65-100	364 320	Male Female	Computer-assisted telephone interview; "How often does your mouth feel dry?". Responses "frequently or always" were count as xerostomia.	Unstimulated whole saliva	24.1 17.3	22.1[a]	5.7
Bergdahl	2000	Sweden	Community	20-69	669 758	Male Female	Self-administered questionnaire: "Does your mouth usually feel dry?"	Unstimulated and stimulated whole saliva	22.0	15.0[a] 22.0[a]	2.0
Reichart	2000	Germany	Community	35-44 65-74	655 1367	Male Female	Personal interview according to WHO* and ICD-DA.**	N/A	0 0.4 (Total)	N/A	N/A
Field et al.	2001	UK	Dental clinic patients	Over 18	458 645	Males Females	Question adapted from SS criteria; "Have you suffered from a persistent dry mouth for the past 3 months?"	N/A	10.3 14.4	N/A	N/A
Espinoza et al.	2003	Chile	Community	Over 65	889	Male Female	Personal interview according to WHO*.	N/A	44.0 (Total)	N/A	N/A

* WHO: Recording of data based on World Health Organization, ** ICD-DA: International Classification of Disease in Dentistry

[a]: the prevalence of unstimulated SGH, [b]: the prevalence of stimulated SGH

Table 1: Continued

Author	Year	Sample					Assessment		Prevalence (%)		
		Country	Population	Age	Total	Sex	Xerostomia	SGH	Xeros-tomia	SGH	Both
Jansson et al.	2003	Sweden	Community	53-54	1180	Female	Self-administered questionnaire. Different extragenital symptoms.	N/A	16.0	N/A	N/A
Ikebe et al.	2007	Japan	Community	60-81	168 110	Male Female	Personal interview: "Does your mouth feel dry when eating a meal?"	Stimulated whole saliva	8.3 (Total)	19.0[b]	3.3
Flink et al.	2008	Sweden	Community	20-69	669 758	Male Female	Self-administered questionnaire and interview; "Does your mouth usually feel dry?"	Unstimulated and stimulated whole saliva	15.1 28.6	14.9[a]/2.3[b] 21.5[a]/3.2[b]	N/A

[*] WHO: Recording of data based on World Health Organization, [**] ICD-DA: International Classification of Disease in Dentistry
[a]: the prevalence of unstimulated SGH, [b]: the prevalence of stimulated SGH

Table 1 shows varying prevalence for xerostomia and SGH, which might be explained by the different methods and definitions used. However, it is worth noting that all the studies defined xerostomia as subjective symptoms of oral dryness and SGH as decreased salivary secretion. Then only different methods will be considered.

Various studies have used interviews (Osterberg et al., 1984; Thomson et al., 1999; Field et al., 2001) and self-assessment (Nederfors et al., 1997; Bergdahl and Bergdahl, 2000; Flink et al., 2008) methods to evaluate xerostomia. The prevalence yielded by these two techniques is similar. The questions used in these studies can be categorised into frequency questions and general questions. Studies employing frequency questions, such as "How often does your mouth feel dry?" (Thomson et al., 1999), have revealed xerostomia prevalence ranging from 14.9% to 35.7% (Nederfors et al., 1997; Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Flink et al., 2008). Conversely, studies utilising general questions, for example, "Does your mouth feel dry?" (Narhi, 1994), tend to report higher prevalence rates (16.0% - 46.0%) (Osterberg et al., 1984; Narhi, 1994). This discrepancy may stem from the fact that many individuals have previously experienced oral dryness, potentially leading to higher prevalence with general questions. Consequently, frequency questions might offer greater validity and precision in evaluating xerostomia, which will be discussed in the following section.

Interestingly, Reichart (2000) reported a xerostomia prevalence of 0.4% among an older adult group (aged 65 - 74 years; n = 1367) and no prevalence in younger adults (aged 35 - 44 years; n = 655). One plausible explanation for the low prevalence could be the extensive nature of the questionnaire, containing 28 questions about various oral lesions. While the researcher provided images and definitions for each lesion, the comprehensiveness of the questionnaire might have made it too challenging for participants to fully comprehend. This potential complexity could have impacted the validity (and reliability) of the findings.

For SGH, the studies used a cut-off value at 0.1 mL/min for unstimulated hyposalivation (Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Flink et al., 2008). For stimulated hyposalivation, the cut-off value was 0.7 mL/min (Anttila et al., 1998; Flink et al., 2008), yet one study used 0.5 mL/min (Ikebe et al., 2007). The prevalence of unstimulated hyposalivation ranged 14.9% to 39.8% (Osterberg et al., 1984; Anttila et al., 1998; Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Flink et al., 2008). The prevalence of stimulated hyposalivation ranged 2.3% to 31.7% (Osterberg et al., 1984;

Anttila et al., 1998; Ikebe et al., 2007; Flink et al., 2008). Most studies collected saliva in the morning, except Ikebe et al. (2007) collected between 9 am – 3 pm. All studies collected whole saliva, which is the combination of saliva and gingival crevicular fluid by spiting and drain methods. Saliva collection methods will be discussed in a later section.

The prevalence of xerostomia and SGH combined was 2.0% to 5.7% (Thomson et al., 1999; Bergdahl and Bergdahl, 2000; Ikebe et al., 2007) and there was a generally higher prevalence in women than men (Osterberg et al., 1984; Locker, 1993; Anttila et al., 1998; Field et al., 2001; Flink et al., 2008). There was also a tendency of higher prevalence of oral dryness with increasing age (Nederfors et al., 1997; Field et al., 2001). However, it is not possible to identify a specific relationship between age and dry mouth as most participants were older adults.

In accordance with the previous study, Flink et al. (2008) randomly selected 1427 individuals in those aged 20 - 69 who attended 14 dental clinics in two countries in northern Sweden. They asked, “Does your mouth usually feel dry?” to examine xerostomia. They found that 22.3% answered positively (28.6% for females and 15.1% for males). The study divided the participants into ten groups, according to age (20 - 29, 30 - 39, 40 - 49, 50 - 59, and 60 - 69) and sex. They found that prevalence of xerostomia increased with age in men, with prevalence reported as 12.2%, 8.3%, 11.5%, 14.2%, and 25.5% respectively. For women, prevalence in each age group was 13.9%, 25.5%, 26.1%, 33.1%, and 39.0% respectively. The prevalence in women was significantly higher than men in all age groups, except the youngest age group. The prevalence in the 60 – 69 - year-old group was also significantly greater than in other groups when compared in the same sex, except 50 – 59 - year-old women.

In addition, Flink et al. (2008) investigated hyposalivation. Masticated stimulated, and the unstimulated salivary flow rate was collected by trained staff in clinics between 9 and 11 am. One hour before, participants were asked to cease eating, drinking, tooth brushing, and tobacco use. The previous study stated that the average flow of unstimulated saliva is 0.3 mL/min, the accepted normal range for unstimulated saliva is above 0.1 mL/min, below 0.1 mL/min thus was considered SGH (Humphrey and Williamson, 2001). For stimulated saliva, the rate can reach 7 mL/min, accepted the least flow rate is 0.2 mL/min (Humphrey and Williamson, 2001). The accepted cut-off flow rate for stimulated hyposalivation is 0.7 mL/min (Navazesh and Kumar, 2008).

Flink et al. (2008) used the low salivary flow rate cut-off of 0.1 - 0.2 ml/min for unstimulated salivary flow and 0.7 - 1.0 ml/ min for stimulated salivary flow. The very low salivary flow rate cut-off was less than 0.1 ml/min for unstimulated salivary flow, and less than 0.7 ml/min for stimulated salivary flow. Prevalence was 21.9% and 18.5% for low and very low unstimulated salivary flow, respectively. For stimulated salivary flow, the prevalence was 4.8% and 2.8% for low and very low salivary flow, respectively. The study observed a significantly higher prevalence of very low unstimulated saliva in women (21.5%) compared to men (14.9%). Similarly, for low unstimulated saliva, the prevalence was higher in women (24.0%) than in men (19.5%). This trend persisted for stimulated saliva, with a significant difference found only in the prevalence of low stimulated saliva (6.7% for women, and 2.7% for men).

Besides, the prevalence of very low unstimulated saliva in 60 - 69 was significantly higher in both sexes compared to younger age groups. However, this trend was not observed in the case of low unstimulated saliva and stimulated saliva. It is noteworthy that the co-occurrence between xerostomia and both low and very low levels of unstimulated and stimulated saliva was observed, although not in all cases.

Overall, the study showed a higher prevalence of xerostomia and hyposalivation in women than men; also, the prevalence of these increased with age. Notably, the study reported diseases and medications in women more than men and more in the older adults. These factors might be confounders which lead women and the older adults to present more prevalence.

As stated earlier, the prevalence of xerostomia and hyposalivation are different between age and sex. Both most commonly occur in the older adults and are more common in women than men. It can be estimated one-fifth of older people experience dry mouth (Thomson, 2015). For more examples, Nederfors et al. (1997) found a strong association between xerostomia and increasing age. The study also reported a higher prevalence of xerostomia in women compared to men. Thomson et al. (1999) examined the prevalence and the degree of concurrence between xerostomia and hyposalivation of 684 older people in South Australia. The age ranged from 65 to 100 years, with a mean age of 75 years. The study assessed xerostomia by using the single item, “How often does your mouth feel dry?” with the response options; never, occasionally, frequently, and always was used. The “frequently and always” responses were counted as xerostomia. The prevalence of xerostomia was 24.1% and 17.3% for women and men respectively. SGH, was investigated by collecting unstimulated salivary flow. One-hour prior to collection, the participants were asked to avoid having meals, drinking, and smoking. Hyposalivation cut-off flow rate was 0.1 mL/min. The amount of hyposalivation was 26.6% and 18.1% for women and men respectively. Women had a higher prevalence than men both for xerostomia and hyposalivation. Also, the mean salivary flow rate in women was lower than men.

Conversely, no association was found between increasing age and xerostomia as well as SGH. It is possible that the study only investigated older people, and no data on drug-taking or systemic diseases were collected and so their impact could not be investigated. As mentioned by Flink et al. (2008), drugs and systemic diseases may be confounding factors. If the prevalence of drugs and systemic diseases did not vary across age groups, it might lead to a lack of association between age and dry mouth.

There have been no studies to date in Thailand nor Southeast Asia that have examined the prevalence of dry mouth. This means there are no population estimates of the number of people who have or report dry mouth, yet there are studies on specific groups. For example, a study conducted in Phitsanuloke, Thailand, from 73 selected visually impaired patients, with a mean age of 64 years (Samnieng, 2015). The study investigated hyposalivation (cut-off value at 0.1 mL/min for unstimulated salivary flow rate, 0.5 mL/min for stimulated salivary flow rate) and found that 43.8% had hyposalivation. A dentist examined the oral status and reported 82% had periodontitis, the mean number of remaining teeth was 12.8 $\pm$ 3.9 and the mean number of dental caries was 5.2 $\pm$ 2.5. Of the 73 patients, 74.8% reported having a systemic disease and 76.1% reported taking drugs. The author also assessed problems with oral function and revealed that almost half of participants had swallowing, speaking, and taste problems and 76.2% had difficulty chewing. The study also reported that 69.8% were at risk of undernutrition and 8.2% of malnutrition. Of note, this study found a significant association between hyposalivation and diseases, medications, swallowing as well as chewing problems, poor oral hygiene, and poor nutrition. In part they might be due to visually impaired patients performing oral care suboptimally. This, combined with swallowing and chewing problems, may lead to changes in their eating behaviours and could result in malnutrition.

In conclusion, the prevalence of dry mouth, xerostomia and hyposalivation, has been found to be wide-ranging. Inconsistencies in prevalence may be due to differences in both the definitions and measurement tools used in the literature. In addition, studies to date have found some differences between sex and age as to the prevalence; however, diseases and drug-induced dry mouth may be confounding variables in this case.

In the next sections, the measurement of dry mouth will be considered.

2.2.3 Measurement of dry mouth

As noted earlier, dry mouth can be divided into subjective and objective measurement. Subjective is indicated as individuals' feeling, or symptoms of dry mouth, while the objective is indicated as SGH. To date, these have been measured in a variety of ways as both xerostomia and SGH, subjective symptoms can be measured by single-item approaches or multi-item approaches, and hyposalivation can be evaluated by unstimulated and stimulated salivary flow rate. In the section below, the measurement of xerostomia will first be discussed, followed by the measurement of SGH.

2.2.3.1 Xerostomia measurement

Xerostomia is an individual subjective perception dryness of the oral cavity, and hence the estimation can be determined by asking the individual themselves to self-report through interview or questionnaire. The xerostomia measurement can be evaluated by single-item approaches or multi-item approaches (Joanna and Thomson, 2015).

1) Single-item approaches

Single-item or global items are, as their name implies, an assessment of xerostomia with a single question. These approaches require participants to succinctly summarise their perception, experience, and behaviour to evaluate xerostomia by themselves (Thomson, 2015). Here are some examples of single-item questions:

- "Does your mouth feel distinctly dry?" (Osterberg et al., 1984)
- "Do you have mouth dryness?" (Osterberg et al., 1992)
- "Does your mouth feel dry?" (Narhi, 1994)
- "Does your mouth usually feel dry?" (Nederfors et al., 1997)
- "How often does your mouth feel dry?" (Thomson et al., 1999)

Such questions have been reported to be unclear to participants, who have frequently been found to ask whether they should reply in relation to their current symptom or in general (Thomson et al., 1999). In addition, as the question is fairly generic, individuals may not have the ability to discriminate their symptoms. The single-item methods have also used the all-or-none approach, misclassification bias can thus occur. For example, Fure and

Zickert (1989) used the question “Do you feel dryness in the mouth at any time?” to determine dry mouth or xerostomia. They found that almost 100% of participants had positive response to this question owing to everyone should have previous experience of dryness. Consequently, the responses of these questions could be overestimating the prevalence of xerostomia (Thomson et al., 1999).

It has been suggested previously that defining the symptom frequency could be a way of improving the instruments in order to measure more accurate information (Thomson et al., 1999). For instance, Nederfors et al. (1997) studied the prevalence of dry mouth in adult Swedish participants. The study used “Does your mouth usually feel dry?” to investigate xerostomia. The prevalence was around 20% for both men and women. Gilbert et al. (1993) used “Is your mouth sometimes dry?” to determine xerostomia and found that 39% also had positive responses. Similarly, Thomson et al. (1993) reported the prevalence of xerostomia in aged 65 years and over institutionalised older people in New Zealand. The participants were asked, “How often does your mouth feel dry?”. Four choices were available: “always”, “frequently”, “occasionally”, or “never”. The participants were included as experiencing xerostomia when the answers were “always or frequently”, and the prevalence of xerostomia was 20%. Improving the response options to single-item measures and making the time more specific have benefits. However, the questions in single-items still do not consider other aspects of dry mouth including physical, functional, psychological, and social experiences. This limitation has led to the development of multi-item approaches, which will be discussed in the section below.

2) Multi-item approaches

Single-item methods have been widely used. These methods can be used together with multi-item methods to give more valid and precise results (Thomson, 2015) due to including more questions covering dry mouth experiences. There are two methods of multi-item approach: batteries of items and summated rating scales (Joanna and Thomson, 2015).

- **Batteries of items**

Batteries of items are a list of closed questions, subsequently analysed by using the sum of positive response as an index score (Thomson, 2015). This approach has been commonly used in past xerostomia studies. For instance, Narhi (1994) studied the prevalence of dry mouth in the independent older adults living at home in Helsinki, Finland. The participants were asked “Does your mouth feel dry?” as the first question to screen xerostomia, if the participants answered yes then they were asked, “Do you feel dry in the morning, periodically during the day, in the evening, or at night?”. The participants were grouped as having xerostomia when they had positive responses to all questions. The prevalence of xerostomia was 12%, and was more frequent in women than men, 14% and 6% respectively. The prevalence of xerostomia in this study was relatively low which might be because participants were only diagnosed as having xerostomia when they had all symptoms on the list. Locker (2003) used a battery of seven xerostomia questions which pertained to experiences of oral dryness, functional limitations due to xerostomia; speaking, chewing, and swallowing as well as behaviour changes to relieve dry mouth symptoms. The responses were yes (coded 1), and no (coded 2), after which the answers were summed and grouped based on the score; 0 was no xerostomia, 1 or 2 was mild xerostomia, and 3 to 7 was marked xerostomia. The study reported good internal consistency reliability. The prevalence was 36.9% for no xerostomia, 32.0% for mild, and 31.1% for marked xerostomia. Although batteries of items can assess xerostomia prevalence and discriminate severity, the separate analysis of items and all-or-none approach can lead to misclassification bias.

- **Summated rating scales**

Batteries of items are beneficial to examine xerostomia; nevertheless, the formats are mostly closed questions and items are analysed separately. The measurement may thus not fully cover the entire experience of xerostomia from the patient’s perspective and cannot show the severity of xerostomia. A summated rating scale is more refined than the batteries of item method. It uses the rank number to determine the severity of the symptom (Joanna and Thomson, 2015). A well-known example of the summated rating scale is the Xerostomia Inventory (XI), developed by Thomson et al. (1999). They reviewed studies that investigated xerostomia and created a framework from previously used questions to explore xerostomia. Then, convenience samples were interviewed; the answers were grouped in themes and became the format — these covered experiences and behaviour change due to xerostomia. The XI consisted of 11 items (Table 2) referring to the previous four-week symptoms, which asked the participant to rate the severity of xerostomia; “never” (scoring 1); “hardly ever” (2); “occasionally” (3); “fairly often” (4); “very often” (5). The XI was tested with 708 older people (aged 65 - 100 years) in Australia. The question “How often does your mouth feel dry?” with four responses (“never”, “occasionally”, “frequently”, and “always”) was asked. The study revealed the significant association between the XI and the standard question. The authors claimed that the XI had been subjectively validated, covered more comprehensive symptoms and conditions of xerostomia, as well as the severity of symptoms. Of note, the XI has used qualitative variables (symptoms) and quantitative variables (rating severity) to assess xerostomia. Therefore, the XI can measure the experience of xerostomia due to a variety of symptoms more thoroughly and precisely and the individuals can rate their severity which, in turn, can be used to determine which domain of dry mouth has a greater impact on individuals. However, psychological variables should be considered as the study had a higher prevalence of individuals with mental distress which, in turn, might act as an intervening variable in this study.

Table 2: The Xerostomia Inventory (Thomson and Williams, 2000; Thomson et al., 2011)

Original version	Short version
I sip liquids to aid in swallowing food	My mouth feels dry when eating a meal
My mouth feels dry when eating a meal	My mouth feels dry
I get up at night to drink	I have difficulty eating dry foods
My mouth feels dry	I have difficulties swallowing certain foods
I have difficulty eating dry foods	My lips feel dry
I suck sweets or cough lollies to relieve dry mouth	
I have difficulties swallowing certain foods	
The skin of my face feels dry	
My eyes feel dry	
My lips feel dry	
The inside of my nose feels dry	

As can be seen in Table 2, the XI contains items on symptoms of other organs not directly related to dry mouth, for example, eyes, nose, and facial skin. As a result, the short version of XI (SXI) was developed. Putten et al. (2011) studied 55 physically impaired nursing home residents (mean aged 78.1 years) in the Netherlands. The XI was back translated into Dutch from English. A pilot study was tested in 15 physically disabled older adult participants to investigate the ability to differentiate the five option responses of each item. The pilot study showed that participants could not discriminate among five choices, which led to reducing selections from five to three: never scoring 1; occasionally scoring 2; ever scoring 3. The study did not find an association between xerostomia and drinking at night as well as the feeling of dry nose; otherwise, xerostomia had moderate associations with the feeling of oral dryness, feeling dry while eating, difficulty in eating dry food, difficulty in swallowing some foods, and dry lips. Consequently, the SXI-Dutch version consists of five items with three severity scales.

To date, there have been many studies in the literature that have utilised the original and short versions of XI to measure the impact of xerostomia from the patient's perspective (Table 3).

Table 3: Studies using the Xerostomia Inventory

Author (Year)	Sample				XI version	Key findings
	Country	Population	Age	Total		
Thomson et al. (1999)	Australia	Community	65-100	708	Original	- Significantly associated with a standard question; "How often does your mouth feel dry?". - XI and the standard question negatively related to salivary flow rate. - XI showed validity.
Thomson and Williams (2000)	New Zealand	Radiotherapy Community	29-87 52-90	79 71	Original	- Radiotherapy group showed a large increase in XI scores within two months from baseline, after which was sustained at four and six months. - Normal group showed lower XI scores and the change in score over the 6 months was less than the radiotherapy group. - Concurrent validity and temporal stability were acceptable.
Johnstone et al. (2001)	USA	Head and neck patients with radiotherapy	No data	20	Original	- XI values before acupuncture ranged from 32-51. - Different XI values between before and acupuncture ranged from 0-22. - Almost half of patients reported better scores 10 points or greater on the XI.
Baker et al. (2007)	UK	Outpatient clinic of rheumatology, liver, pain management, oral medicine, speech and language and Sjogren's syndrome	59.8±11.5	85	Original	This study aimed to test Wilson and Cleary's model and used XI to assess the symptom status. - Details will be discussed further in the Wilson and Cleary's model section.
Thomson (2007)	New Zealand	Radiotherapy Community (Secondary data from a study conducted in 1997 and 1998)	29-87 63-90	53 42	Original	- Validity and responsiveness were acceptable. - XI score that changed 6 or more points presented clinically meaningful difference.

Table 3: Continued

Author (Year)	Sample				XI version	Key findings
	Country	Population	Age	Total		
Putten et al. (2011)	The Netherlands	Physically impaired residents of a nursing home	53-98	55	Short	- The prevalence of xerostomia was 52% (Based on the response scores 2 and 3 to the item; “My mouth feels dry”). - No statistical differences of xerostomia by sex and age.
Thomson et al. (2011)	Australia, The Netherlands, Japan, and New Zealand	Secondary data from the studies that used the XI. - 2 institutionalized - 3 community (The settings were not weighted for this study)	50-103	50-637	All studies but Dutch study used the original version	- SXI had acceptable psychometric properties and validity in various settings and populations. - SXI had better face validity than the original version. - Three options of response had demonstrated the competence in difference among the xerostomia severity.
Fan et al. (2013)	China	Maintenance hemodialysis patients	65.2±10.9	42	Original	- Mean XI score was 19.5±7.9. - Women showed marked higher XI score than men. - XI and dialysis thirst inventory was significantly associated.
Hahnel et al. (2014)	Germany	Community	60-93	68	Short	- The prevalence of xerostomia was 16% (Based on the XI scores≥10).
Leoncini et al. (2014)	New Zealand	Sjogren’s syndrome patients	More than 35 years	10	Original	- Mean XI scores before and after treatment were 43.0±5.3 and 39.0±6.3, respectively. - Significant improvement XI score in after treatment group. - Significantly change in XI score to be better in using humidifier patients than non-using patients.
Amaral et al. (2018)	Portugal	Community	61.7±15.5	103	Short	- Strong association with the standard question; “How often does your mouth feel dry?”. - SXI Portuguese version was reliable and valid, as with English version.

Table 3: Continued

Author (Year)	Sample				XI version	Key findings
	Country	Population	Age	Total		
Bulthuis et al. (2018)	The Netherlands	Patients in the saliva clinic of the Centre for Special Care Dentistry	12-99	114	Original	- XI scores in patients with higher stress levels were significantly greater than patients with lower stress levels. - Patients with higher stress levels had lower unstimulated salivary flow rate than patients with lower stress levels, but differences were not significant.
Vathanophas (2019)	Thailand	Outpatients of Otorhinolaryngology	19-81	202	Short	- Xerostomia prevalence in those with xerostomia symptoms along with dryness signs in the oral cavity were significantly higher than in those with only xerostomia symptoms.

Table 3 shows the studies that have used the XI across the world. The number of participants ranged from 10 to 708. Most studies investigated xerostomia in older people (Thomson et al., 1999; Thomson and Williams, 2000; Putten et al., 2011; Fan et al., 2013; Hahnel et al., 2014; Amaral et al., 2018), but four examined xerostomia in younger adults and studied specifically in relation to head and neck cancer (Thomson and Williams, 2000), Sjogren syndromes (Baker et al., 2007; Leoncini et al., 2014), and ear, nose and throat region diseases (Vathanophas, 2019).

XI assesses many aspects of the dry mouth experience, encompassing symptoms and behaviour changes aimed to alleviating those symptoms. The items have demonstrated content validity, indicating that XI covers the entire domain associated with xerostomia (Thomson et al., 1999). Several studies examined xerostomia by XI compared to the standard question; “How often does your mouth feel dry?” (Thomson et al., 1999; Thomson and Williams, 2000; Amaral et al., 2018). The results have shown an association between these measurements. This reveals the concurrent validity of XI. Thomson et al. (2011) have pointed out that the SXI may have better face validity than the original version due to all items being directly related to xerostomia.

Although many studies have reported the mean and mean difference of XI, they have used different case definitions of xerostomia in XI. For example, Putten et al. (2011) reported prevalence of xerostomia based on the item: “My mouth feels dry”, while Hahnel et al. (2014) based it on XI scores $\geq$ 10. This indicated a potential weakness of the XI because there have been no diagnostic criteria for xerostomia. However, the XI can identity the severity of oral dryness symptom in each domain by rating scale, which is a potential strength of XI.

Several studies have utilised XI to monitor change in patient-reported outcomes of dry mouth after treatment and over time. For example, it has been used in head and neck cancer patients (Thomson and Williams, 2000), haemodialysis patients (Fan et al., 2013), and Sjogren's syndrome patients (Leoncini et al., 2014). Thomson and Williams (2000) have suggested utilising XI as a monitoring tool in clinical aspects and as an epidemiological tool as it reduces misclassification bias better than close-ended questions or an all-or-none case definition.

In Thailand, Vathanophas (2019) studied 202 out-patients from the Otorhinolaryngology clinic (aged range 19 - 81 years), patients with radiation therapy were excluded. Patients with history of dry mouth symptoms and who responded positively to at least one item of

SXI - Dutch version were invited to take part. An oral examination was conducted, physical changes due to dry mouth, namely dry lips, a lack of saliva pool in the floor of the mouth, dry oral mucosa, dry tongue, bad breath, atypical pattern of dental caries, oral candidiasis, and angular cheilitis were recorded. Patients were grouped into clinical cases (86 patients exhibiting both symptoms and clinical findings of dry mouth) and control cases (116 patients experiencing symptoms but lacking clinical findings of dryness). This study used the SXI - Dutch version but did not allow patients to rate their severity, merely yes or no responses. The study revealed the significantly higher XI prevalence in clinical cases than control cases. Of note, two items; “My mouth feels dry”, and “my lips feel dry”, were the most common reported items, 87.2% and 76.7% for clinical cases and 64.7% and 33.6% for the control cases, respectively.

In sum, there are a variety of ways to examine xerostomia, many of which have been used recently. The XI is a comprehensive measure of xerostomia. It has been widely used and has been validated and allows individuals themselves to rate the severity of symptoms.

The section below will discuss salivary flow rate measurements.

2.2.3.2 Salivary flow rate measurement

As previously stated, dry mouth can be generally categorised into two conditions: xerostomia and hyposalivation (Thomson, 2015), yet the conditions do not always coincide. For this reason, most studies evaluate both. This section will consider the salivary flow rate measurements.

There are several methods of salivary flow assessments. The techniques are dependent on collecting from individual salivary glands or whole saliva (Navazesh and Kumar, 2008). Whole saliva is entire saliva in the mouth which also contain gingival fluid, desquamated epithelial cells, microorganisms and its products, food debris, leukocyte, and mucus from nasal cavity and pharynx (Falcão et al., 2013). Whole saliva collection is more common owing to ease and similar to the *in vivo* situation (Thomson, 2005), while individual gland collections require custom-made devices (Navazesh and Kumar, 2008). Whole saliva assessments can be divided into four methods; passive (drain), active (spit), suction, and swab (Thomson, 2005; Falcão et al., 2013; Thomson, 2015) as presented in Table 4.

Table 4: Collecting techniques to investigate whole saliva (Thomson, 2005; Falcão et al., 2013; Thomson, 2015)

Methods	Measurement technique	Advantages	Disadvantages
Passive (drain)	Let saliva drool into the container passively	- Reliable	- Evaporation of saliva
Active (spit)	Accumulate saliva in the mouth and then void into the container	- Reliable	- Evaporation of saliva - There is a small stimulant of spitting action
Suction	Use suction tube to collect saliva from the floor of mouth	- Independent of the patient's cooperation	- There is a small stimulant from suction
Swab	Use pre-weighed swabs place on the floor of mouth and collects saliva	- Easy-to-handle method	- There is a small stimulant from swab - Less reliable

The spit method is widely used due to a simple process and is easy to apply with a large number of participants (Thomson, 2005). The passive method may be unpleasant for some participants in that they may be unhappy to passively drool saliva into the container (Thomson, 2005). As suction and swabs themselves are stimulant, they suit collecting stimulated salivary flow (Thomson, 2005).

Measurement can include both unstimulated and stimulated salivary flow. Unstimulated salivary flow is when there are no exogenous stimulants (Dawes, 1987). A variety of stimuli have been used, for example, 2% solution of citric acid, paraffin wax and pre-softened polyvinyl acetate gum (Navazesh and Kumar, 2008). Acid is the most potent stimulant for salivation, but it is easy to dilute by saliva. Therefore, during the salivary collection, it has to add acid frequently. Adding acid also might impact some properties of saliva (Dawes, 1987). Mechanical stimulants (e.g. paraffin wax and pre-softened polyvinyl acetate gum) do not interrupt participants during the collection and do not interfere with the salivary composition (Dawes, 1987).

The analysis process can be computed by volumetric or gravimetric methods. However, volumetric method tends to be more subject to error because the level of fluid cannot be clearly seen due to the presence of bubbles (Thomson, 2005).

Mean flow rate for unstimulated salivary flow has been reported to be 0.3 ml/min (Thomson, 2005; Dawes et al., 2015), and 1.7 ml/min for stimulated salivary flow (Thomson, 2005). The cut-off values for hyposalivation vary. Cut-off values for unstimulated hyposalivation is 0.1 ml/min (Narhi, 1994; Dawes, 2008; Putten et al., 2011; Samnieng, 2015). For stimulated hyposalivation are 0.5 ml/min (Putten et al., 2011; Samnieng, 2015), 0.7 ml/min (Hahnel et al., 2014; Islas-Granillo et al., 2017), and 0.8 ml/min (Narhi, 1994).

Further, there have been other factors that influence the salivary flow rate, (Table 5). For example, a previous study found diurnal variation in salivary flow; the highest unstimulated salivary flow occurred in the late afternoon, and lowest unstimulated salivary flow occurred around midnight (Dawes, 1987).

Table 5: Factors affecting salivary flow rate (Dawes, 1987; Pedersen et al., 2002; Dawes, 2008; Rad et al., 2010; Dawes et al., 2015)

Factors	The effects on salivary flow
State of hydration	- Dehydration can cause reduced salivary secretion
	- Hyperhydration can cause increased salivary secretion
Body position	- Standing has been reported having the highest salivary flow
	- Lying has been reported having the lowest salivary flow
Light exposure	- Salivary flow has been reported reducing in the dark
Circadian rhythm	- The highest salivary flow secretes in the late afternoon
	- The lowest salivary flow secretes around midnight
Olfactory stimulation	- Smell can cause increased salivary secretion
Consumption	- Salivary flow increases about an hour after food intake
Smoking	- Smoking can cause decreased salivary secretion

As can be seen in Table 5, many factors influence salivary flow rate. These can be the confounding factors that influence differences in the prevalence of SGH; thus, the salivary collection procedure should be standardised to control for confounding variables.

In conclusion, several methods have been proposed to assess dry mouth for both xerostomia and SGH. Xerostomia assessments aim to examine subjective symptoms or feeling; in turn, the tools are statements or questions which lead individuals to evaluate themselves. SGH is significantly decreased salivary flow, thus investigation of salivary flow rate is needed. As mentioned previously, the two conditions can be concurrent, but not always. Therefore, xerostomia and SGH should be examined for understanding both conditions.

The next section will discuss the causes of dry mouth.

2.2.4 Causes of dry mouth

Saliva is produced and delivered by three major salivary glands (parotid, submandibular, and sublingual) and also the many minor glands which are located under the oral mucosa (Proctor, 2016). Salivary glands are exocrine glands that produce and secrete saliva into the oral cavity from the ductal system (Proctor, 2016). The salivary glands are made of basic units that consist of clusters of secretory pieces called acini and small collecting ducts (Pedersen et al., 2002). The clusters are engirdled and supplied by arterioles which are innervated by the autonomic nervous system (Proctor, 2016). The salivary glands thus are under the control of the autonomic nervous system which includes sympathetic and parasympathetic innervation (Porter et al., 2004; Thomson, 2015; Proctor, 2016).

The parasympathetic nervous system is the primary mechanism controlling salivation (Thomson, 2015) because the parasympathetic nerves play an important role in operating the normal salivary flow rate (Proctor, 2016). Indeed, the two nervous systems closely collaborate in generating and secreting saliva from salivary glands. Sympathetic impulses stimulate high-protein secretion, while parasympathetic impulses stimulate a high volume of saliva and mucin secretion (Porter et al., 2004; Proctor, 2016). Consequently, any factors that have adverse effects on the autonomic nervous system, saliva secretion process, or salivary glands can contribute to xerostomia and hyposalivation (Proctor, 2016).

The mechanisms of hyposalivation have been linked to six processes, namely neurotransmitter receptor dysfunction, glandular parenchyma loss, change in immune system processes, annihilation radiation that damages glandular tissues, changes in fluid and electrolytes, or combinations of the previously mentioned (Bultzingslowen et al., 2007). Thus, conditions that induce deleterious processes (systemic diseases, drugs, treatments, for instance) may cause xerostomia and hyposalivation.

In this section, the aetiology of dry mouth will be discussed under five headings, which are:

- Systemic diseases
- Medications
- Age and sex
- Radiation and other treatments
- Health-related behaviours

2.2.4.1 Systemic diseases

As mentioned previously, salivary glands are under the control of the autonomic nervous system and composed of two general cell types: the acinar cells, and duct cells. Therefore, serious conditions, diseases, and injuries that cause nervous system problems, or damage to salivary glands can result in decreased salivary production. There have been reports of dry mouth manifestations from various systemic diseases (Table 6). For example, diabetes mellitus which is an endocrine disease may cause degenerative disorders to occur in salivary glands leading to the aberration of glandular tissue and reduced salivary production (Liu et al., 2012), details of which will be discussed separately in the topic of diabetes mellitus.

Table 6: Systemic diseases associated with dry mouth (Pedersen et al., 2002; Porter et al., 2004; Bultzingslowen et al., 2007; Liu et al., 2012; Mortazavi et al., 2014; Tanasiewicz et al., 2016; Millsop et al., 2017)

Endocrine disease	
	Diabetes mellitus, Grave disease and autoimmune thyroiditis, Cushing's syndrome, Addison's disease
Neurological disorders	
	Mental depression, Parkinson's disease, narcolepsy, Bell's palsy, Alzheimer's disease, Holme's–Adie syndrome
Virus infections	
	HIV/AIDS, hepatitis C, Epstein–Barr virus, cytomegalovirus, human T-lymphotropic virus type 1, epidemic parotitis
Bacterial infections	
	Actinomycosis, bacterial sialadenitis
Autoimmune diseases	
	Sjogren's syndrome, rheumatoid arthritis, juvenile idiopathic (rheumatoid) arthritis, systemic lupus erythematosus, primary biliary cirrhosis, scleroderma, mixed connective tissue disease, coeliac disease
Granulomatous diseases	
	Sarcoidosis, tuberculosis, Crohn's disease
Storage diseases	
	Hemochromatosis, amyloidosis
Other conditions	
	End-stage renal disease, ageing, chronic graft-versus-host disease after stem cell transplantation, ectodermal dysplasia, amyloidosis, ulcerative colitis, cystic fibrosis, Prader–Willi's syndrome, cerebral vascular accident, spinal cord injury, cachexia, eating disorders, nutritional deficiencies, chronic pancreatitis, Down syndrome, myotonic dystrophy, thalassemia major, mouth breathing, heavy snoring

In another example of endocrine disease, thyroid disorders, including Graves' disease and Hashimoto's thyroiditis also have an adverse effect on salivary glands (Mortazavi et al., 2014). Sjogren's syndrome is one of the most common diseases related to dry mouth. It is an autoimmune disease that produces autoantibodies that destroy the acini of the major and minor salivary glands, which in turn, leads to atrophy of the salivary glands (Millsop et al., 2017). Primary Sjogren's syndrome includes salivary and lacrimal glands disorder, thereby reducing saliva and tear secretion. Secondary Sjogren's syndrome occurs with other autoimmune diseases, for example, rheumatoid arthritis, systemic sclerosis, and systemic lupus erythematosus (Ship et al., 2002).

Viral and bacterial infections can also be related to xerostomia. There are reports of dry mouth in patients with HIV, hepatitis C virus, cytomegalovirus, Epstein-Barr virus or actinomycosis bacteria (Millsop et al., 2017). Other systemic causes include; graft-versus-host disease after transplantation where the lack of discrepancy recognition of the immune system between donor and recipient, leads to fibrosis, lymphocytic infiltration, and destruction of the salivary gland tissue (Millsop et al., 2017). Polyuria and dehydration symptoms in end-stage renal disease can cause dry mouth. In addition, hemochromatosis and amyloidosis links to dry mouth are due to the disorder of iron and amyloid deposition in salivary glands. A long-term degenerative disorder of the central nervous system, Parkinson’s disease, can lead to reduced salivary gland function leading to dry mouth symptoms (Millsop et al., 2017).

As can be seen, dry mouth has been associated with various diseases and conditions. This means that general health should always be considered when patients complain of dry mouth. Moreover, the treatments, e.g. medications, radiation, some surgery can cause dry mouth, which will be discussed in the section below.

2.2.4.2 Medications

Medications are the most common cause of dry mouth (Porter et al., 2004; Shirlaw and Khan, 2017). As indicated above, salivation is controlled by the autonomic nervous system, particularly parasympathetic stimulation. Therefore, some medicines, especially drugs that inhibit neurotransmitter binding to acinar cells, which can induce xerostomia and hyposalivation. Numerous drugs have been reported as being associated with dry mouth (Table 7), for example, antidepressants, anticholinergics, antispasmodics, antihistamines, antihypertensives, sedatives, bronchodilators, diuretics, and analgesics (Guggenheimer et al. 2003; Liu et al., 2012; Millsop et al., 2017). Anticholinergic drugs in particular, directly affect the parasympathetic nervous system; therefore, they inhibit salivation and can lead to dry mouth (Thomson, 2015).

Table 7: Drug-induced dry mouth (Pedersen et al., 2002; Porter et al., 2004; Liu et al., 2012; Proctor, 2016; Tanasiewicz et al., 2016; Villa et al., 2016; Millsop et al., 2017; Shirlaw and Khan, 2017; Wolff et al., 2017; Tan et al., 2018; Arany et al., 2021)

Class of medication	Drugs
Analgesics	tramadol, morphine, naltrexone, tapentadol, paracetamol, oxycodone, buprenorphine, butorphanol, rizatriptan, pethidine, codeine
Psycholeptics	diazepam, oxazepam, lorazepam, nitrazepam, perphenazine, eszopiclone, zolpidem, zopiclone, zaleplon, dexmedetomidine, fentanyl, amisulpride, clozapine, olanzapine, paliperidone, quetiapine, risperidone, sertinole, aripiprazole, lithium, scopolamine
Psychoanaleptics	escitalopram, duloxetine, venlafaxine, bupropion, amitriptyline, imipramine, reboxetine, sertraline, fluoxetine, citalopram, fluoxetine, nitrazepam, paroxetine, desvenlafaxine, nortriptyline, vortioxetine, agomelatine, atomoxetine, lisdexamfetamine, mirtazapine, reboxetine
Antiepileptics	clonazepam, carbamazepine, gabapentin
Antihypertensives	clonidine, methyldopa, methylphenidate, moxonidine, rilmenidine
Nervous system agents	cevimeline, cytisine, nicotine, thioxanthene, butyrophenone, phenothiazine, methadone
Agents for functional gastrointestinal disorders	dicyclomine/dicycloverine, propantheline, atropine
Agents for obstructive airway diseases	glycopyrrolate/glycopyrronium/ipratropium, tiotropium, albuterol, formoterol, salmeterol, terbutaline, inhalatory glucocorticoids
Urologicals	oxybutynin, propiverine, solifenacin, trospium
Diuretics	furosemide, tolvaptan, chlorothiazide, hydrochlorothiazide, bendroflumethiazide
Nasal preparations	pseudoephedrine
Ophthalmologicals	brimonidine, homatropine
Muscle relaxants	tizanidine, cyclobenzaprine
Beta-blocking agents	atenolol, bisoprolol, metoprolol, timolol, propranolol
Antihistamines	azelastine, cetirizine, clemastine, diphenhydramine, ebastine, fexofenadine, levocetirizine, loratidine
Anticholinergic agents	paroxetine, escitalopram, sertraline, fluoxetine, citalopram, duloxetine, venlafaxine, mirtazapine, vilazodone, bupropion, trazodone, dothiepin, amitriptyline, nortriptyline, doxepin, imipramine, trospium, darifenacin, tolterodine, oxybutynin, fesoterodine, solifenacin
Antiemetics	chlorpromazine, cisapride, domperidone, haloperidol, metoclopramide, prochlorperazine
Anti-Parkinson agents	amantadine, rotigotine
Agents for bone diseases	bisphosphonates
Antivirals for systemic use	didanosine, indinavir, nelfinavir, saquinavir
Antibacterials for systemic use	cefadroxil, moxiflaxicin
Anti-inflammatory and antirheumatic agents	naproxen
Calcium channel blockers	verapamil

Table 7: Continued

Class of medication	Drugs
Agents acting on the renin-angiotensin system	captopril, enalapril, ramipril
Lipid modifying agents	perindopril, lisinopril
Antiobesity	sibutramine
Others	dimebon emepronium, B2-adrenomimetics, interferon-alpha, omeprazole, elliptinium

As can be seen, various drugs are associated with xerostomia and SGH. Moreover, there are reports of a marked relationship between polypharmacy and dry mouth (Tan et al., 2018). For example, Nederfors et al. (1997) examined the prevalence of xerostomia in the adult Swedish population. Three hundred men and 300 women were randomly selected for each age group (20, 30, 40, 50, 60, 70 and 80 years). Participants were assessed for xerostomia by asking; "Does your mouth usually feel dry?". The study found xerostomia prevalence of 23.1% for men and 28.3% for women, 35% higher prevalence for women than men. The authors observed a similar pattern of higher prevalence in women than men in non-medicated and medicated groups. The non-medicated group reported xerostomia in 15.3% and 19.1% of men and women respectively. The medicated group showed xerostomia in 30.5% of men and 33.4% of women. Xerostomia prevalence was higher in the medicated group than the non-medicated group, 32.1% and 16.9% respectively. The study also reported a strong association between xerostomia and the number of drugs taken. However, the study did not indicate types and the number of drugs that had more impact on xerostomia. A relationship between xerostomia and increasing age was also related, but the study did not show data in each age groups. In sum, the study revealed the association between xerostomia, medications, the number of drugs, sex, and age. Of note, after adjustment for age and drug use, the difference of xerostomia between sex was still found. All things considered, xerostomia is associated not only with medications but also age, and sex. Consequently, older females who take medications may suffer more from xerostomia than other people.

In their systematic review, Tan et al. (2018) explored medications that cause dry mouth in older people. The study included 52 English-language articles from 1990 to 2016 and included experimental and observational studies undertaken in North America, Europe, and Asia. The number of participants ranged from 11 to 13,508 people. Most focused on healthy or non-serious illness in the older adults. The study found that medications were significantly associated with xerostomia as well as SGH. The drugs acting on urogenital systems were reported as most commonly affecting salivary glands, followed by antidepressants and psycholeptics. The study also found significant relationship between the number of drugs used and xerostomia as well as SGH. However, a risk score for drug-induced dry mouth was not considered in this study. The authors limited the search to English-language articles from 1990 to 2016. Therefore, non-English studies, as well as those published before and after 1990 to 2016 were excluded. Studies that did not have dry mouth as a primary outcome in the title or abstract were missed. This might lead to a lack of evidence about some drugs. In addition, the validity and reliability of the results might diminish because the variety of definitions and methods to evaluate dry mouth in each study might impact on comparative analysis.

As is evidenced, dry mouth is associated with medications and polypharmacy. Therefore, consideration of their drug consumption is essential to aid in monitoring and medication management. Moreover, age and sex are observed associated with dry mouth; details will be discussed in the section below.

2.2.4.3 Age and Sex

As stated earlier, age and sex may influence salivary gland function and, in turn, lead to xerostomia and SGH. Higher prevalence of dry mouth has been reported in the older adults and women (Nederfors et al., 1997). Studies have reported decreased number of acinar cells in salivary glands in the older adults (Liu et al., 2012). Yet, some studies found normal salivary secretion in healthy older people (Turner and Ship, 2007).

Affoo et al. (2015) aimed to ascertain the association between age and salivary flow rate. The study in this meta-analysis included English language publications since June 2013. Studies were categorised into two groups; younger group (aged 18 - 40) and older group (aged 60 and older), the studies which could not be classified into these were excluded. Forty-seven studies were included; sample sizes ranged from 15 to 1,427. Of these, 15 found decreased salivary flow rates in older people, 21 studies did not find a difference in mean salivary flow rate between age groups, one study reported the relation between salivary flow and ageing, and ten studies showed ambiguous results. Affoo et al. (2015) analysed salivary flow rate from each gland. The study found that unstimulated and stimulated whole salivary flow rate were significantly lower in older people. Similar results (decreased in older adults) were presented for submandibular and sublingual salivary flow rates.

In contrast, the parotid gland salivary flow rate was not lower in older people. For minor glands, the study showed unstimulated salivary flow rate was significantly lower in older people; the stimulated salivary flow rate did not have enough data to analyse. The study explored salivary flow merely in medication-free samples and found stimulated whole, and unstimulated, as well as stimulated parotid salivary flow were not significantly different between age groups. In sum, the study showed an association between decreased salivary flow rate and ageing. These might be due to the deterioration of cells. In addition, decreased salivary flow in the older adults may be caused by systemic diseases, and medications as many older adults have underlying conditions and take at least one medication. Therefore, systemic diseases and drugs might be confounders contributing to dry mouth in the older adults.

For sex, Inoue et al. (2006) studied in 50 healthy young adults age ranged 20 - 32 years in Japan. Participants who took drugs or had systemic diseases that might affect salivation were excluded. The unstimulated salivary flow was collected by spitting method between 2 - 6 p.m.; no detail about the examiners was provided. Magnetic resonance imaging (MRI) was used to assess the three major salivary glands. The study found the sizes of the parotid and submandibular glands in men were significantly bigger than in women but did not find differences in sublingual glands. In addition, the study also found a significant association between gland sizes and salivary flow rate. In sum, the study showed smaller sizes of salivary glands in women than men, and lower salivary flow rate in women than men.

Overall, it appears that age and sex influence salivary glands. Although previous studies have shown higher prevalence of dry mouth in older people and women, systemic diseases and drug-taking should always be considered as confounding variables. Further, there are treatments that affect salivary glands, which will be discussed in the section below.

2.2.4.4 Radiation and other treatments

As previously mentioned, conditions and treatments harmful to salivary glands can result in decreased salivary flow. Radiation therapy of the head and neck region has serious side effects on salivary glands. The radiation can directly damage the major and minor salivary glands, or injure salivary gland nerve supplies (Porter et al., 2004; Tanasiewicz et al., 2016; Jensen et al., 2019), leading to atrophy, and fibrosis of the salivary gland cells, and temporary or permanent dry mouth (Guggenheimer and Moore, 2003; Millsop et al., 2017; Jensen et al., 2019). The severity of the glandular injury depends on the dose absorbed, duration and area size of exposure (Tanasiewicz et al., 2016; Jensen et al., 2019).

In support of this, Jensen et al. (2019) undertook a systematic review which included English language original articles from January 1970 to June 2013. Seventy studies were included and analysed. The study found the radiation dose for head and neck cancer treatment was 50 - 70 Gray, while a dose of more than 52 Gray can cause severe damage to gland tissue and lead to significant reduction of salivation and chronic xerostomia. The decreased salivary flow was observed since the start of radiation until three months after radiotherapy completion. Similarly, Dijkema et al. (2012) reported 65% of head and neck cancer patients experienced xerostomia one year after undergoing radiotherapy. Jensen et al. (2019) also suggested the salivary flow rate could be reduced by 50% - 60% in the first week, and then reduced to less than 10% after that. Radiation also affected the salivary composition including electrolyte levels, proteins, and microbial changes. These have resulted in various oral health problems.

Apart from radiotherapy, stapedectomy can also damage salivary gland function. Stapedectomy is ear surgery to improve hearing. The incision is made in the ear canal. Therefore, sometimes the surgery can damage salivary gland nerve supplies and lead to diminished salivary secretion (Tanasiewicz et al., 2016).

In sum, radiation and some treatments can cause damage to salivary glands, and lead to diminished salivary secretion and chronic dry mouth symptoms. The section below will consider health-related behaviours that related to dry mouth.

2.2.4.5 Health-related behaviours

Apart from systemic diseases, medications and treatments, behaviours can affect dry mouth. Smoking, alcohol consumption, and caffeine use affect salivary secretion and xerostomia (Pedersen et al., 2002; Tanasiewicz et al., 2016; Millsop et al., 2017; Shirlaw and Khan, 2017).

For example, Rad et al. (2010) examined the consequence of long-term smoking on salivary flow rate. The 200 healthy participants who received dental care at Kerman University of Medical Sciences School of Dentistry, Iran were included. Daily smokers who had smoked cigarettes for more than six months were grouped as a smoking group. Non-smokers were grouped as a control. There were 100 participants (96 men and four women) for each group with mean age 36.6 ± 8.9 years and 34.5 ± 7.9 years for smoking and control groups respectively. The smokers had smoked 14.8 ± 8.3 cigarettes per day. The mean duration of smoking was 12.1 $\pm$ 6.8 years. The participants were diagnosed with xerostomia when at least one answer was 'yes' to the following questions: "Do you sip liquids to aid in swallowing dry foods?", "Does your mouth feel dry when eating a meal?", or "Do you have difficulties swallowing any foods?". Saliva was collected by the spitting method between 9 - 12 a.m. The participants were asked not to consume food and water as well as not to clean the oral cavity and smoke at least one hour before salivary collection. Examination of the oral cavity was recorded, but the study did not report details about the examiners and assessment procedures. The study revealed significantly higher prevalence of xerostomia in the smoking group than the control, 39% and 12%, respectively. The study also found mean salivary flow rate in the smoking group was significantly lower than the control. Further, gingivitis, mobility, calculus, and cervical caries were markedly greater in the smoking group than the control. In sum, the study revealed smoking was associated with decreased salivary flow rate, and poor oral health. These results must be interpreted with caution because the study only included healthy participants. Yet, smokers might take care of themselves less well than non-smokers, which might lead to more oral problems. Another problem with this study is that almost all participants were males; therefore, the findings might not be extrapolated to all populations.

To conclude, the aetiologies of dry mouth are various. Most common are diseases, medications, and treatments that negatively affect the salivary glands or autonomic nervous system. In addition, some behaviours, for example, smoking, drinking alcohol, might lead to a reduction in salivary flow rate and chronic xerostomia. A review of the patient's medical and drug history, head and neck radiation, and health-related behaviours are important when examining causes of dry mouth. Further, decreased salivation can cause many domain impacts on individuals that will be described further in the next section.

2.2.5 Impacts of dry mouth

Saliva plays a crucial role in the human mouth. It is important for protecting and maintenance of healthy oral tissue. Saliva is the extracellular fluid delivered by salivary glands that include the three major glands (parotid, submandibular, and sublingual) as well as hundreds of minor salivary glands (Cassolato and Turnbull, 2003). The main component of saliva is water (over 99%). It also contains a number of other substances; for example, protein, mucins, various enzymes, antibacterial compounds, nitrogen products as well as electrolytes including sodium, calcium, magnesium, bicarbonate, and phosphates (Dawes et al., 2015).

Salivary gland secretion can be divided into two main types (Cassolato and Turnbull, 2003). First, serous secretions, the fluid mainly produced from parotid and submandibular glands. This type is a protein-rich secretion composed of bactericidal substances such as proteolytic enzymes and antibodies (Cassolato and Turnbull, 2003). Second, mucous secretions, which are mainly secreted by submandibular and sublingual glands. The secretion mostly contains mucin, which acts as lubricant and precludes oral tissue dryness (Cassolato and Turnbull, 2003; Proctor, 2016). Indeed, submandibular and sublingual glands generate mixed or seromucous secretions (Dodds et al., 2015). Also, the minor salivary glands secrete purely mucous (Cassolato and Turnbull, 2003).

As stated earlier, salivary flow is under the control of the autonomic nervous system. At rest, the central nervous system mandates the resting or unstimulated salivary secretion (Pedersen et al., 2002). Unstimulated salivary flow is small, constant and contributed to by the parotid (20%), submandibular (65%), sublingual (7 - 8%), and minor glands (less than 10%) (Humphrey and Williamson, 2001; Dodds et al., 2015). In term of stimulated salivary flow, it can be provoked by mechanical, gustatory, and olfactory stimulation. Approximately 50% of stimulated secretion generated by parotid glands (Humphrey and Williamson, 2001).

As can be seen, saliva has various components which have a variety of functions. Also, the secretions are different in a circadian cycle. The properties of saliva are summarised in Table 8.

Table 8: The functions of saliva (Dawes et al., 2015; Donaldson and Goodchild, 2019)

Property	Function
- Maintain tissue integrity	- Moisten and lubricate oral tissue; decreased oral mucosa susceptibility to abrasion while eating, speaking, oral hygiene, wearing appliances/prosthetics
- Microbial balance	- Prevent some microbial colonisation but not affect normal flora
- Physiologic buffer	- Buffer acid and temperature
- Maintain/restore structural integrity of teeth	- Assist in forming acquired enamel pellicle - Decrease dental caries risk by buffering acid and controlling plaque pH, and promoting enamel remineralisation
- Digestion	- Facilitate the process of swallowing
- Cleansing	- Facilitate removal of food, drinks, food debris, desquamated epithelium cells and free microorganisms in saliva
- Taste	- Act as the solvent and distributor of flavour around the oral cavity
- Speech	- Lubricate moving oral tissues

As shown in Table 8, saliva has many functions. As a result, reduction of salivary flow can have a range of impacts including physical, functional, psychological, and social, all of which can, in turn, impact an individual's quality of life (QoL), general health and well-being.

In this review, the effects of dry mouth will be discussed under four headings, which are:

- Physical impacts
- Functional impacts
- Psychological impacts
- Social impacts

2.2.5.1 Physical impacts

Since saliva is a vital part of a healthy oral cavity, the lack of saliva may cause many effects on oral tissues. It has been reported that dry mouth could have direct and indirect physical sequelae on the oral cavity as summarised in Table 9.

Table 9: Physical impacts of oral dryness (Locker, 1993; Guggenheimer and Moore, 2003; Folke et al., 2009; Gueiros et al., 2009; Tanasiewicz et al., 2016; Millsop et al., 2017)

- Cracked tongue	- Dental caries
- Dry, peeled, and chapped lips	- Oral infection
- Dehydrated oral mucosa	- Candidiasis
- Traumatic oral lesions	- Denture stomatitis
- Poorly fitting prostheses	- Angular cheilitis
- Bad breath	- Tooth loss; abrasion, attrition, and erosion
- Burning sensation	
- Gingivitis	- Periodontitis

As can be seen in Table 9, reduction in saliva directly impacts the oral cavity, for example, cracked tongue, dehydrated lip, ill-fitting dentures, more prone susceptible to trauma, dental caries, oral infections, periodontal disease, and denture stomatitis (Cassolato and Turnbull, 2003; Shirlaw and Khan, 2017). Patients with decreased salivary flow always present juiceless, and tough mucosa, frothy saliva, and little saliva in the floor of mouth (Cassolato and Turnbull, 2003; Shirlaw and Khan, 2017).

As indicated earlier, salivary secretions have mainly two types. One of these, mucous, which is rich in mucin, establishes a thin and viscoelastic film. The film covers the entire oral mucous membrane, tongue, and teeth. Because of its features and characteristics, saliva keeps the oral cavity moist and behaves like a lubricant. Further, the slimy and viscoelastic cover lubricates and eases the contact among the oral tissue and teeth in the mouth or prostheses and acts as a shield to defend against irritants (Dawes et al., 2015).

Consequently, patients with dry mouth typically report dry, peeled and chapped lips, dry and fissured tongue, dehydrated oral mucosa, tooth surface loss; abrasion, attrition and erosion as well as mouth sores and ulcers due to trauma (Dawes, 2008; Joanna and Thomson, 2015).

Turner and Ship (2007) reviewed the effects of dry mouth, especially in older people. They reported signs of dry mouth including tongue, buccal mucosa, floor of the mouth, palate, posterior oral pharynx, are more susceptible to desiccation and brittleness. In addition, Turner and Ship (2007) reported that there are obstacles for denture wearers owing to reduced salivation. The main cause of the problems is that saliva performs an important role in prostheses retention, which is the resistance to the denture moving away from supporting tissues (Turner et al., 2008). Hence, without sufficient salivary secretion, the denture may lose retention and result in denture sores (Turner and Ship, 2007). However, the study only included English language articles published in the past ten years but did not report a specific time. The study also made no attempt to explain the methodology, inclusion and exclusion criteria, and the number of articles that had been reviewed.

The vital characteristic part of the multifunctional role of saliva is the ability of pH buffering. The salivary pH plays a crucial role in mitigating tooth decay, particularly in relation to the pH of dental plaque (Humphrey and Williamson, 2001). The pH of dental plaque plays a leading role in the process of remineralisation of active initial carious lesions. Dietary factors can lead plaque pH reduction due to the acidic by-products of bacteria metabolism fermenting carbohydrates, especially sugars. When the plaque pH is below than a critical value, in turn, leading the saliva or plaque to be unsaturated with respect tooth enamel. Because of this, tooth enamel starts to dissolve and erode. However, bicarbonate in saliva buffers the acid resulting in plaque pH rising; consequently, the saliva or plaque come to be supersaturated with respect tooth enamel, and start the repairing process to tooth enamel (Dodds et al., 2015). Therefore, reduction in saliva can result in the imbalance between demineralisation and remineralisation, which leads to progression of carious lesions.

In addition, the clearance ability of saliva helps to wash away food, drinks, food debris, desquamated epithelial and microorganisms from the oral cavity and helps to reduce the risk of dental caries (Dawes et al., 2015). Consequently, decreased salivary flow results in a reduction of the clearance ability of saliva and promotes dental caries in dry mouth patients.

Guggenheimer and Moore (2003) reviewed the literature over the past 20 years. The study did not report inclusion and exclusion criteria, and the number of articles reviewed. The review suggested that reduction in saliva may indirectly impact oral health by leading individuals to more frequently consume cariogenic food such as sugary candies or beverages to relieve dryness symptoms, which in turn, may lead to promotion of dental caries incidence. To date, there are no studies specific to the association between consumption of cariogenic food and dry mouth.

In terms of antimicrobial factors in saliva, many components have anti-bacterial, anti-viral and anti-fungal effects. Also, mucins in saliva restrain direct bacterial agglomeration to oral mucosa by binding itself to bacteria and washing away the bacteria during swallowing (Pedersen et al., 2002). The saliva thus is important in protecting and sustaining the normal flora and forestalls the colonisation of pathogenic microorganisms (Dawes et al., 2015). As a result, lack of salivary secretion contributes to the increase in oral infection. Also, candidiasis is always found in patients with dry mouth, signs include a pseudomembrane, erythema of the underlying tissues and a burning sensation of oral tissues (Turner and Ship, 2007). Angular cheilitis or angular stomatitis is often found in hyposalivation patients (Cassolato and Turnbull, 2003). Fungal-associated denture stomatitis has also been reported in patients with decreased salivary output (Turner and Ship, 2007; Turner et al., 2008).

In contrast, Altarawneh et al. (2013) investigated the association between denture stomatitis and salivary flow among 32 Americans with a mean age of 64.8 years; the study included patients with complete maxillary dentures (15 with denture stomatitis and 17 healthy). Participants collected stimulated and unstimulated salivary flow rates between 9 - 11 a.m. and were asked not to eat, drink, smoke, and brush their teeth at least 15 minutes before salivary collection. Xerostomia was determined by a questionnaire that contained questions about eating, swallowing, speaking function, as well as dryness feeling in the oral cavity. The study did not explain the diagnostic criteria for xerostomia. Altarawneh et al. (2013) observed that neither the reduced salivary flow rate nor xerostomia was significantly associated with denture stomatitis. However, the sample size may have been too small to detect a difference. The authors suggested that the antimicrobial functions of saliva might not relate to salivary flow or xerostomia and proposed an investigation of salivary immunoglobulins and antifungal components in a further study.

In conclusion, dry mouth has been associated with various negative effects on oral health.

Saliva plays a crucial role in the oral cavity, including maintaining moisture, acting as a lubricant, resisting denture adhesion, buffering pH levels, and cleansing. Consequently, a reduction in salivary flow can increase the likelihood of individuals developing dental caries, periodontitis, oral infections, traumatic ulcers, denture loosening, and denture stomatitis. These effects collectively impair functionality of the oral cavity, a topic that will be further discussed in the subsequent section.

2.2.5.2 Functional impacts

As can be seen, dry mouth has a broad range of effects on oral cavity, which in turn, diminish some functions related to the oral cavity in people's daily life. There have been reports of difficulty in eating, swallowing, speaking, taste alteration, walking, running, singing, tooth brushing and sleeping in patients with dry mouth (Locker, 2003; Gerdin et al., 2005; Ikebe et al., 2005; Folke et al., 2009; Niklander et al., 2017; Gibson et al., 2020). This section will describe the mechanism of functional impairment due to lack of saliva, and some studies in this area will be illustrated.

Saliva contains mucins which are hydrophilic, and over 99% of saliva is water (Pedersen et al., 2002). As a result, lubrication and humidity are the dominant features of saliva; saliva has a positive effect on the process of mastication, speech, and swallowing (Pedersen et al., 2002; Dawes et al., 2015; Joanna and Thomson, 2015). Saliva not only lubricates and moistens the oral tissue, but also protects adjacent tissues by forming a mucous layer that covers the oral mucosal tissues (Dawes et al., 2015), and thereby facilitates chewing and speaking.

One of the most important functions of saliva in the swallowing process is food bolus creation. Saliva softens food particles and holds the masticated food together by salivary mucins (Dawes et al., 2015). Consequently, the food bolus becomes rounded, smooth and greasy (Pedersen et al., 2002). The food bolus formation allows the masticated food to be passed easily along the oesophagus and does not detriment the oral mucosa, as well as diminishes the risk of choking (Pedersen et al., 2002).

Furthermore, saliva is crucial for taste by dissolving flavour and transporting them to the taste buds (Dawes et al., 2015). Component of saliva, i.e., sodium, calcium, potassium, and bicarbonate, are closely linked with the food taste. Also, pain, temperature, and food texture influence taste (Pedersen et al., 2002). Indeed, the dehydrated oral cavity may injure the taste buds, leading to increasing taste thresholds (Dawes et al., 2015).

To date, there have been no systematic reviews of the literature specific to the functional impacts of dry mouth, yet functional impairment can be determined by OHRQoL assessment, which will be discussed later. In this section, studies related to functional impacts of dry mouth will be considered. For example, Niklander et al. (2017) studied the impacts of dry mouth on OHRQoL among 566 adults in the dental school clinic, Chile. The question: "How often do you feel that your mouth is dry?" was asked with four options; never, sometimes, usually, and always. Participants who responded to usually or always were counted as having xerostomia. The study reported xerostomia prevalence to be 10.8% and was more common in women than men. Seventy participants (35 for dry mouth group and 35 for non-dry mouth group) were examined for their unstimulated and stimulated salivary flow rate between 9.30 - 11.30 a.m. The study reported significantly higher prevalence of unstimulated hyposalivation in the xerostomia group than the control group (28.6% and 5.7%, respectively), yet the differences were not found to be significant in stimulated hyposalivation (14.3% for xerostomia group, and 8.6% for control group).

In addition, the short-form Oral Health Impact Profile (OHIP-14) consisted of seven domains, namely functional limitation, physical pain, psychological discomfort, physical incapacity, psychological incapacity, social incapacity, and social disadvantage, Spanish version, was used to investigate the OHRQoL. Higher scores of OHIP-14 indicate worse impacts of dry mouth. The study found every domain score of OHIP-14 in the xerostomia group were significantly higher than the control. Physical pain, psychological discomfort, and psychological incapacity domains in the xerostomia group were reported to be the highest mean scores of OHIP-14; 3.4, 4, 1, and 3.8, respectively. The study also reported the xerostomia group had a significantly higher impact on difficulty in eating and taste alteration. Participants with xerostomia were also more likely to have reported symptoms of burning sensation, self-perceived bad breath, and increasing liquid-taking to aid in the swallowing process.

In sum, the study revealed dry mouth impacted functions of the oral cavity such as eating, taste perception and swallowing. However, these findings must be interpreted with caution as the study collected data from dental clinics, so the prevalence of dry mouth might be overestimated. Also, the xerostomia assessment was a single item that might not have been validated. The study might have been much more persuasive if the authors had conducted a population-based study, and used a validated assessment, such as the xerostomia inventory.

Moreover, in Osaka, Japan, Ikebe et al. (2005) studied 989 community independent living people with dentures aged 60 - 88 years. Participants were diagnosed as having xerostomia if they perceived oral dryness while having a meal. The study reported 9% xerostomia prevalence. Participants were asked to self-report oral function and satisfaction with their denture by answering: “Are you satisfied with your ability to chew?”, “Are you satisfied with your ability to speak clearly?”, and “Are you satisfied with your ability to taste foods?” with three options: satisfied, fairly satisfied, and dissatisfied. Ikebe et al. (2005) observed that complete denture wearers with xerostomia were significantly more displeased with chewing, speaking, and were more dissatisfied with their dentures. The study also reported that dry mouth predisposes complete denture wearers to dislike food tastes, denture instability, discomfort with the denture, and more prone to soreness, although relationships were not statically significant. However, removable partial denture wearers with dry mouth were only significantly associated with poor self-rated chewing ability and tended to have more soreness beneath the denture. Interestingly, both complete denture and removable partial denture wearers, with oral dryness were reported to be closely linked with low body mass index. One possible reason why dry mouth has a more deleterious effect on complete than removable partial denture wearers is that saliva plays an important role in soft tissue retention of the former. It is noteworthy that the study had a small sample size and a prevalence of xerostomia, of 9%, which might have been inadequate to have sufficient power to detect a meaningful difference among the variables.

In sum, dry mouth can negatively impact on oral function, for example, eating, swallowing, and speaking. Further, psychological impacts have been reported in the previous examples, which will be discussed in the section below.

2.2.5.3 Psychological impacts

As can be seen from the above sections, the physical and functional impacts of dry mouth can be both wide-ranging and significant for individuals. In addition to these, there have been a number of psychological and social impacts reported in the literature. In terms of the psychological impacts, these have included being anxious, annoyed, agitated, angry, confused, depressed, indespair, disgusted, embarrassed, forlorn, fearful, frightened, frustrated, gnawing, grumpy, helpless, irritated, melancholic, mad, nervous, nerve wrecking, panicked, regretful, sad, shamed, stressed, struggling, self-conscious, self-aware, tense, upset, uneasy, and worried (Locker, 2003; Gerdin et al., 2005; Thomson et al., 2006; Ikebe et al., 2007; Folke et al., 2009; Gibson et al., 2020).

For example, Thomson et al. (2006) studied 923 individuals aged 32 years who participated in the longitudinal study at the Queen Mary Hospital, Dunedin, New Zealand. The participants were asked "How often does your mouth feel dry?" with four options, namely always, frequently, occasionally, and never. "Frequently and occasionally" responses were scored as xerostomia. The study found the prevalence of xerostomia was 9.9%. The OHIP-14 was used to assess the association between xerostomia and OHRQoL. Participants rated the frequency of the problem in the previous four weeks, which included four choices: very often, fairly often, occasionally, hardly ever, and never. The study found a significant association between all items of OHIP-14 and xerostomia. The study also revealed that xerostomia was closely associated with functional impairments. Apart from these, the authors reported a link between xerostomia and negative emotions, for example, being stressed, upset, and annoyed. The study reported 25.3% of those with xerostomia had a heightened sense of self-awareness. Similarly, 19.8% of those with xerostomia felt a bit ashamed, and 13.2% were having trouble enjoying their time off. As a result, participants with xerostomia reported having work difficulty and less life satisfaction. It is noteworthy that oral dryness was correlated with worse OHRQoL. The conclusions might have been far stronger if the authors had also investigated the salivary flow rate.

Gerdin et al. (2005) interviewed 41 frail older adults in Sweden. The study used the Visual Analogue Scale (VAS) for dry mouth symptoms to measure xerostomia. Participants were asked to rate symptoms: difficulty in speaking and swallowing, amount of saliva, dryness of mouth, throat, lips and tongue, and level of thirst on a VAS scale (0: no problem to 100: chronic severe problems). The scores were summed, and participants were grouped as 'no, or weak dry mouth symptoms' (VAS-sum < 472, or < 54 for each question), and 'symptoms' (VAS-sum ≥ 472, or ≥ 54 for each question). A prevalence of xerostomia of 78% was reported. Most suffered from dry lips (67%), dryness in the mouth (61%), low amount of saliva (41%), and thirst (39%). The study also investigated salivary flow rate using the swab technique. There was a 44% prevalence of hyposalivation.

In addition, Gerdin et al. (2005) assessed the OHRQoL using OHIP-14. The study found a significant association between xerostomia and the overall OHIP-14 score, particularly items, difficulty in speaking, taste alteration, and tense. Also, five dry mouth symptom questions: difficulty in speaking, difficulty in swallowing, dryness of mouth, lips, and throat were significantly associated with the summed OHIP-14 score. However, hyposalivation was not significantly associated with the summed OHIP-14 score but was with oral pain and self-consciousness. Notably, xerostomia and hyposalivation were related to the different domains of OHRQoL. Gerdin et al. (2005) critiqued the factors that might influence the results, including the potential for loss of cognitive function in participants which could affect understanding and recall, as well as the complexity of the questions. In addition, the VAS method might not suit chronic conditions such as dry mouth.

Following the earlier examples, individuals with dry mouth may have a variety of psychological impacts. These might occur due to the symptoms and functional limitation which may lead individuals to have mental health problems. In addition to these, those with xerostomia have impacted which affect them doing their jobs, and their life satisfaction. Individuals who cannot cope with these impacts might avoid social participation, which will be discussed in the section below.

2.2.5.4 Social impacts

As stated earlier, dry mouth has various signs and symptoms that can influence functional limitation and mental health, and lead to individuals having negative social consequences. There have been reports of social impacts such as problems with: speaking to others, interacting in groups, eating with others due to being ashamed of their eating habits, feeling different, kissing, sexual intercourse, having trouble enjoying their time off, having work difficulty, less life satisfaction, being burdensome to drink water all the time which lead to stop some activities such as fitness programmes, or chorus singing, poor retention of dentures resulting in less confidence in various social settings (Thomson et al., 2006; Ikebe et al., 2007; Folke et al., 2009; Gibson et al., 2020).

Gibson et al. (2020) qualitatively explored the impacts of dry mouth on symptomatic, physical, emotional, and social aspects of people's life. The study interviewed 17 adult participants (14 women, 3 men) about their dry mouth experiences. Of these, six were patients with Sjogren's syndrome and 11 experienced dry mouth for other reasons, for example, chemotherapy and prescription drugs. The study pointed out that symptoms of dry mouth could result in problems of physical, psychological, and social functioning. These effects also depended on psychological, social, and environmental variables. Psychological factors were illness beliefs, health identity, adaptation, coping and personal blame. Social and environmental determinants were age, employment, or facilities in workplaces, restaurants and while travelling.

Gibson et al. (2020) reported diverse symptoms with various severity of dry mouth. For example, “dehydrated”, “I’m gasping”, “gnawing”, “mouth is like cardboard”, “wiped off with tissue”, “an itch”, “cotton wool in your mouth”, “no mucous”, “choking”, “retching” and “gagging” were reported as dry mouth symptoms. Participants revealed behavioural changes due to dry mouth symptoms, for example, cleaning the mouth every time after drinking coffee because of its bad taste, and drinking water all the time even at night. Symptoms became more serious when they started choking. Because of this, dry mouth can result in difficulties in daily life. Participants reported that they had problems with speaking, especially difficulty in pronouncing words, due to a sticky and dry feeling in their mouth. Some faced swallowing problems which led them to drink a lot of water during meals in order to facilitate swallowing and avoid choking on food. Consequently, they tended to order soup or have a liquid diet, which led to overthinking when going out for a meal at restaurants.

In addition, some had a bad experience due to oral dryness. One reported choking at night, and other reported choking in public as a terrible experience that put them on centre stage and feelings of being ashamed. Many reported feelings anxious, annoyed, and agitated by having bad breath, and this was particularly problematic when they had to speak closely with others. One of the interviewees had to stop her work because it had deleterious effects on her dry mouth symptoms. The study showed the apparent effects of dry mouth on individuals’ daily life and well-being in the physical, functional, psychological, and social dimensions. However, the study was limited in that the participants were from the United Kingdom only and most were women. The results, therefore, lack the variety in the context of ethnicity, culture, and belief, which may be important in terms of the experience of dry mouth.

Further, Folke et al. (2009) conducted a qualitative study to determine the main concern of xerostomia and the ways of dealing with symptoms. The study interviewed 15 participants (5 men and 10 women) who experienced xerostomia, aged range 19 - 81 year in Sweden. The study used a range of questions, for example, “Please tell me what it means to suffer from xerostomia”, “What impact does xerostomia have on your well-being and everyday life?” to start the conversations, with follow-up questions; “In what way?”, “How does that feel?”, “Can you describe such a situation” and “What do you do in a situation like that?”. A grounded theory approach was used as a guide in the analytical process. The results were grouped into three categories, namely professional consultation, search for affirmation and social withdrawal.

For professional consultation, Folke et al. (2009) identified the symptoms that led the participants to seek advice from health care professionals. Participants reported constant oral discomfort, for example, sandpaper-like sensation in the mouth, dry lips, dehydrated oral mucosa resulting in the tongue sticking to the palate, leading to difficulty in pronouncing words. Oral dryness also caused mastication and swallowing problems. In addition to these, the participants had more dental problems, which were new cavities, especially root caries of the anterior teeth and secondary caries. Participants also reported problems of wearing occlusal splints due to hyposalivation, in turn, increasing tooth wear and impaired appearance of the front teeth.

The participants searched for affirmation but found inadequate social support due to others not perceiving dry mouth symptoms as a serious condition. Moreover, health care professionals paid little or no attention to xerostomia and lacked information to provide for their patients on its causes, symptoms, and impacts. Oral discomfort, symptoms, functional limitations, and lack of empathy from others was also reported as bringing about social isolation. Participants were ashamed of slurred speech or eating habits and sleep deprivation due to dry mouth symptoms and led to them avoiding participation in any activities.

To conclude, social impacts of dry mouth can be the consequence of physical, functional, and psychological impacts. Also, it appears dry mouth and its effect have been somewhat neglected by (dental) health care professionals. These have led individuals to have less self-confidence and feelings of stigmatization. Consequently, individuals with dry mouth have reported social isolation and reduced community participation.

For more examples, Table 10 includes studies that have determined an association between dry mouth and OHRQoL.

Table 10: The association between dry mouth and OHRQoL

Authors	Samples			Xerostomia		OHRQoL measurement	Key findings
	Population	Sex	Total	Prevalence (%)	Assessment		
Locker (2003)	Residents aged range 52-100 years of the Baycrest Centre for Geriatric Care in Canada	Male Female	225 (total)	32.0 (mild) 31.1 (marked)	Personal interview using questions; "During the past four weeks, have you had a dry mouth or tongue during the daytime?" and the remaining six questions related to the problems of dry mouth (functional limitations and behaviour changes due to dry mouth) with responses "yes" (1) or "no" (0); summed scores; 1-2 indicating mild, 3-7 indicating marked xerostomia	- GOHAI* - Six-item index of chewing capacity - OHIP-14**	- There were 60.4% of participants having chewing problems. - For GOHAI, uncomfortable when eating, mastication problems and unhappy with the oral appearance were most frequently concerns. - For OHIP-14, uncomfortable when eating and being self-awareness as well as embarrassed by oral problems were the main effects.
Gerdin et al. (2005)	Frail older people aged range 83-88 years in Sweden	Male Female	41 (total)	78.0 (total)	Visual Analogue Scale for dry mouth symptoms; difficulty in speaking and swallowing, amount of saliva, dryness of mouth, throat, lips and tongue, and level of thirst	OHIP-14**	- Xerostomia was statistically significantly associated with the overall OHIP-14, particularly difficulty in speaking, taste alteration, and being bad-tempered. - Hyposalivation was not statistically significantly associated with overall OHIP-14, yet significantly associated with oral pain and self-awareness.

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, ***SXI: Short version of Xerostomia Inventory

[a]PD: Idiopathic Parkinson's disease, [b]CA: Caries active, [c]CI: Caries inactive

Table 10: Continued

Authors	Samples			Xerostomia		OHRQoL measurement	Key findings
	Population	Sex	Total	Prevalence (%)	Assessment		
Ikebe et al. (2005)	People wearing denture aged range 60-88 years in Japan	Male Female	258 235	12.4 8.9	Questionnaire: “Does your mouth feel dry when eating a meal?” “Yes” was counted as xerostomia.	Questionnaire: “Are you satisfied with your ability to chew?”, “Are you satisfied with your ability to speak clearly?”, and “Are you satisfied with your ability to taste foods?” with three options; “satisfied”, “fairly satisfied”, and “dissatisfied”	- Complete denture wearers with xerostomia were significantly displeased with chewing, speaking, and dissatisfied with their dentures. - Removable partial denture wearers with dry mouth were only significantly associated with poor self-rated chewing ability.
Thomson et al. (2006)	People at age 32 years who were born at the Queen Mary Hospital between April 1972 and March 1973 in New Zealand	Male Female	923 (total)	9.9 (total)	Questionnaire: “How often do you feel that your mouth is dry?”, with four options; “never”, “occasionally”, “frequently”, and “always”. “Frequently and always” were counted as xerostomia.	OHIP-14**	- Xerostomia showed statistically significant association with overall OHIP-14 score. - Twenty-five per cent of patients with xerostomia reported being self-conscious, followed by being embarrassed (around 20%), and difficulty in eating (around 16%).

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, *** SXI: Short version of Xerostomia Inventory
[a]PD: Idiopathic Parkinson’s disease, [b]CA: Caries active, [c]CI: Caries inactive

Table 10: Continued

Authors	Samples			Xerostomia		OHRQoL measurement	Key findings
	Population	Sex	Total	Prevalence (%)	Assessment		
Ikebe et al. (2007)	Community-dwelling people aged range 60-81 years in Japan	Male Female	168 110	8.3 (total)	Personal interview: "Does your mouth feel dry when eating a meal?"	OHIP-14** (Japanese version)	- Xerostomia and SGH groups showed statistically significantly higher summed OHIP-14 scores than control. - Xerostomia was statistically significantly associated with items of bad taste perception, being self-conscious, stress, having to interrupt meals, difficult to relax, difficulty doing usual jobs, less satisfying of life and totally unable to function. - SGH was statistically significantly associated with items of having to interrupt meals, difficult to relax, difficulty doing usual jobs, less satisfying of life and totally unable to function.
Folke et al. (2009)	Patients aged range 19-81 years who had history of dry mouth symptoms in Sweden	Male Female	5 10	100 (total)	Study only included patients who experienced dry mouth.	Qualitative, conversational style interviews	- Xerostomia had negative effects on multiple domains of well-being. - Participants reported the problems of xerostomia as aesthetic concerns, halitosis, slurred speech, and anxiety, these also influenced self-confidence.

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, *** SXI: Short version of Xerostomia Inventory
[a]PD: Idiopathic Parkinson's disease, [b]CA: Caries active, [c]CI: Caries inactive

Table 10: Continued

Authors	Samples: Population	Samples: Sex	Samples: Total	Xerostomia: Prevalence (%)	Xerostomia: Assessment	OHRQoL measurement	Key findings
Hahnel et al. (2014)	Patients aged range 60-93 years in the Department of Prosthodontics in Germany	Male Female	19 49	16	Patients with SXI*** scores≥10 were diagnosed as xerostomia	GOHAI* (German version)	- The statistically significant predictor of GOHAI: a one-unit increase in the SXI*** score corresponded to a decrease of the GOHAI score of almost 2 units.
Barbe et al. (2017)	Outpatients' clinic of the Department of Operative Dentistry and Periodontology, Germany	PD[a] No PD[a]	30 30	50.0 0	Questionnaire; "Is there a lake of saliva on the mouth floor?", "Does the mucosal surface appears shiny?", "Are lips strongly reddened or cracked?" and "Is there a cheilitis angularis?" No data of the diagnostic criteria	OHIP-14** (German version)	- The mean OHIP-14 were not statistically significantly different between PD[a] patients with and without xerostomia. - The mean OHIP-14 of PD[a] patients were statistically significantly higher than controls.

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, *** SXI: Short version of Xerostomia Inventory
[a]PD: Idiopathic Parkinson's disease, [b]CA: Caries active, [c]CI: Caries inactive

Table 10: Continued

Authors	Samples			Xerostomia		OHRQoL measurement	Key findings
	Population	Sex	Total	Prevalence (%)	Assessment		
Niklander et al. (2017)	Patients aged range 18-83 years in dental school in Chile	Male Female	566	10.8 (total)	Questionnaire: "How often do you feel that your mouth is dry?", with four options; never, sometimes, usually, and always. "Usually and always" were counted as xerostomia.	OHIP-14** (Spanish version)	- Every domain score of OHIP-14 in xerostomia group were statistically significantly higher than control. - Physical pain, psychological discomfort, and psychological incapacity domains in xerostomia group were reported to be the highest mean scores of OHIP-14. - The xerostomia group had statistically significantly higher impact of difficulty in eating and taste alteration.
Bulthuis et al. (2018)	Patients aged range 12-99 years in the saliva clinic in The Netherlands	Male Female	81 63	100 (total)	Study included only patients who experienced dry mouth.	OHIP-14** (Dutch version)	- Patients with stress showed higher score of OHIP-14.
Flink et al. (2020)	Patients aged range 25-50 years at the Public Dental Clinic in Sweden	CA[b] CI[c]	134 40	24.0 0	Questionnaire: "How often has your mouth felt dry?" with five options; "never", "hardly ever", "occasionally", "often" and "very often"; "often and very often" were counted as xerostomia	OHIP-14**	- General health and unstimulated whole salivary flow were positively associated with perceived oral health, yet xerostomia symptoms were negatively related. - There was no statistically significant difference between CA[b] and CI[c], however, the functional limitation and physical pain domains were significantly higher in CA[b].

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, *** SXI: Short version of Xerostomia Inventory
[a]PD: Idiopathic Parkinson's disease, [b]CA: Caries active, [c]CI: Caries inactive

Table 10: Continued

Authors	Samples			Xerostomia		OHRQoL measurement	Key findings
	Population	Sex	Total	Prevalence (%)	Assessment		
Gibson et al. (2020)	Patients aged range 30-80 years who had history of dry mouth symptoms in UK	Male Female	3 14	100 (total)	Study included only patients who experienced dry mouth.	Semi-structured interview based on biopsychosocial approach	- Study showed various symptoms of dry mouth, namely dehydration, feeling like cardboard or cotton wool in the mouth, choking and gagging. - Dry mouth led individuals to avoid social participations due to being ashamed when choking, limitation of food choice and lack of self-confidence because of bad breath.

*GOHAI: Geriatric Oral Health Assessment Index, **OHIP-14: The short-form Oral Health Impact Profile, *** SXI: Short version of Xerostomia Inventory
[a]PD: Idiopathic Parkinson's disease, [b]CA: Caries active, [c]CI: Caries inactive

As can be seen in Table 10, there have been reports of various dry mouth impacts on physical changes as well as discomfort, functional limitations, psychological and social aspects. The studies have revealed problems of chewing, speaking and taste alteration in patients with xerostomia (Locker, 2003; Gerdin et al., 2005; Ikebe et al., 2005; Thomson et al., 2006; Ikebe et al., 2007; Folke et al., 2009; Niklander et al., 2017; Gibson et al., 2020). The studies also have reported bad breath and aesthetic problems stemming from dry mouth (Locker, 2003; Folke et al., 2009; Gibson et al., 2020). The effects of dry mouth include stress, being ashamed or embarrassed, anxiety, self-awareness, and lack of self-confidence (Locker, 2003; Gerdin et al., 2005; Thomson et al., 2006; Folke et al., 2009; Gibson et al., 2020). Dry mouth can eventually cause individuals to avoid participating in activities and society (Folke et al., 2009; Gibson et al., 2020). It is noteworthy that dry mouth can influence OHRQoL and well-being. Studies have used several different methods to determine this; GOHAI (Locker, 2003; Hahnel et al., 2014), OHIP-14 (Locker, 2003; Gerdin et al., 2005; Thomson et al., 2006; Ikebe et al., 2007; Barbe et al., 2017; Niklander et al., 2017; Bulthuis et al., 2018; Flink et al., 2020), six-item index of chewing capacity (Locker, 2003), questions related to oral ability and satisfication with oral ability (Ikebe et al., 2005) and in-depth interviews (Folke et al., 2009; Gibson et al., 2020), the OHRQoL and well-being assessments will be discussed later.

2.2.6 Conclusions

Dry mouth is a multifactorial condition that has been generally categorised into two conditions; xerostomia (subjective feeling of oral dryness) and SGH (decreased salivary flow). The conditions can coexist but not always. The prevalence of dry mouth has varied due to the different definitions and methods of assessments. Dry mouth can be a consequence of systemic diseases (e.g., diabetes), medications, age, sex, radiation, and health-related behaviours. Dry mouth can lead to negative impacts on oral health, functions, mental health, and social engagement, resulting in poorer OHRQoL and well-being.

In Thailand, few studies have explored dry mouth in the population, including with diabetic patients. Moreover, there has been an upward trend in the number of people with diabetes mellitus in recent years. This draws attention to the need to investigate dry mouth in diabetic patients in Thailand, in addition to the clinical, psychological, and social factors that impact on individual’s experience of the condition. In the next section, diabetes mellitus will be considered.

2.3 Diabetes mellitus

As has been seen in the dry mouth sections above, an association between dry mouth and diabetes mellitus has been noted in the literature. The following section will review the literature on diabetes mellitus. The first part will begin with an overview of diabetes mellitus, which includes its definition, prevalence, healthcare services, causes, and effects. The next part will discuss the oral manifestation of diabetes mellitus and focus on dry mouth effects. The last part will consider other factors relating to QoL in diabetic patients.

2.3.1 Overview of diabetes mellitus

2.3.1.1 Definition of diabetes mellitus

Diabetes mellitus (DM), also known as diabetes, is a metabolic syndrome (Guthrie and Guthrie, 2004; American Diabetes Association, 2014). The condition of diabetes is defined as a lifelong high blood sugar level, also known as hyperglycemia stemming from a deficiency in insulin secretion, or insulin resistance (American Diabetes Association, 2014).

Insulin is a protein hormone made by B cells of the islets of Langerhans of the pancreas (Guthrie and Guthrie, 2004). Insulin is delivered into vascular circulation and binds with insulin receptors on the target cell surface (Guthrie and Guthrie, 2004). The primary function of insulin is to control glucose levels (Guthrie and Guthrie, 2004). Therefore, insulin deficiency or resistance can lead to hyperglycemia.

In general, DM is divided into four types (Guthrie and Guthrie, 2004; Deshpande et al., 2008; American Diabetes Association, 2020);

First, Type 1 diabetes is a genetic disease in which B cells are destroyed by autoimmune pathologic processes arising in the pancreatic islets as well as external triggers, for example, viruses, such as coxsackie in cow’s milk. In this condition there is an absolute deficiency of insulin secretion. Around 5 to 10% of diabetic patients have this type.

Second, Type 2 diabetes affects the majority of diabetic patients. The causal role of Type 2 diabetes has been demonstrated by the combination of defective insulin performance and a lacking compensatory insulin response. Type 2 diabetes has several causes which are B cell exhaustion by insulin hypersecretion, glucose- or lipid-induced B cell toxicity, or genetic factors.

Third, gestational diabetes mellitus, this occurs in the second or third trimester of pregnancy.

Forth, diabetes mellitus which caused by other factors, for example, drug- or chemical-induced diabetes, disease of the exocrine pancreas, and monogenic diabetes syndromes.

To date, the tests used to diagnose diabetes are fasting plasma glucose (FPG) value or the 2-h plasma glucose (2-h PG) value during a 75-g oral glucose tolerance test (OGTT) and A1C criteria. The fasting plasma glucose (FPG) ≥ 126 mg/dL, 2-h PG ≥ 200 mg/dL and A1C ≥ 6.5% are the criteria for the diagnosis of diabetes (American Diabetes Association, 2020).

To conclude, diabetes mellitus is a condition that has high blood sugar or hyperglycemia due to a lack of insulin or insulin resistance. There are four types of diabetes, and the most common are Type 1 and Type 2.

In the section that follows, the prevalence of diabetes mellitus will be discussed.

2.3.1.2 Prevalence of diabetes mellitus

In 2019, a global estimate of diabetes in 20 - 79 years old adult prevalence was 463 million people or 9.3% of the adult population. The number of diabetic patients is predicted to increase to 578 million (10.2%) in 2030 and 700 million (10.9%) in 2045 (Saeedi et al., 2019). The number of diabetic patients in South-East Asia in 2019 was 87.6 million (11.3%), and projected to increase to 115.1 (12.2%), and 152.8 (12.6%) in 2030 and 2045 respectively (Saeedi et al., 2019). There are many reasons for this increase, for example, sedentary lifestyle, high intake of energy-dense foods and a greater prevalence of obesity (Forouhi and Wareham, 2014; Saeedi et al., 2019).

In Thailand, diabetes is one of the leading causes of death, with an estimated adult diabetes population of 4.4 million (9.5%) (Diabetes Association of Thailand, 2017). Diabetes prevalence has been steadily increasing and is projected to continue rising (Aekplakorn et al., 2007; Deerochanawong and Ferrario, 2013; Reutrakul and Deerochanawong, 2016). In 2014, the most recent Thai National Health Examination Surveys, conducted every five years, reported a diabetes prevalence of 9.9% among adults aged 20 and older (Aekplakorn et al., 2018). However, a study from 2017 to 2021 involving 235,491 members of the Royal Thai Army found a higher diabetes prevalence of 18.4% (Sakboonyarat et al., 2023). This discrepancy in prevalence rates might be due to the inclusion of older participants in the Royal Thai Army compared to the National Surveys. Moreover, the National surveys showed a higher prevalence in urban areas (Aekplakorn et al., 2007; Aekplakorn et al., 2011; Aekplakorn et al., 2018), a finding consistent with the

Royal Thai Army study, where the majority of participants resided in urban areas (Sakboonyarat et al., 2023).

Previous studies have indicated higher diabetes rates among those with obesity, older age, smoking habits, chronic alcohol consumption, sedentary behaviours, lower socioeconomic status, lower education levels, and hypertension (Aekplakorn et al., 2007; Aekplakorn et al., 2011; Deerochanawong and Ferrario, 2013; Puangpet et al., 2022; Sakboonyarat et al., 2023). Additionally, poor control of Type 2 diabetes (HbA1c $\geq$ 7%) has been associated with sex, age, region of residence, BMI, diabetic duration, comorbidity with hypertension, hospital levels, and health insurance schemes, (Sakboonyarat et al., 2021).

As can be seen, trends in diabetes prevalence are increasing worldwide and this includes in Thailand. Several factors which are likely to be associated with diabetes, including hospital levels and health insurance schemes, will be discussed in the next section.

2.3.1.3 Healthcare services for diabetes mellitus in Thailand

There are three main health care schemes in Thailand: the civil servant medical benefit scheme, the social security scheme (for private officers), and the universal health coverage scheme (covering all uninsured individuals, approximately 75% of the population) (Sakboonyarat et al., 2021). These insurance schemes provide free services for basic health problems, including diabetes (Sakboonyarat et al., 2021). Although there are some differences in service details among the schemes, essential treatment for diabetes remains consistent. Free services encompass in- and out-patient care, prescription drugs (such as metformin and insulin), laboratory investigations, and basic dental procedures (Deerochanawong and Ferrario, 2013).

Additionally, there is a national plan aimed at reducing the prevalence, complications, disability, mortality, and cost of illness associated with five major non-communicable diseases including diabetes. This plan covers educational programs for community health care workers and diabetes patients, as well as annual eye and foot examinations, urine albumin excretion tests, serum creatinine monitoring for diabetes complications, and dental screening and treatment (Deerochanawong and Ferrario, 2013).

In Thailand, hospitals are organised into three levels: community (district) hospitals providing primary care, general (province) hospital providing secondary care, and regional hospitals providing tertiary care (Sakboonyarat et al., 2021). Although each level of hospital has varying capabilities, they are all required to serve the residents within their designated area. Therefore, regional hospitals serve a broader population of individuals with diabetes mellitus (further details on the hospital setting in this study will be provided in section 3.2.3).

In sum, Thailand's healthcare system provides insurance coverage for basic care for diabetes mellitus. The following section will discuss the causes of diabetes mellitus.

2.3.1.4 Causes of diabetes mellitus

As mentioned earlier, diabetes is a condition where blood sugar is too high due to insulin deficiency or insulin resistance. The following section will describe the role of insulin and causes of diabetes.

Insulin is a peptide hormone secreted by B cells of the islets of Langerhans of the pancreas. It circulates through the bloodstream to the body's cells. Insulin binds to insulin receptors present on the cell surface and induces the translocation of glucose transporters (GLUT4 in adipose tissues and striated muscle). GLUT4 mediates the diffusion of glucose and other nutrients into cells. In addition, insulin stimulates glycogen, and fat synthesis and also suppresses the metabolic processes (Guthrie and Guthrie, 2004). Insulin thus helps cells to take up glucose to be used and stored for energy and suppresses the process of converting glucose into energy. Therefore, the lack of insulin or insulin resistance can lead to starvation and the rapid break down of glycogen and fat. Consequently, cells cannot generate energy via metabolic pathways resulting in the body creating glucose from protein and glycerol which leads to hyperglycaemia (Guthrie and Guthrie, 2004).

Two leading causes of diabetes mellitus are insulin deficiency and insulin resistance. For Type 1 diabetes, the causes can be genetic that lead the immune system to destroy B cells of the pancreas, or viruses, such as coxsackie viruses also have been reported to stimulate the destruction of B cells (Guthrie and Guthrie, 2004). Other risk factors for Type 1 diabetes are family history, ethnicity, and history of viral infections (Deshpande et al., 2008). For Type 2 diabetes, the causes may occur due to B cell exhaustion by insulin hypersecretion, glucose- or lipid-induced B cell toxicity, or genetic factors. Obesity has been reported in association with diabetes, yet not all obese people develop diabetes. Genetics may play an essential role in the disease process (Guthrie and Guthrie, 2004). The potential factors playing a role in Type 1 and Type 2 diabetes are summarised in Table 11.

Table 11: The potential factors playing a role in Type 1 and Type 2 diabetes (Deshpande et al., 2008; Forouhi and Wareham, 2014; Saeedi et al., 2019)

- Age	- Ethnicity
- Family history	- Low birth weight
- History of gestational diabetes	- Being sedentary
- Dietary intake; high intake of red and processed meat, drinks with added sugar, and reduced fruit and vegetable consumption	- Unknown factors; the intergenerational effects of hyperglycemia in pregnancy and aging

In conclusion, two main causes of diabetes mellitus are insulin deficiency and insulin resistance. In addition, age, family history, being physically inactive, dietary consumption, especially sugar, are also risk factors for diabetes.

2.3.1.5 Effects of diabetes mellitus

As noted earlier, diabetes is a metabolic syndrome that affects the metabolic process. Thus diabetes impacts on various organs, particularly, the eyes, kidneys, nerves, heart, and blood vessels (American Diabetes Association, 2014). This section will discuss the effects of diabetes mellitus on the body.

The common complications of diabetes include polyuria (excess urination), polydipsia (excess thirst), weight loss, polyphagia (excess hunger), and blurred vision (American Diabetes Association, 2014).

There are three types of complications, namely macrovascular, microvascular, and neurologic complications (Guthrie and Guthrie, 2004). Macrovascular complications consist of cardiovascular diseases, for example, heart attacks, strokes, and peripheral vascular disease. The pathogenesis of the diseases is similar to patients without diabetes; however, diabetes frequently accelerates progressive disease (Guthrie and Guthrie, 2004; Deshpande et al., 2008).

For microvascular and neurologic complications, the eyes and the kidneys are the organs most affected. Since vascular and nerve tissues are permeable to glucose without the presence of insulin, the glucose concentration inside cells will be equal with blood. When sugar levels in cells are too high, glucose is disposed of by three main mechanisms: the polyol pathway; enzymatic glycosylation; and non-enzymatic glycosylation (Guthrie and Guthrie, 2004). Although the body can diminish glucose levels, the mechanisms can cause side effects to the blood vessels and nerves. The processes initiate diabetic nephropathy, which leads to proteinuria, or protein leak into the urine. A similar abnormality occurs to the retina of the eyes by leakage of the fluorescein. In addition, it causes oxidative stress and cellular destruction (Guthrie and Guthrie, 2004). Microvascular and neurologic complications and consequences include chronic kidney disease, amputations of feet or toes, foot lesions, numbness in feet, retinopathy, decreased resistance to infections, and birth complications among diabetic mothers (Deshpande et al., 2008). Diabetes also impacts oral health; it increases the risk of dental caries, salivary gland dysfunction, oral infection, taste disturbance, gingivitis and periodontitis (Lamster et al., 2008). Table 12 below summarises the health consequences of diabetes.

Table 12: The health consequences of diabetes (Guthrie and Guthrie, 2004; Deshpande et al., 2008; Lamster et al., 2008; Skyler et al., 2017)

Macrovascular complications - Heart attacks, strokes, and peripheral vascular disease Microvascular and neurologic complications - Chronic kidney disease, amputation of feet or toes, foot lesions, numbness in feet, retinopathy, decreased resistance to infections, signs of premature arterial stiffening, birth complications among diabetic mothers, salivary gland dysfunction, oral infection, gingivitis, and periodontitis

On the whole, diabetes negatively affects various organs due to hyperglycaemia and glucose disposal processes. Oral health is also impacted by diabetes. The following section will discuss the association between diabetes and oral health.

2.3.2 Diabetes mellitus and oral health

As mentioned earlier, there are links between DM and oral health problems. This section will be divided into two subsections. First, the oral manifestations of diabetes which will be followed by dry mouth in diabetic patients.

2.3.2.1 Oral manifestation of diabetes mellitus

Diabetes mellitus develops due to insulin deficiency or insulin resistance. Diabetes leads to various complications in many organs, including the oral cavity. The causes that lead to oral health problems comprise neutrophil function impairment, increased collagenase activity, reduction in collagen synthesis, microvascular complications, and neuropathy (Rohani, 2019). The oral manifestations of diabetes are summarised in Table 13.

Table 13: The oral manifestations related to diabetes mellitus (Ship, 2003; Deshpande et al., 2008; Mauri-Obradors et al., 2017; Rohani, 2019)

− Dry mouth; xerostomia, SGH	− Benign parotid hypertrophy
− Dental caries	− Burning mouth syndrome
− Periodontal disease and gingivitis	− Taste disorders
− Geographic tongue and fissured tongue	− Pulp necrosis and periodontal abscess
− Neurosensory dysaesthesias	− Oral infections; oral candidiasis, rhinocerebral zygomycosis (mucormycosis), aspergillosis, oral lichen planus
− Delayed wound healing and increased incidence of infections following surgery	

Moreover, a systematic review was conducted by Mauri-Obradors et al. (2017) on the association between oral health and diabetes. Two reviewers selected studies published in English between January 1998 and January 2016 focusing on the oral manifestation of diabetes in MEDLINE, Cochrane, and other databases. Studies that met inclusion criteria had samples of at least 30 patients. Secondary data including, systematic reviews, and meta-analyses were excluded. Nineteen studies (four longitudinal, and 15 cross-sectional) were included (Table 14). The study included 3,712 participants, of which 2,084 had diabetes.

Table 14: Studies investigated the association between diabetes mellitus and oral diseases (Mauri-Obradors et al., 2017)

Author	Year	Country	Design	Sample		Oral diseases	Significant association with DM
				Total	Sex		
Petrou-Amerikanou et al.	1998	Greece	Cross-sectional	135 DM1 353 DM2 274 H	65M, 74W 127M, 225W 110M,164W	Mucosal lesion (Lichen planus)	Yes
Lin et al.	1999	USA	Cross-sectional	24 DM 18 H	10M, 14W 10M, 8W	Caries	Yes
Stolbova et al.	1999	Czech Republic	Cross-sectional	73 DM2 11 DM1 12 Obese 29 H	26M, 47W 4M, 7W 4M, 8W 6M, 23W	Taste disturbance	Yes
Guggenheimer	2000	USA	Cross-sectional	405 DM1 268 H	N/A	Mucosal lesion	Yes
Chavez et al.	2001	USA	Longitudinal 1 year	24 DM 15 H	10M, 14W 9M, 6W	Xerostomia	Yes
Pa et al.	2001	USA	Longitudinal 6-8 years	390DM1 202 H	199M, 191W 76M, 126W	Root caries	Yes
Miralles et al.	2002	Spain	Cross-sectional	30 DM1 30 H	N/A	Caries Mucosal lesion Periodontal disease	No No Yes
Kadir et al.	2002	Turkey	Cross-sectional	45 DM1,2 55 H	18M,27W 26M, 29W	Mucosal lesion (Candida)	Yes
Arrieta-Blanco et al.	2003	Spain	Cross-sectional	70DM 74H	30M, 40W 29M, 45W	Periodontal disease	Yes
Arrieta-Blanco et al.	2003	Spain	Cross-sectional	70 DM1,2 74 H	30M, 40W 29M, 45W	Caries	No
Fouad	2003	USA	Longitudinal 2 years	74* 464**	N/A	Periapical lesion	Yes
Carda et al.	2006	Spain	Cross-sectional	17 DM2 16 H	10M, 7W 8M, 8W	Xerostomia	Yes

H: Healthy, M: Men, W: Women, *: Teeth endodontic patients with DM, **: Teeth endodontic patients without DM

Table 14: Continued

Author	Year	Country	Design	Sample		Oral diseases	Significant association with DM
				Total	Sex		
Cristina de Lima et al	2008	Brazil	Cross-sectional	30 DM 30 H	11M, 19W 9M, 21W	Mucosal lesion	No
Lopez-Lopez et al.	2011	Spain	Cross-sectional	50DM2 50H	20M, 30W 22M, 28W	Periapical lesion	Yes
Wang et al.	2011	Taiwan	Longitudinal 2 years	49*	N/A	Periapical lesion	Yes
Sousa et al.	2011	Brazil	Cross-sectional	96 DM2 100 H	31M, 65W 27M, 73W	Mucosal lesion	No
Busato et al.	2012	Brazil	Cross-sectional	51 DM1 51 H	N/A	Xerostomia	Yes
Ivanoski et al.	2012	Macedonia	Cross-sectional	30 DM1 30 H	N/A	Xerostomia	Yes
Bharateesh et al.	2012	India	Cross-sectional	300 DM 300 H	186M, 114W, 180M, 120W	Caries	No

H: Healthy, M: Men, W: Women, *: Teeth endodontic patients with DM, **: Teeth endodontic patients without DM

As can be seen in Table 14, 14 studies found a significantly higher prevalence of oral diseases in diabetic patients than in controls. Xerostomia, altered taste, periodontitis, and periapical lesions were all found to be significantly more prevalent in diabetic groups than controls in every study. In contrast, the association between dental caries and mucosal lesions were mixed. Although the study revealed associations between diabetes and oral health problems, the findings may not be generalisable to other regions since the studies conducted mostly in the USA, Spain, and Brazil. The remainder were Taiwan, Macedonia, India, Greece, Czech Republic, and Turkey. Each country may have its own cultures as well as behaviours, and diabetes is related to behaviours. Although the systematic review did not mention other factors that might relate to oral health in diabetic patients, it has been reported that age, sex, income, or education level may relate to oral health in diabetic patients. This will be discussed below.

For example, Azogui-Levy et al. (2018) determined the association between oral health status and OHRQoL in diabetic patients. The study included outpatients in the diabetes outpatient unit of a university hospital in France. Those patients who were aged over 18 years with diabetes Type 1 or Type 2 and had received treatment in the unit within at least one year were invited to take part. Those in pregnancy, diagnosed with cognitive problems, not proficient in French and currently hospitalised were excluded. Three-hundred and sixteen participants (196 males, 120 females) with mean age 57 ± 15.4 years were included. The study collected sociodemographic characteristics (age, sex, education level and income) of the participants by interview with a trained investigator. OHRQoL was assessed by GOHAI questionnaire which contains 12 items, namely physical (eating, speaking, and swallowing), psychological (oral health concern, appearance concern, self-consciousness, and social withdrawal) and pain aspects (medication used to alleviate pain and oral discomfort). Each item had five options; “always”, “often”, “sometimes”, “seldom” and “never”; a higher score indicated better oral health. There had been no cut-off value for discrimination between good and poor oral health using GOHAI published in the literature, so the authors used a cut-off at 50 to separate participants into two groups: poor and moderate to high OHRQoL. Participants also had to self-report their oral status including missing teeth, use of removable dentures, bleeding during brushing, abscess, perceived need for treatment and received treatment. Oral health status was grouped as good and poor. Poor oral health was having at least one missing tooth and not replaced, bleeding during brushing and having an abscess during the past year.

The study revealed 65.5% working as employees, 48.2% graduated high school and higher, 30.3% had low income, 61.7% were diagnosed as diabetes Type 2, and 53.3% were diagnosed as having diabetes for more than ten years. The prevalence of poor oral health was 66.6%. The mean GOHAI score was 53.5 $\pm$ 7.6, and 24.6% of participants had a low GOHAI score. Low GOHAI scores were found more frequently among the unemployed, those with low income and a low level of education. The study also found that low GOHAI scores were significantly associated with being aged 40 - 60 years, aged more than 60 years, female, primary and high school graduated, low and average income, Hba1c below 9, Type 2 diabetes, poor oral health, xerostomia, and removable denture wearer. In sum, the study revealed that the GOHAI score was significantly associated with sociodemographic characteristics (sex, level of education, income) , diabetes characteristics (HbA1c level, type of diabetes, duration of diabetes) and dental characteristics (number of teeth, oral health perception, dry mouth, dental prostheses).

All things considered, diabetes has various effects on the oral cavity, including dry mouth. There have been reports of higher prevalence of oral problems such as periodontitis, periapical lesions, taste alteration, xerostomia, in diabetic patients than non-diabetic controls. In addition, other factors, for example, age, sex, income, or education level, may influence oral health in diabetic patients. The next section will discuss diabetes mellitus in relation to dry mouth.

2.3.2.2 Dry mouth in diabetic patients

As stated earlier, diabetes has a deleterious effect on the salivary gland resulting in salivary gland hypofunction and xerostomia. This part of the literature review will consider diabetes with dry mouth, including aetiology and prevalence.

Dry mouth has been reported as a common symptom of diabetes mellitus due to dehydration, polyurea, neuropathies, microvascular, and acinar cell change (American Diabetes Association, 2014; Rohani, 2019). Diabetes mellitus may also cause sialosis. Sialosis has been defined as non-inflammatory disease-causing bilateral swelling of the salivary glands. The enlargement generates by adipose infiltration or by acinar hypertrophy (Carda et al., 2006). Sialosis also may cause glandular dysfunction, and this leads to hyposalivation and xerostomia (Carda et al., 2006).

The prevalence of xerostomia in diabetic patients ranges from 20% to 76.4% (Sreebny et al., 1992; Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Busato et al., 2009; Khovidhunkit et al., 2009; Borges et al., 2010; Malicka et al., 2014), and 11.8% to 48% for SGH (Moore et al., 2001; Busato et al., 2009; Khovidhunkit et al., 2009; Borges et al., 2010; Lone et al., 2017) (Table 15). Diabetic patients have a higher prevalence of xerostomia than non-diabetic controls (Ben-Aryeh et al., 1993; Moore et al., 2001; Khovidhunkit et al., 2009; Malicka et al., 2014), with the same findings for hyposalivation prevalence (Moore et al., 2001; Khovidhunkit et al., 2009; Borges et al., 2010; Lone et al., 2017).

Table 15: The prevalence of xerostomia in diabetic patients

Author (Year)	Country	Sample				Assessment		Prevalence (%)		
		Population	Mean age	Total	Health status	Xerostomia	SGH	Xeros-tomia	SGH	Both
Sreebny et al. (1992)	USA	Outpatients from the Family Medicine and Diabetic Clinic	N/A	40	DM	Self-administered questionnaire included symptoms, functional impairment, and behaviour changes due to symptom relief. No data of diagnostic criteria.	Unstimulated and stimulated whole saliva	43.0	N/A	N/A
Ben-Aryeh et al. (1993)	Israel	Patients in the Diabetic Clinic	38.9 45.9 40.4	20 19 20	DM1 DM2 H	N/A	Unstimulated and stimulated whole, submandibular, and parotid saliva	20.0 25.0 15.0	N/A	N/A
Moore et al. (2001)	USA	Participants of the ongoing University of Pittsburgh "Epidemiology of Diabetes Complications" study	33.0 ± 0.4	406 268	DM1 H	Self-administered questionnaire: - "Does your mouth feel dry when eating a meal?" - "Do you have difficulty swallowing dry foods?" - "Do you sip liquids to aid in swallowing dry foods?" - "Does the amount of saliva in your mouth seem to be too little, too much, or you don't notice it?" Answer positive to at least one would be counted as xerostomia.	Unstimulated and stimulated whole saliva	24.1* 17.6	11.8U, 12.4S 2.7U, 5.5S	N/A

DM1: Diabetes mellitus type 1, DM2: Diabetes mellitus type 2, H1: Control for DM1, H2: Control for DM2
U: Unstimulated saliva flow, S: Stimulated saliva flow
*: Differences statistically significant $p < 0.05$, **: Differences statistically significant $p < 0.01$

Table 15: Continued

Author (Year)	Country	Sample: Population	Mean age	Total	Health status	Assessment: Xerostomia	SGH	Prevalence (%): Xerostomia	SGH	Both
Carda et al. (2006)	Spain	Patients in the Department of Pathology of the Clinic University Hospital and the Department of Maxillofacial Surgery of the "La Fe" of Valencia	26-86 26-86	17 16	DM2 H	Questionnaire: - "How would you describe the amount of saliva in your mouth?" - "Do you have sensation of dryness mouth?" - "Do you have trouble to swallow the meal?" - "Do you have the need drink to swallow the meal?" No data of diagnostic criteria.	N/A	76.4	N/A	N/A
Busato et al. (2009)	Brazil	Outpatients at the Diabetes Outpatient Department	14-19	56	DM1	Self-administered questionnaire, if they had a dry mouth during each day of the past 6 months, a positive response was diagnosed as xerostomia.	Stimulated whole saliva	52.9	40.8	N/A
Khovidhunkit et al. (2009)	Thailand	Ambulatory patients at the Endocrinology Clinic	63.0 ± 10.0 65.0 ± 10.0	154 50	DM2 H	Personal interview: - "Do you feel that your mouth is dry?" - "Do you have any difficulty eating dry foods?" - "Do you feel that your tongue sticks to the palate when you wake up in the morning?" No data of diagnostic criteria.	Unstimulated saliva using a modified Schirmer test	62^{**} 36	46^{*} 28	N/A

DM1: Diabetes mellitus type 1, DM2: Diabetes mellitus type 2, H1: Control for DM1, H2: Control for DM2
U: Unstimulated saliva flow, S: Stimulated saliva flow
*: Differences statistically significant $p < 0.05$, **: Differences statistically significant $p < 0.01$

Table 15: Continued

Author (Year)	Country	Sample				Assessment		Prevalence (%)		
		Population	Mean age	Total	Health status	Xerostomia	SGH	Xeros-tomia	SGH	Both
Borges et al. (2010)	Brazil	Non-institutionalised functionally independent individuals	70.5 ± 7.1	52	DM2	Self-administered questionnaire; - "Do you have a constant sensation of dry mouth?" - "Do you feel the need to ingest liquids during meals?" Participants who answered "yes" to both questions were counted as xerostomia	Unstimulated and stimulated whole saliva	25	48U 46S	N/A
Malicka et al. (2014)	Poland	Not mentioned	37.5 65.0 37.0 63.7	34 59 30 33	DM1 DM2 H1 H2	Self-administered questionnaire included symptoms, functional impairment, and behaviour changes due to symptom relief; No data of diagnostic criteria	Unstimulated whole saliva	23.5* 25.4* 10.0 21.2	DM1 vs DM2 DM1 vs H1** DM2 vs H2	N/A
Lone et al. (2017)	Pakistan	Patients at primary health-care centre	60-70	70 40	DM H	Included only patients with xerostomia	Unstimulated whole saliva	100	70 30	N/A

DM1: Diabetes mellitus type 1, DM2: Diabetes mellitus type 2, H1: Control for DM1, H2: Control for DM2
U: Unstimulated saliva flow, S: Stimulated saliva flow
*: Differences statistically significant $p < 0.05$, **: Differences statistically significant $p < 0.01$

As can be seen in Table 15, the wide range of xerostomia prevalence and salivary gland hypofunction prevalence might be due to the different measures used in each study, which was discussed in the previous section. Four studies showed xerostomia prevalence ranging from 20% to 25% in diabetic patients. All of these studies used self-administered questionnaire to examine xerostomia apart from Ben-Aryeh et al. (1993), who did not give detail about their measurement. Moore et al. (2001) in their study in the USA, diagnosed xerostomia if participants had at least one of the following symptoms: 1) Perceived dry mouth during eating 2) Sipped liquid to aid swallowing dry food, or 3) Felt amount of saliva seemed to be little, reported a prevalence of xerostomia of 24.1%. While Borges et al. (2010) in Brazil diagnosed xerostomia when participants had mouth dryness symptom and had to drink to aid eating and swallowing, and found a xerostomia prevalence of 25%. In addition, Malicka et al. (2014) in Poland revealed the prevalence of xerostomia at 23.5% for Diabetes Type 1 and 25.4% for Diabetes Type 2. The study examined xerostomia by asking whether participants had symptoms, functional limitation, and behavioural changes due to xerostomia, however, the study did not describe diagnostic criteria.

Interestingly, three studies reported much higher prevalence of xerostomia at around 50% in diabetic patients. The study in the USA by Sreebny et al. (1992) used mouth dryness symptoms, functional limitation, and behavioural changes to examine xerostomia, but the study did not report diagnostic criteria. The study found 43% xerostomia prevalence. Busato et al. (2009) studied in Brazil and found 52.9% of participants had perceived dry mouth symptoms in the previous six months. In addition, Khovidhunkit et al. (2009) found 62% xerostomia prevalence in Thailand. The study used the feeling of dry mouth, difficulty in eating and sticking tongue to the palate to determine xerostomia, but did not report diagnostic criteria. Carda et al. (2006) also investigated the prevalence of xerostomia. The study asked participants to answer if they had the sensation of mouth dryness, difficulty in swallowing, drinking to help swallowing, and described the amount of saliva without reporting diagnostic criteria. The study found 76.4% of xerostomia prevalence in diabetic patients. The higher prevalence of xerostomia reported might be because in these three studies participants were asked whether they had dry mouth sensations as part of the diagnosis. Others merely used functional limitation as the criterion for xerostomia.

For SGH, studies examined unstimulated whole saliva and found the prevalence of hyposalivation ranged from 11.8% to 70% (Moore et al., 2001; Khovidhunkit et al., 2009; Borges et al., 2010; Lone et al., 2017). For stimulated whole saliva, the studies found the prevalence of hyposalivation ranged from 12.4% to 46% (Moore et al., 2001; Busato et al., 2009; Borges et al., 2010).

Overall, studies have shown those with diabetes presented with a higher prevalence of xerostomia (Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Khovidhunkit et al., 2009; Malicka et al., 2014), and SGH than non-diabetic controls (Moore et al., 2001; Khovidhunkit et al., 2009; Lone et al., 2017), regardless of the measurement tool used, type of diabetes and across different countries. As such, it is possible to conclude those with diabetes are more likely to report dry mouth compared to those without.

To illustrate, a study investigated the prevalence of xerostomia and hyposalivation by Malicka et al. (2014) in Poland. The study separated participants into four groups: 34 participants with diabetes Type 1 (T1DM, mean age 37.5 years), 59 participants with diabetes Type 2 (T2DM, mean age 65.0 years), 30 healthy participants (H1, mean age 37.5 years) and 33 healthy participants (H2, mean age 63.7 years). Diabetic groups were subdivided into well-controlled, and poor-controlled groups (A1, A2 refers to well-controlled diabetes Type 1 and 2, respectively and B1, B2 refers to poor-controlled diabetes Type 1 and 2, respectively), were also subdivided into patients with history of diabetes less than ten years and more than ten years groups (D1, D2 refers to history of diabetes Type 1 and 2 less than ten years, respectively and E1, E2 refers to history of diabetes Type 1 and 2 more than ten years, respectively). The study assessed xerostomia by using questionnaires that covered symptoms, limited function, and behaviour changes due to mitigating symptoms of dry mouth. The study revealed that xerostomia prevalence of T1DM (23.5%) was significantly higher than H1 (10.0%) but there was no difference between T2DM (25.4%) and H2 (21.2%), also no difference between T1DM and T2DM as well as H1 and H2.

In addition, unstimulated whole saliva flow rate was examined during the morning. The study showed that the salivary flow rate of T1DM (0.38 ± 0.19) was significantly lower than H1 (0.50 ± 0.20) but not different to T1DM and T2DM (0.36 ± 0.21) as well as T2DM and H2 (0.45 ± 0.25). The authors did not find significant differences in xerostomia prevalence among A1, A2, B1, B2, and observed similar salivary flow rates in these groups.

In sum, the study showed a significantly higher prevalence of xerostomia in participants with diabetes Type 1 than healthy participants group 1 yet did not find significant differences in salivary flow rate in any group. Interestingly, participants with diabetes Type 2 and healthy participants group 2 were older adults, and the xerostomia prevalence of the two groups was similar to participants diabetes Type 1, suggesting that age might be a confounder. Participants with diabetes Type 1 and 2 had lower salivary flow rates than healthy participants. This might be due to pathogenesis of chronic hyperglycaemia leading to SGH.

Sreebny et al. (1992) investigated the xerostomia prevalence in 40 diabetic out-patients. They studied the difference in salivary flow rates and dry mouth symptoms between diabetic and non-diabetic groups. The study reported the mean resting flow rate of 0.12 ± 0.14 ml/min for the diabetic group was lower than the normal reference range (0.3 - 0.4 ml/min). The mean stimulated salivary flow rate was in the normal reference range. The prevalence of hyposalivation in the diabetic group was 58% and 35% for resting and stimulated saliva, respectively. Further, the study found a significantly positive correlation between unstimulated and stimulated salivary flow rates and xerostomia prevalence was 43%, 82% of which were women. There were no significant differences between age, type of diabetes, or duration of diabetes. However, the mean salivary flow rates in the control group were higher than the diabetic group for both resting and stimulated saliva. Of special interest was the flow rates in the non-xerostomia diabetic group were similar to those in the xerostomia non-diabetic group.

In Thailand, a study by Khovidhunkit et al. (2009) interviewed 194 (154 with diabetes type 2 and 50 without diabetes), age 20 years, who attended the Endocrinology Clinic of the King Chulalongkorn Memorial Hospital, Bangkok. The study assessed xerostomia using the questions; "Do you feel that your mouth is dry?" "Do you have any difficulty eating dry food?" and "Do you feel that your tongue sticks to the palate when you wake up in the morning?". Participants who responded positively to at least one question were defined as having xerostomia. The prevalence of xerostomia was 62% of the diabetic group, which was significantly greater than the control group (36%). A modified Schirmer test (MST) was used to examine unstimulated salivary flow. Saliva was collected between 8 - 12 in the morning and participants were asked to avoid taking food and beverage 2 hours before collecting saliva. Hyposalivation was diagnosed using the cut-off MST value of less than, or equal 25 ml at 3 min, the study reported a SGH prevalence of 46% which was significantly higher than the control group (28%). Interestingly, the mean MST value in diabetic patients was lower than healthy participants. This is the only study that examined xerostomia and hyposalivation in diabetic patients in Thailand.

In sum, diabetic patients tend to have a higher prevalence of xerostomia and SGH and lower salivary flow than those without diabetes. Dry mouth and subsequent associated problems, including dental caries, difficulty in chewing, swallowing, and speaking can influence the QoL of these patients, which will be considered in the next section.

2.3.2.3 Impact of dry mouth on OHRQoL in diabetic patients

As stated earlier, dry mouth is a prominent oral health problem among diabetic patients, which leads patients to encounter numerous difficulties in daily life, including both clinical and social problems. All of these can lead to poorer QoL. To date, there have been two studies that have investigated dry mouth and its impact on OHRQoL in those with diabetes (Table 16) (Busato et al., 2009; Molania et al., 2017).

Table 16: Studies investigated dry mouth and OHRQoL in diabetes

Variables / Authors	Busato et al. (2009)	Molania et al. (2017)
Country	Brazil	Iran
Number	51	200
Mean age	17.2 ± 1.3	56.4 ± 13.1
Type of DM	Type 1	Type 2
Assessment of OHRQoL	OHIP-14 (Likert scale 0-4; never to always)	OHIP-14 (Likert scale 1-5; never to always)
OHIP-14 score	5.2 ± 4.5	38.1 ± 7.8
Xerostomia (%)	52.9	100 (Inclusion at the beginning)
Xerostomia assessments	Interview: “Dry mouth during the day over the last 6 months?” “Yes” responses were diagnosed as xerostomia.	Interview: “Dry mouth during the day over the last 6 months?” “Yes” responses were diagnosed as xerostomia.
Hyposalivation (%) (SSFR ≤ 0.7 mL/min)	40.8	56.0
Stimulant	Mastication	Suction
Amount of saliva referred		
Low	9.8	68.5
Normal	90.2	31.5
Difficulty in swallowing		
Yes	5.9	48.0
No	94.1	52.0
Need to drink		
Yes	23.5	36.0
No	76.5	64.0

OHRQoL = Oral health related-quality of life; OHIP-14 = Oral Health Impact Profile (14 items).
SSFR = Stimulated salivary flow rate

As can be seen in Table 16, the studies were conducted in Brazil and Iran in Type 1 and Type 2 diabetes, respectively. The age of participants in the two studies is different due to diabetes Type 1 being diagnosed in adolescents, while diabetes Type 2 is typically diagnosed in adults. Both used OHIP-14 with five Likert scales to assess OHRQoL, but different in the number of each scale. Busato et al. (2009) used number 0 to 4 to represent each point of scale, while Molania et al. (2017) used 1 to 5. In Busato et al. (2009), patients with diabetes Type 1 were asked by a closed-ended question about dry mouth symptoms in the past six months. Positive responses were categorised as xerostomia and found 52.9% presented with xerostomia; 9.8% of participants perceived low amounts of saliva, 6% reported swallowing problems, and 23.5% had to drink water during meals. There were no statistical differences between patients with and without xerostomia among these questions. The study found a prevalence of hyposalivation of 40.8% and no difference between patients with and without xerostomia. In addition, there were no statistical differences in sex, age, duration of diabetes, glucose levels, HbA1C levels, and salivary flow rates between patients with and without xerostomia.

In contrast, the authors found statistical difference in OHIP-14 score between patients with and without xerostomia, 7.0 ± 5.0 and 2.7 ± 2.0 respectively. It can be concluded that patients with xerostomia have worse OHRQoL than patients without xerostomia. The OHIP-14 score at seven meant the dry mouth has negative impacts on OHRQoL. The domains that showed marked adverse effects were difficulty in speaking, pain in the oral cavity, stress and hard to relax, feeling embarrassed, a bit shy with others, irritated usual jobs, and unhappy with overall life.

Molania et al. (2017) studied those with diabetes Type 2 and reported similar results. The study only included patients with xerostomia; of which, 56% had hyposalivation. The authors collected stimulated salivary flow rate in the same way as Busato et al. (2009), except they used a suction method instead of mastication to stimulate salivary secretion. The responses to the three questions; perceived low amount of saliva, difficulty in swallowing and need to drink during meals, were greater than Busato et al. (2009), 68.5%, 48.0% and 36.0%, respectively. The authors also found statistical differences in responses between hyposalivation and non-hyposalivation participants. In addition, there were statistically significant differences in stimulated salivary flow rate and HbA1C level between patients with and without hyposalivation.

However, age, sex, diabetic duration, and glucose levels were not significantly different between hyposalivation and non-hyposalivation patients. The study also found that there was no marked difference in OHIP-14 scores between hyposalivation and non-hyposalivation patients. The mean OHIP-14 score was 38.1 ± 7.8, which was based on the rating scale 1 - 5 for each domain. Calculating the mean OHIP-14 score based on 0 - 4 rating scale, the mean OHIP-14 score would have been 8.7, which represented a similar result to Busato et al. (2009). Although the study did not find a significant difference between hyposalivation and non-hyposalivation patients, the study only included patients with xerostomia, and it revealed that xerostomia had a negative impact on OHRQoL.

In conclusion, the two studies, Busato et al. (2009) and Molania et al. (2017), have shown the negative effect of dry mouth on OHRQoL in diabetic patients. Even though the two studies investigated in many different ways the type of diabetes, age range, and countries, the results were somewhat similar. It can therefore be concluded that dry mouth can have negative effects on OHRQoL in diabetic patients. To date, however, there have been few studies in this area and further research for understanding the impact of dry mouth in diabetes is urgently required to improve patient care.

2.3.3 Other factors relating to the QoL in diabetic patients

Diabetes mellitus is a chronic disease. As mentioned earlier, there have been reports of the consequences of diabetes to general and oral health, which have negative effects on QoL. There are a large number of factors related to the QoL in diabetic patients, which have been summarised in Table 17.

Table 17: Factors associated with QoL in diabetic patients (Glasgow et al., 1997; Rubin and Peyrot, 1999; Goldney et al., 2004; Schram et al., 2009)

Sex	Treatment regimen (exercise, oral medications, insulin)
Age	Depression
Education level	Glycemic control
Income level	Number of diabetes complications
Living situation (alone or with another)	Number of comorbid diseases
Health insurance	Number of times hospitalised
Type of diabetes	Duration of diabetes
Psychosocial factors (health beliefs, social support, coping strategies, personality traits, locus of control, self-efficacy)	

As can be seen in Table 17, numerous factors influence the QoL in diabetic patients, for example, patient characteristics, socioeconomic status, and disease status. Therefore, all aspects should be considered in any study of the QoL of diabetic patients.

2.3.4 Conclusions

Diabetes mellitus is a chronic metabolic syndrome that is linked to a high blood sugar level. Global incidence of diabetes is increasing due to lifestyle factors such as, higher sedentary lifestyles, high intake of energy-dense foods and increasing prevalence of overweight/obesity, which are risk factors for Type 2 diabetes. There have been various consequences of diabetes reported in the literature including polyuria, polydipsia, weight loss, polyphagia, and blurred vision. Diabetes also leads to other diseases, for example, heart attacks, strokes, and peripheral vascular disease. For oral health, there have been reports of the association between diabetes and oral problems such as dry mouth, dental caries, gingivitis, periodontitis, delayed wound healing, and oral infections. Dry mouth is a common symptom of diabetes. The studies to date have reported more frequent dry mouth symptoms in diabetic patients compared to those without and that dry mouth can cause poorer QoL in diabetic patients, yet there have been few studies conducted in this area. In Thailand, specifically, there has been no study in relation to dry mouth and OHRQoL in diabetes. Therefore, further investigations are required to gain knowledge and understand about dry mouth and OHRQoL in diabetic patients. In the next section, OHRQoL will be discussed.

2.4 Oral health-related quality of life

As mentioned previously, dry mouth and diabetes can have negative consequences which impact on individual's physical, functional, psychological, and social well-being. All of which might, in turn, lead an individual to experience worst QoL. This section will discuss OHRQoL; definitions of QoL, health-related quality of life (HRQoL), and OHRQoL. Following this, the most commonly used models within OHRQoL life research will be discussed.

2.4.1 Definitions

QoL has been described in many different ways. Overall, QoL is defined as the individual's life satisfaction, where persons appraise their current status compared to their expectations (Cella, 1994; Allen, 2003). QoL is a multidimensional concept. The multidimensionality of QoL covers physical, functional, emotional, psychological, and social well-being (Cella, 1994). QoL is also influenced by individual ideas, opinions, feelings, and experiences (Cella, 1994; Locker and Allen, 2007). Since individual expectations, attitudes, feelings, and experiences vary over time, QoL is seen as a dynamic construct (Cella, 1994; Allen, 2003).

HRQoL is the one concept of the QoL that particularly focuses on health (Robinson et al., 2015). In general, HRQoL is described as the consequences of medical conditions as any illness, injury, or disease as well as treatments that impact upon a person's life satisfaction (Robinson et al., 2015; Robinson, 2016). Although HRQoL is focused on health, other factors are also included as some can influence health, for example, income, education, age, social supports, and the healthcare system (Ferrans et al., 2005; Robinson et al., 2015; Robinson, 2016).

For OHRQoL, the definition is similar to HRQoL, but the key 'target' has changed from health to oral health (Robinson et al., 2015). Therefore, OHRQoL is the concept of the oral health which includes oral disorders, diseases, conditions, and treatment impacting on health, well-being, and life fulfilment (Baker, 2007b; Locker and Allen, 2007; Robinson et al., 2015). OHRQoL has become a crucial tool to determine the effect of oral health on well-being as well as on clinical outcomes (Baker, 2007b).

In sum, QoL is the individual's life satisfaction which the individuals rate themselves. There are many factors that influence QoL, for example, expectations, experiences, economics, and education (Cella, 1994; Allen, 2003; Robinson et al., 2015; Robinson, 2016). For HRQoL and OHRQoL, the focus has shifted to health and oral health that impact on physical, functional, emotional, psychological, and social well-being. These also depend on expectations, experiences, and environments (Robinson et al., 2015; Robinson, 2016). QoL is thus an individual, patient's perspective, and is dynamic over time. The OHRQoL concept will be utilised and applied in this study, which aims to determine the impacts of dry mouth on the well-being of diabetic patients. The next section will describe frequently used models in OHRQoL.

2.4.2 Conceptual models of oral health-related quality of life

As stated earlier, OHRQoL is a multidimensional construct which includes physical, functional, emotional, psychological, and social well-being (Cella, 1994). Further, there are individual and environment factors that influence it, such as sense of coherence, self-esteem, health locus of control, education, or income (Baker et al., 2010).

As OHRQoL is a complex and multidimensional construct, it has been suggested that a QoL study should be guided by a conceptual model that can clarify the relationship among its different aspects (Ojelabi et al., 2017), as well as help to formulate appropriate research questions and hypotheses (Baiju et al., 2017). Robinson et al. (2015) suggested that a conceptual model can be utilised in four ways. First, it can be used as an explanatory tool, as it helps to explain causal relationships among various variables. Second, the model can help formulate study hypotheses and predict probable outcomes of oral diseases. Third, the model can help guide action and/or investigation through further study. Fourth, the model can be used as a framework to guide statistical analysis and to help estimate the power of the effects amongst variables.

To date, there are three main conceptual models which have been used within OHRQoL research, namely Locker (1988), the International Classification of Functioning, Disability and Health (ICF) (2001), and the Wilson and Cleary model (1995). This section will introduce the three models.

2.4.2.1 Locker's conceptual model

Locker's conceptual model operates on a combination of diseases, individual, and society (Robinson et al., 2015). Locker (1988) proposed that oral conditions impact on individuals in five main ways namely impairment, functional limitation, pain and discomfort, disability, and handicap as illustrated in Figure 1 (Allen, 2003; Baker, 2007b; Robinson et al., 2015).

The model can be applied to understanding dry mouth as follows; the condition refers to a disease, infection or trauma that leads organs to anomalies and impairment. In relation to dry mouth, the condition refers to salivary gland hypofunction. The impairment is the state of having conditions that part of the body cannot work correctly, for example, in relation to dry mouth this would be reduced salivary secretion and decreased salivary flow rate. The impairment contributes, in turn, to discomfort and pain, functional limitation, disability as well as handicap. Discomfort and pain are the symptoms that include physical and psychological conditions reported by patients such as xerostomia or burning sensation. Functional limitations are restrictions to carrying out tasks in the usual way, such as difficulty in mastication, swallowing, and pronouncing words. These functional limitations and pain can cause individual disability in performing routine activities of daily living, for instance, in relation to dry mouth, difficulty in speaking and eating, or sleep deprivation. All of these may, eventually over time, lead to handicap. Handicap is the limitation in individual's social role such as having work difficulties due to it being burdensome to drink water all the time, avoiding eating with others because of limitations in having to liquify food (Allen, 2003; Baker, 2007b; Robinson et al., 2015).

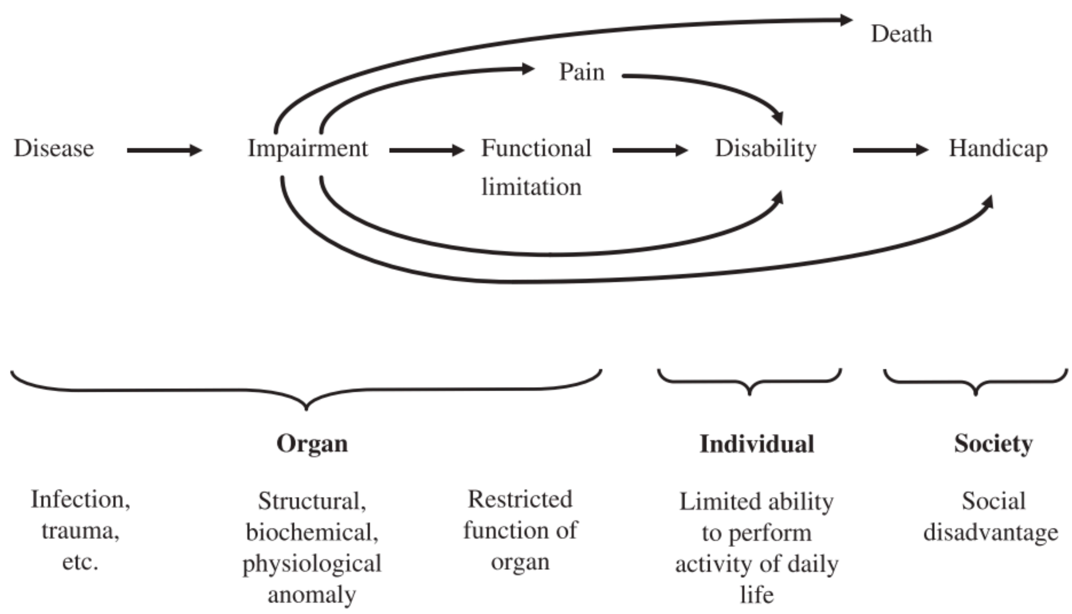


Figure 1: Locker’s conceptual model (Copyright from Robinson et al. (2015))

Locker’s conceptual model has focused upon the individual as a whole; that is, the model considers not only the abnormal organ (e.g., salivary glands) but also the patient’s perspective; pain and discomfort, functional limitations, disability, and social disadvantage. Thus, the model helps understanding of the causal relationships between conditions and patient-reported outcomes (pain and discomfort, functional limitations, disability, and handicap) . However, Locker’s model does not include contextual factors, for example, those individual and environmental factors that are known to influence people’s experiences of their (oral) health conditions (Locker and Quinonez, 2011; Baiju et al., 2017) e.g. age, income, or self-esteem. Many of these factors are known to be interrelated with health including adjustment to a health condition, coping and longer-term outcomes (Ferrans et al., 2005; Baiju et al., 2017). Without an understanding of these key contextual factors, the model will not adequately represent the patient’s health experience or its impact.

2.4.2.2 The International Classification of Functioning, Disability and Health (ICF)

The International Classification of Functioning, Disability and Health (ICF) (2001) is an amended and further developed version of the International Classification of Impairment, Disability and Handicap (ICIDH) (1980) (WHO, 2001). ICIDH forms the basic principles for the conceptual framework of HRQoL. ICIDH combines the two approaches: biomedical and social approaches. However, ICIDH rather focuses on the individual level and does not consider the environmental variables; ICF was therefore developed to further develop the role of environmental variables in relation to HRQoL (WHO, 2001).

ICF is the framework of health that is based on performing function (WHO, 2002a). The model provides the function which covers body function, activity, and participation as results of the conceptual link between health conditions and contextual factors as shown in Figure 2 (WHO, 2001; WHO, 2002a).

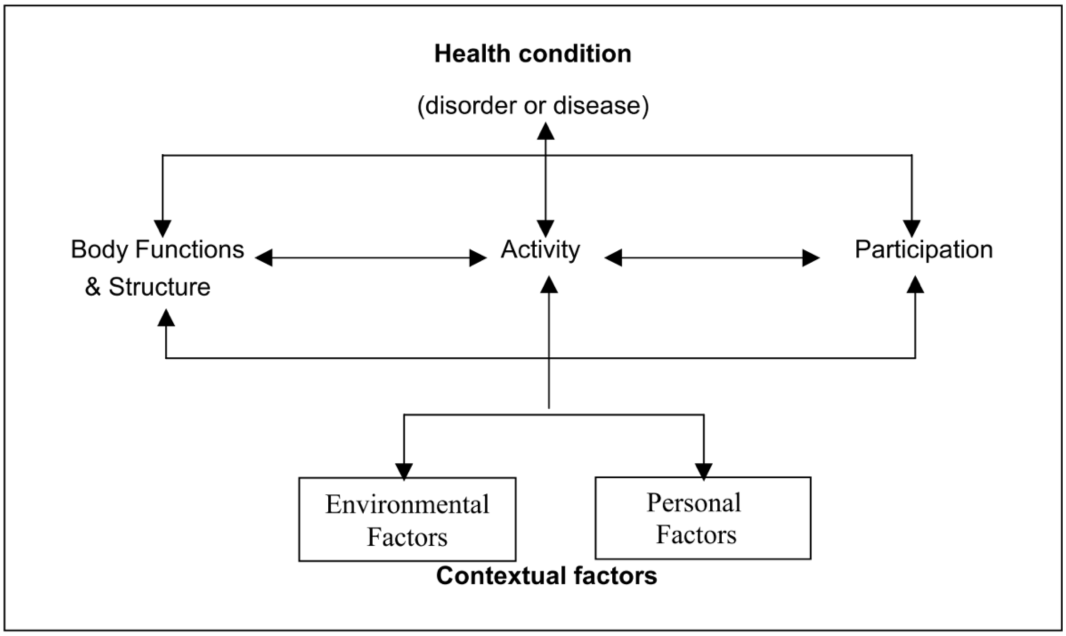


Figure 2: ICF conceptual model (Copyright from WHO (2002a))

As can be seen in Figure 2, function is divided into three levels: body functions and structure (organs), activity (person), and participation (society). Organ level focuses on the functions of organs and body systems including both physiological and psychological functions (e.g., salivary gland hypofunction, xerostomia). Personal level is the performing tasks or activities by an individual (e.g., slurred speech, taste alteration). Social level is the ability to take part in society (e.g., avoid eating with others due to ashamed of eating habits, lack of saliva leading to poor retention of denture resulting in lesser confidence in various social settings). Further, the model also combines contextual factors which are environmental and personal factors. The environmental factors are the conditions which people live and have activities, social attitudes, architectural characteristics, or policy, for instance. For personal factors, the factors are internal personality and inner self, such as age, sex, education, experience, or coping skills (WHO, 2002a).

In sum, the ICF framework indicates the outcomes of health status as functions at different levels. The ICF also considers contextual factors that might influence individual functions, which is the obvious difference between the ICF and Locker model. Nevertheless, the ICF model specifically focuses on health status but does not include QoL which is the one important outcome. Health status and QoL might not be consistent as QoL also depends on a person's expectations. Therefore, persons who have poor health status might have good QoL. The ICF model thus seems to lack the vital factor of QoL. It also emphasises the classification and family of diseases rather than being a guide to examine the proposed conceptual framework (Baiju et al., 2017).

2.4.2.3 Wilson and Cleary model

The Wilson and Cleary model (1995) combines clinical and psychosocial approaches to health care (Robinson et al., 2015; Ojelabi et al., 2017). The model also considers cultural, environmental, and psychosocial factors that might affect an individual (Allen, 2003). Importantly, the model is simple to understand and could be utilised with all individuals, diseases, and cultures (Ojelabi et al., 2017).

In the Wilson and Cleary (1995) model, the dominant causal associations between five domains are depicted as in Figure 3. The five domains consist of biological and physiological variables, symptom status, functional status, general health perceptions and overall QoL. Firstly, biological, and physiological variables focus on cells and their function (e.g., SGH). Secondly, symptoms change focus from specific organ to person. Symptoms represent subjective perception, experiences, emotional or cognitive status (e.g., xerostomia, having to sip water to aid in swallowing, choking, gagging, bad breath, bad taste). The researcher should always consider that some physiological abnormalities might not present as symptoms and, in contrast, some symptoms related to disorders might not present as physiological abnormality. Thirdly, functional status is defined as the ability to do tasks and roles which include physical and mental as well as the person's performance (e.g., difficulty in eating, being annoyed, problems with eating in restaurants). Fourthly, general health perception is a summary of how a person judge's their health (e.g., overall perception of an individual's oral health). Finally, overall QoL represents an individual's overall life satisfaction which is unstable as satisfaction depends on a person's expectations and aspirations as circumstances change. Overall QoL is influenced not only by health but also many nonmedical factors (e.g., policy, healthcare services, insurance) (Wilson and Cleary, 1995; Robinson et al., 2015; Ojelabi et al., 2017).

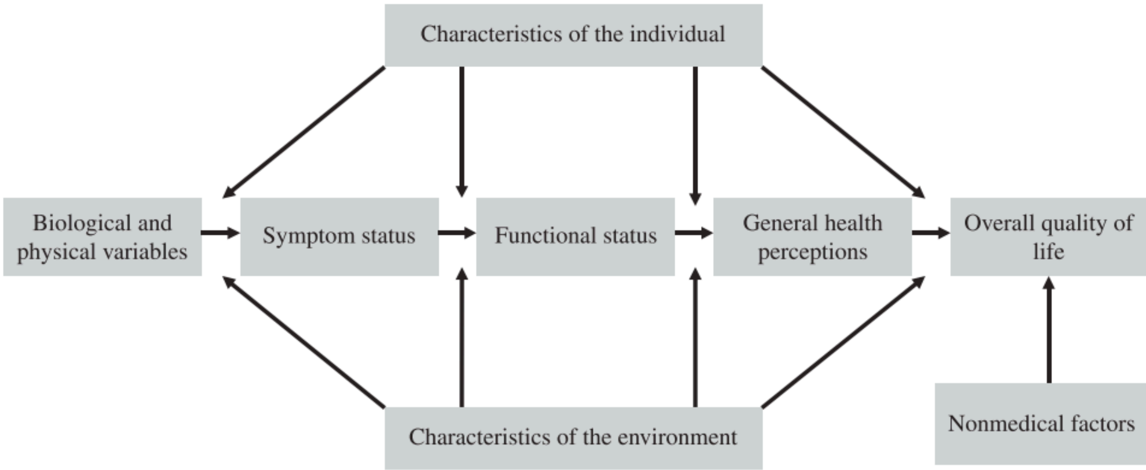


Figure 3: Wilson and Cleary model (Copyright from Robinson et al. (2015))

As shown in the Figure 3, there are arrows between the factors. The arrows refer to causal relationships among the variables. Wilson and Cleary proposed a linear indirect relationship between abnormal conditions (biological and physical variables) and overall QoL. This relationship is via symptoms, functioning, and general health perceptions (Robinson et al., 2015). For dry mouth, it would therefore be hypothesised that the effects of SGH on OHRQoL and well-being is via the perception of symptoms, impacting on functioning, and worse health perceptions. To date, there have been studies which have found a link between nonadjacent factors (Baker et al., 2007; Baker et al., 2010; Gururatana et al., 2014), and a bidirectional relationship has been suggested, for example, the functional limitations such as difficulty in brushing can lead to periodontitis and adverse symptoms (Robinson et al., 2015; Ojelabi et al., 2017). In addition, the relationship is also influenced by a range of individual (e.g. sense of coherence, health locus of control, self-esteem, and oral health beliefs) and environmental factors (e.g. social support systems, cultural tradition, workplace) (Wilson and Cleary, 1995; Ferrans et al., 2005; Baker et al., 2010; Gururatana et al., 2014; Robinson et al., 2015).

The Wilson and Cleary model has been utilised throughout the health literature. Ojelabi et al. (2017) conducted a systematic review of the use of the Wilson and Cleary model in chronic disease studies. The authors found 26 studies across 15 countries: the USA, Norway, Canada, the Netherlands, Thailand, UK, France, Austria, Sweden, Brazil, Hong Kong, Botswana, Lesotho, South Africa, and Swaziland. The total number of participants was 11,849, with a mean age of 50.5 years. These studies employed the Wilson and Cleary model in various chronic diseases including heart failure/ surgery, HIV/ AIDS, coronary artery disease, oral diseases, obesity, chronic obstructive pulmonary disease and asthma, diabetes, Hodgkin's lymphoma, kidney, Pompe disease, generalized anxiety disorder and stroke.

Ojelabi et al. (2017) found evidence to support the hypothesised relationships depicted in the Wilson and Cleary model. The studies presented the adjacent and non-adjacent linkage, as depicted in Figure 4. The numbers alongside each pathway represents the number of studies that have demonstrated support for that association.

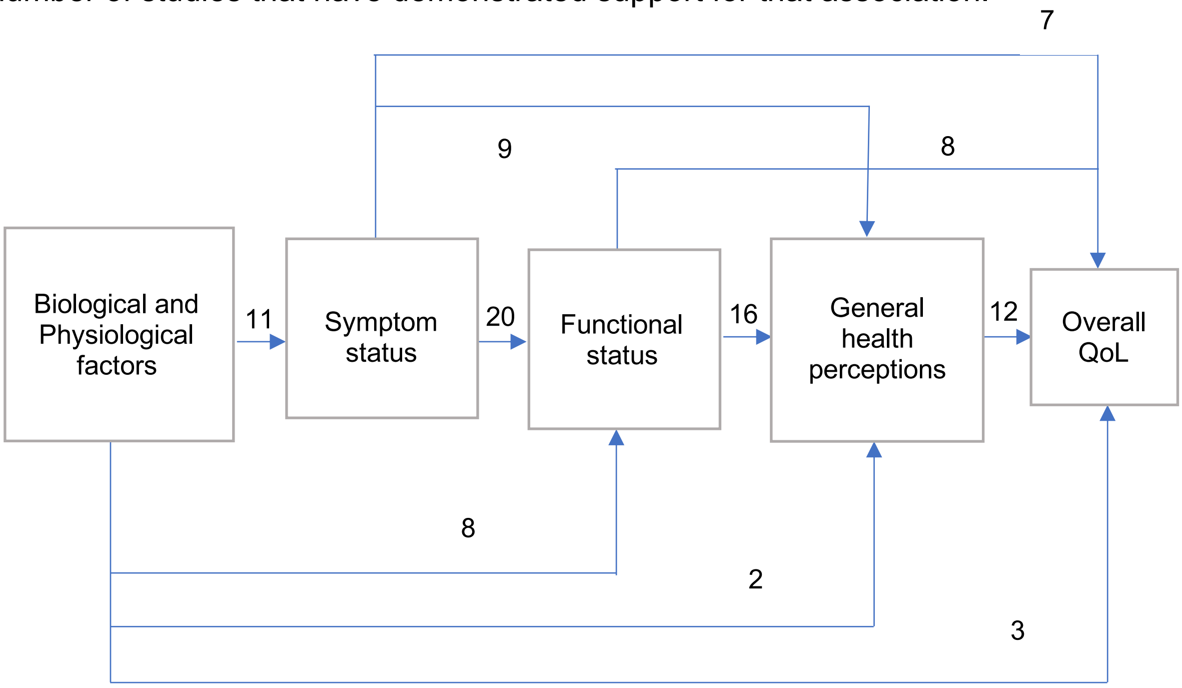


Figure 4: Adjacent and non-adjacent linkages in the Wilson and Cleary model (Copyright from Ojelabi et al. (2017)).

As can be seen in Figure 4, the proposed conceptual framework in the Wilson and Cleary model was supported by the studies in the systematic review, particularly associations between adjacent levels. In addition, Ojelabi et al. (2017) showed the model's application in various countries which demonstrates its utility across different cultures and contexts and that it is appropriate across a range of chronic diseases, including oral diseases.

However, Ojelabi et al. (2017) pointed out that the variability of diseases, health status, and measurements in the studies may have affected the findings. Also, the individual and environmental variables related to different diseases may have important but varying effects that need to be understood in greater detail. The authors suggested that further study is required to understand the important variables relevant to each disease.

In summary, the three conceptual models are underpinned by a biopsychosocial approach to health, which considers the patient viewpoint and the whole person rather than just disease processes and the somatic symptoms (e.g., a biomedical approach). The models have suggested relationships between abnormal conditions and adverse consequences for the individual. However, Locker's model does not consider the individual and environmental factors while the ICF framework combines these factors, but does not include QoL, or well-being. While the Wilson and Cleary model emphasises the main variables, biological and physiological variables, symptom status, functional status, general health perception, and overall QoL. The model is therefore simple and comprehensive. In addition, the model treats an individual as a whole body and mind including cultural and social contexts which leads to a holistic approach to understanding overall health and well-being. This study will use the Wilson and Cleary model as a guide to explore the associations between dry mouth in diabetic patients and its impact on functioning, health perceptions and overall well-being. The next section will give examples of the studies to date that have used the Wilson and Cleary model in relation to oral health.

2.4.3 Wilson and Cleary model with oral health

The Wilson and Cleary model has been applied in oral health research (Robinson et al., 2015; Ojelabi et al., 2017) in an attempt to have a comprehensive understanding of the impact of diseases on the daily lives and well-being of patients. Several studies have applied the Wilson and Cleary model to oral health (Table 18).

Table 18: Example studies using Wilson and Cleary model in oral health

Authors	Country	Design	Oral health condition	Samples				Assessment	Key findings
				Population	Age	Sex	Total		
Baker et al. (2007)	UK	Cross-sectional study (Secondary data)	Xerostomia	Outpatients at rheumatology, liver, pain management, oral medicine, speech and language, and Sjogren's syndrome clinics at two London hospitals	59.8±11.5	Male Female	20 65	- Salivary flow and clinical signs[1] - XI[2,a] - OHIP-14[3,b] - Global oral health rating of the patient's overall perception of their oral health[4] - HADS[5,c]	Findings have supported the Wilson and Cleary model; details will be discussed in the following section.
Baker et al. (2008)	UK	Longitudinal study (Secondary data)	Edentulism	Patients at Community Dental Service	80.0±8.4	Male Female	32 101	- Chewing difficulty, eating impact and perceptions of dry mouth[2] - OHIP[3,d] - Two single-item ratings of global health and oral health[4]	- The study has supported the Wilson and Cleary model. - The study found direct effects between variables; symptom status – functional status, functional status – global oral health perceptions. - The study also revealed indirect effect; symptom status – global oral health perceptions, mediated by functional status.

Assessment for; [1]: Biological and Physical variables, [2]: Symptom status, [3]: Functional status, [4]: General health perception, [5]: Overall quality of life, [6]: Individual factors

[a]: Xerostomia Inventory, [b]: Short version of the oral health impact profile, [c]: Hospital Anxiety and Depression Scale, [d]: Oral health impact profile,
[e]: Child Perceptions Questionnaire, [f]: Sense of coherence, [g]: Dental Coping Beliefs Scale, [h]: Socio-economic status, [i]: Decayed, missing and filled teeth index,
[j]: Geriatric oral health assessment index

Table 18: Continued

Authors	Country	Design	Oral health condition	Samples				Assessment	Key findings
				Population	Age	Sex	Total		
Gururatana et al. (2014)	Thailand	Longitudinal study	- Caries - Malocclu-sion - Gingival health - Dental opacity	Children in the school which participate a dental screening clinic	10.7	Both	455	- Untreated caries, malocclusion, gingival health, dental opacity[1] - CPQ_{11-14} [5,e] - SOC-13[6,f] - DCBS[6,g] - SES[6,h]	- Clinical variables were weakly associated with oral impacts. - The higher SOC and DCB predicted the better OHRQoL. - SES had indirect effects on OHRQoL, mediated by SOC. - The better parental SES predicted the higher SOC with resulting in the better OHRQoL.

Assessment for; [1]: Biological and Physical variables, [2]: Symptom status, [3]: Functional status, [4]: General health perception, [5]: Overall quality of life, [6]: Individual factors
[a]: Xerostomia Inventory, [b]: Short version of the oral health impact profile, [c]: Hospital Anxiety and Depression Scale, [d]: Oral health impact profile,
[e]: Child Perceptions Questionnaire, [f]: Sense of coherence, [g]: Dental Coping Beliefs Scale, [h]: Socio-economic status, [i]: Decayed, missing and filled teeth index,
[j]: Geriatric oral health assessment index

Table 18: Continued

Authors	Country	Design	Oral health condition	Samples				Assessment	Key findings
				Population	Age	Sex	Total		
Santos et al. (2015)	Brazil	Cross-sectional study (Secondary data)	Edentulism	Community-dwelling older people	68.0±6.3	Both	872	- Edentulism[1] - "Are you satisfied with the appearance of your teeth or dental prosthesis?"[2] - "Have you decreased or changed the type and/or amount of food because of problems with your teeth or dental prosthesis? "[3] - "Compared with others your age, how would you rate the health of your mouth overall?"[4] - OHIP-14[5,b]	- The results have supported the proposed relationships in the Wilson and Cleary model. - The study found age, sex, and geographic locations effected biological variables. - Age was associated with lower scores in OHIP-14.

Assessment for; [1]: Biological and Physical variables, [2]: Symptom status, [3]: Functional status, [4]: General health perception, [5]: Overall quality of life, [6]: Individual factors
[a]: Xerostomia Inventory, [b]: Short version of the oral health impact profile, [c]: Hospital Anxiety and Depression Scale, [d]: Oral health impact profile,
[e]: Child Perceptions Questionnaire, [f]: Sense of coherence, [g]: Dental Coping Beliefs Scale, [h]: Socio-economic status, [i]: Decayed, missing and filled teeth index,
[j]: Geriatric oral health assessment index

Table 18: Continued

Authors	Country	Design	Oral health condition	Samples				Assessment	Key findings
				Population	Age	Sex	Total		
Rebelo et al. (2016)	Brazil	Cross-sectional study	Dental caries and need for dentures	The older adults living in Manaus	69.2±3.0	Both	613	- Upper and lower denture need, DMFT[i,1] - GOHAI[5,j] - Age, sex, education, income[6]	- Clinical status related with OHRQoL. - Lower socioeconomic (education and income) status predicted poorer OHRQoL. - Age and income have direct effect on clinical status. - Age, education, and income were indirect predictor OHRQoL.

Assessment for; [1]: Biological and Physical variables, [2]: Symptom status, [3]: Functional status, [4]: General health perception, [5]: Overall quality of life, [6]: Individual factors
[a]: Xerostomia Inventory, [b]: Short version of the oral health impact profile, [c]: Hospital Anxiety and Depression Scale, [d]: Oral health impact profile,
[e]: Child Perceptions Questionnaire, [f]: Sense of coherence, [g]: Dental Coping Beliefs Scale, [h]: Socio-economic status, [i]: Decayed, missing and filled teeth index,
[j]: Geriatric oral health assessment index

As can be seen from the examples in Table 18, there have been several studies which have used the Wilson and Cleary model as a guiding causal framework. Three studies were cross-sectional in design (Baker et al., 2007; Santos et al., 2015; Rebelo et al., 2016), and two were longitudinal (Baker et al., 2008; Gururatana et al., 2014). The participant number ranged from 85 - 872, with ages from 10 - 80 years. Most examined the impacts in adults and older people (Baker et al., 2007; Baker et al., 2008; Santos et al., 2015; Rebelo et al., 2016), with only one study including children (Gururatana et al., 2014). Two studies determined the relationship in participants with edentulism (Baker et al., 2008; Santos et al., 2015), two were a combination of oral diseases and conditions (e.g. dental caries, gingival health, denture needs etc.) (Gururatana et al., 2014; Rebelo et al., 2016), and one study examined participants with xerostomia (Baker et al., 2007).

The studies supported the proposed conceptual model and revealed the impacts of oral health on QoL and well-being via symptom status, functional status, and general health perceptions. Yet, some studies did not find a relationship between general health perceptions and subjective well-being (Baker et al., 2007), or biological factors and symptom status (Santos et al., 2015). These might be due to the study using different instruments to assess each variable, as no assessment fits each variable perfectly. Further, various diseases have different progression, prognosis, and effects on the individual, resulting in potentially different results. Variation in participant characteristics and analytical approaches also influence the relationships within the proposed model.

Interestingly, the studies showed that individual factors including socio-demographic and psychological factors affect relationships between levels of the model. For socio-demographic factors, age, sex, dwelling, education, and income impacted on OHRQoL (Santos et al., 2015; Rebelo et al., 2016). In children, parent socio-economic status also affected the children OHRQoL (Gururatana et al., 2014).

For dry mouth, Baker et al. (2007) explored the relationships between the key concepts in a sample of patients experiencing xerostomia. The study included 85 participants (20 males, 65 females) with mean aged 59.8 ± 11.5 years from rheumatology, liver, pain management, oral medicine, speech, and language, and Sjogren's syndrome clinics in London. The assessments for each of the five main concepts (e.g., symptoms, functioning etc.) were selected on a pragmatic/best-fit basis (as this was a secondary analysis of existing data). For biological and physiological factors, the study measured unstimulated whole saliva and examined ten clinical signs (dry or cracked lips, dry nose, dry skin, coated or fissure tongue, and dry, thin, or red mucous). The XI was used to assess symptom status; OHIP-14 was used to evaluate functional status; global oral health was assessed by the patient's overall perception of their oral health; the Hospital Anxiety and Depression Scale (HADS) was used to assess subjective well-being.

Baker et al. (2007) tested the model as the basic model (model 1), the full model (model 2), and the final model (model 3). The basic model (model 1) examined the relationship between adjacent variables. The model hypothesised that the biological factors related with symptom status, the symptom status related with functional status, the functional status related with general (oral) health perceptions, and the general health perceptions related with subjective well-being. The findings showed the model did not fit the data well.

The full model (model 2) tested direct and indirect effects among all variables. For direct effects, the results showed three adjacent relationships: clinical signs to symptom status, symptom status to functional status, functional status to general (oral) health perceptions. The results were interpreted to mean that the severe clinical signs predicted worse symptom status, more symptom burden predicted worse functional status, and poorer functional status predicted lower general (oral) health perceptions. The findings also revealed two non-adjacent direct effects; worse functional status predicted poorer subjective well-being. And, interestingly, higher salivary flow rate and severe clinical signs predicted poorer subjective well-being.

For the indirect effects, there were three relationships; clinical signs impacted on functional status mediated by symptom status, and symptom status impact on subjective well-being mediated by functional status. The study also found symptom status influenced general (oral) health perceptions; however, the mediation proportion could not be calculated because of suppression effects. The full model was found to fit the data well, and significantly better than the basic model.

The final model (model 3) removed all non-significant associations. Therefore, the direct effect of clinical signs to subjective well-being was removed. Yet, two indirect effect relationships were added: clinical signs to subjective well-being, and clinical signs to general (oral) health perceptions. The final model, as shown in Figure 5, was better fit with the data.

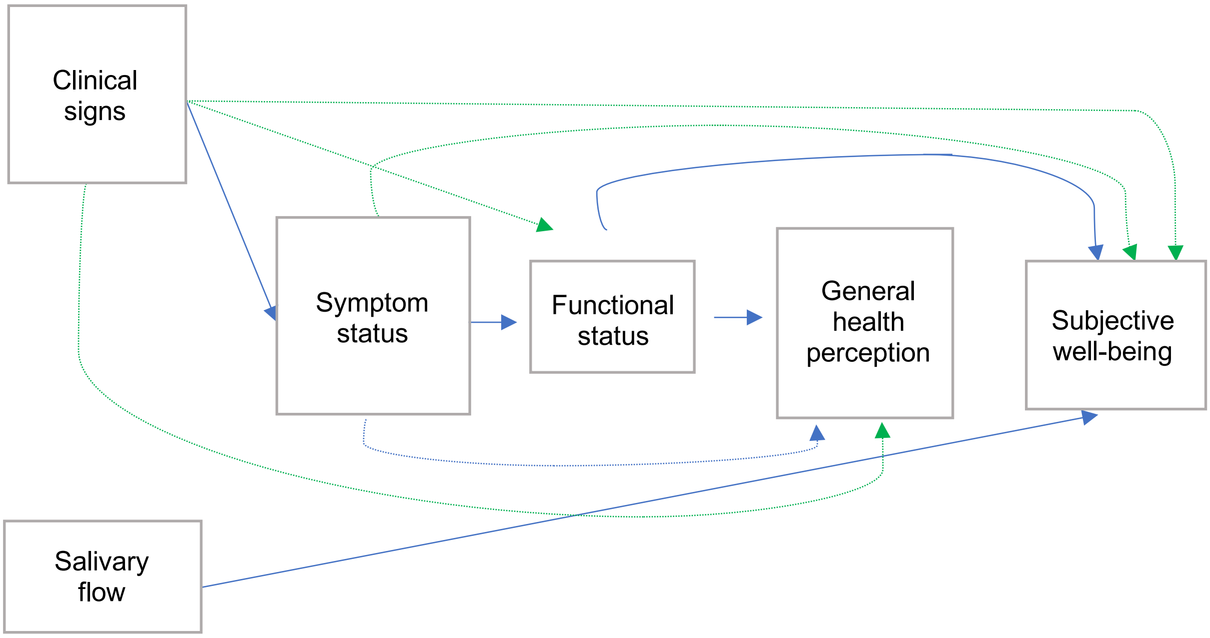


Figure 5: The final model of the associations among the variables in the Wilson and Cleary model (Copyright from Baker et al. (2007)); Blue lines: Direct effects, Green lines: Indirect effects

In sum, Baker et al. (2007) lent support to the associations within the Wilson and Cleary model. The study also demonstrated the association between non-adjacent variables and indirect effects. The study re-emphasised the importance of considering clinical alongside non-clinical variables in oral health research and practice. However, the study did not find the association between general (oral) health perception and subjective well-being. This might be due to the limitation of the measure of well-being – the HADS - which only assesses one aspect of overall well-being/life satisfaction: namely, psychological distress. Further, many participants reported anxiety and depression. The model might fit better if the study had used anxiety and depression as intervening factors and chosen other assessment methods for the subjective well-being concept.

In addition, the study also lacked data on individual and environmental factors which can play an important role in individual's perception of their symptoms, functioning and

QoL. The findings would have been more persuasive if the study had included a range of individual and environmental factors and was of a longitudinal design, which would have lent support to causal as well as potentially bidirectional links. A longitudinal study could also measure subjective perceptions that change over time, which could highlight important causal relationships between key concepts. The authors also recommended applying the model – including alternative models – within additional participant samples in order to validate the findings.

All things considered, the Wilson and Cleary model can be considered suitable as a framework to explore the impact of dry mouth on individual well-being. The model is clear, comprehensive, and also includes the individual and environmental variables that have considerable influence on individuals' experiences of their (oral) health. To date, only one study has utilised the Wilson and Cleary model in relation to dry mouth, and this study was of a cross-sectional design and did not include key environmental and individual factors. It was also a secondary analysis of existing data which limits the conclusions that can be drawn, and the sample had a limited range of older people. Therefore, a study which collects primary data within a longitudinal design, including individual and environmental factors, alongside measures of the key concepts within the Wilson and Cleary model, and a greater age range of participants is necessary to 1) further expand knowledge in the area of dry mouth, diabetes and OHRQoL and 2) further validate the Wilson and Cleary model for oral health.

2.4.4 Conclusions

QoL is defined in many ways within the literature but includes how individuals perceive and judge their life satisfaction. OHRQoL focuses on the impact oral conditions have on QoL and well-being. As OHRQoL is a multidimensional concept, conceptual models are useful tools for understanding how components relate to one another. The Wilson and Cleary model is one such comprehensive, clear, and explicit framework. The model is thus suitable to guide the study of determining the relationship between dry mouth and OHRQoL. To date, in Thailand, specifically, no studies have used the Wilson and Cleary model as a guiding framework to explore the effects of dry mouth on well-being in diabetic patients, and none have been of longitudinal design.

2.5 Rationale for the present study

Dry mouth is a chronic condition that negatively impacts oral health, functioning, psychological well-being, and social well-being, resulting in poor OHRQoL. However, most studies on dry mouth have focused on clinical aspects, treatment, and clinical management, with few investigating its impact on OHRQoL from the individual's perspective. Only one study has examined the individual psychological and demographic factors that impact dry mouth.

Diabetes is a non-communicable disease and a leading cause of death in Thailand. Trends in diabetes prevalence are increasing from a young age due to lifestyle changes such as increased consumption of sugary foods and sedentary behaviours. Diabetes has various effects on the oral cavity, including dry mouth. Previous studies have shown a higher prevalence of xerostomia and SGH in diabetes compared to non-diabetic individuals (Ben-Aryeh et al., 1993; Moore et al., 2001; Khovidhunkit et al., 2009; Borges et al., 2010; Malicka et al., 2014; Lone et al., 2017). This could be attributed to diabetes' deleterious effect on the salivary gland, resulting in xerostomia and SGH.

Therefore, dry mouth is a common symptom and a prominent oral health problem among individuals with diabetes mellitus (Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Khovidhunkit et al., 2009; Malicka et al., 2014). However, there have been very few studies on the impact of dry mouth in diabetic patients, and to date, no studies have been conducted in Thailand or more broadly in Asia.

This draws attention to further investigating dry mouth in diabetic patients in Thailand, in addition to the clinical, psychological, and social factors that impact an individual's OHRQoL, as well as wider well-being. As OHRQoL is a multidimensional construct, it has been suggested that any OHRQoL study should be guided by the conceptual model that can clarify the relationship among the differing aspects (Ojelabi et al., 2017). The Wilson and Cleary model is a comprehensive and explicit model that has proposed the direct and indirect relationships between variables and includes individual and environmental contextual factors. The model has been utilised in oral health, including xerostomia (Baker et al., 2007). The present study utilises the Wilson and Cleary model to explore the associations between dry mouth and OHRQoL in diabetic patients in Songkhla province, Thailand.

2.6 Aim and research questions

2.6.1 Aim

To examine the associations between dry mouth and OHRQoL in diabetic patients in Songkhla province, Thailand

2.6.2 Research questions

1. How is dry mouth associated with OHRQoL in diabetic patients?
2. What is the association between clinical, and individual factors in dry mouth patients with diabetes?

2.7 Hypotheses

The study will test the following hypotheses:

Primary hypotheses:

- The severity of dry mouth in diabetic patients is associated with overall QoL and this is mediated by symptom status, functioning, and (oral) health perceptions.
- These associations will be mediated by individual variables (multimorbidity, polypharmacy, sense of coherence, and self-esteem).

Secondary hypotheses:

- Severe symptom status predicts worse functional status.
- Poorer functional status predicts lower general (oral) health perceptions.
- Lower general (oral) health perceptions predict poorer overall QoL.

Chapter Three

Methods

3.1 Introduction

The aim of this study was to examine the association between dry mouth and oral health-related quality of life (OHRQoL) in diabetic patients in Songkhla province, Thailand. The proposed study was a prospective observational study with a three-month follow-up, which corresponds to the follow-up period of diabetic patients in the hospital where recruitment took place.

3.2 Participants

3.2.1 Target population

Type 1 or Type 2 Diabetic patients aged over 18 years in Hatyai hospital, Songkhla province, Thailand.

3.2.2 Sample size

The sample size was calculated using Free Statistics Calculators version 4.0, which is based on error function, lower bound sample size for a structural equation model, and normal distribution cumulative distribution function calculation (Soper, 2020). A sample size of 161 participants was required to detect a difference with 80% power at $p < 0.05$ and an effect size of 0.3 for complex models with six latent variables and 26 predictors (refer to Figure 7 for detailed information on the variables within the model).

Previous study indicates that 35.6% of older adults were lost to follow up within two years, primarily due to relocation and mortality (Zunzunegui et al., 2001). Additionally, a study involving school children reported a 10.8% loss to follow up within nine months (Gururatana et al., 2014). Given the present study's focus on adults aged older 18 years with a three-month follow-up period, and assuming a 25% loss to follow-up during this period, a final sample size of 202 was required.

3.2.3 Intended sample

Two hundred and two Type 1 or Type 2 diabetic patients aged over 18 years were recruited from the non-communicable diseases (NCD) clinic at Hatyai hospital, located in Songkhla province, Thailand. Hatyai hospital serves as a regional hospital catering to residents of Hatyai district and operates as a tertiary care facility where patients are referred from community and general hospitals for specialised treatment. Consequently, the inclusion of participants from Hatyai hospital captures a broad spectrum of diabetic patients and may be representative of the wider diabetic population in Thailand.

3.2.4 Inclusion criteria for participants

- Participants with diabetes Type 1 or Type 2
- Participants aged over 18 years
- Participants who live in Songkhla province, Thailand

3.2.5 Exclusion criteria for participants

- Participants who did not consent to the study
- Participants who did not have the ability to understand Thai language
- Participants who had gestational diabetes mellitus
- Participants who recently received head and neck radiation therapy within three months due to the radiation having damaged the salivary gland cells
- Participants who had medical and cognitive problems with memory impairment, or communication difficulties

3.3 Recruitment and randomisation

Multistage sampling was applied in this study. Age and sex were used to divide the population into subgroups as both age and sex affect dry mouth (Nederfors et al., 1997; Flink et al., 2008; Affoo et al., 2015).

3.3.1 Sampling

1) Recruit diabetic patients using ICD10 (E10 - E11; Type 1 and Type 2 diabetic patients) from Hatyai hospital database
2) Patients who did not live in Songkhla and were not Thai were excluded
3) Patients who did not have phone numbers were excluded
4) Patients who met the criteria were grouped according to age 18 - 29, 30 - 39, 40 - 49, 50 - 59, 60 and older
5) Age groups were divided into male and female

6) Random sampling was applied to each group; there were 210 participants at baseline (105 males and 105 females)

Due to COVID-19, Hatyai hospital did not allow researchers to contact participants in person for reducing transmission and safety reasons. Therefore, the method for approaching and recruiting research participants was changed from in-person to telephone as shown in Figure 6. After ethical approval, the researcher (AS) contacted the hospital database to access diabetic patients' names and phone numbers. Patients who were coded using ICD10 (E10 - E11; Type 1 and Type 2 diabetic patients) and had received treatment during 2019 were approached via phone to take part in the study. The information sheets, consent form and the questionnaire were sent to the patients who initially agreed to take part in the study. Participants were asked to return the consent form to the researcher and an interview via phone was then arranged. After completing the baseline interview, all participants were given an interview slot for their three-month follow-up. The three-month period was chosen as this is the time (three- to six-months) that most diabetic patients will be given a routine follow-up appointment. Considering the time limitation within the PhD, participants were interviewed for follow-up at three-months. The researcher called and reminded the participants two weeks before the follow-up interview date. Participants were assured that they could withdraw from the study at any time, and that this would not affect their treatment.

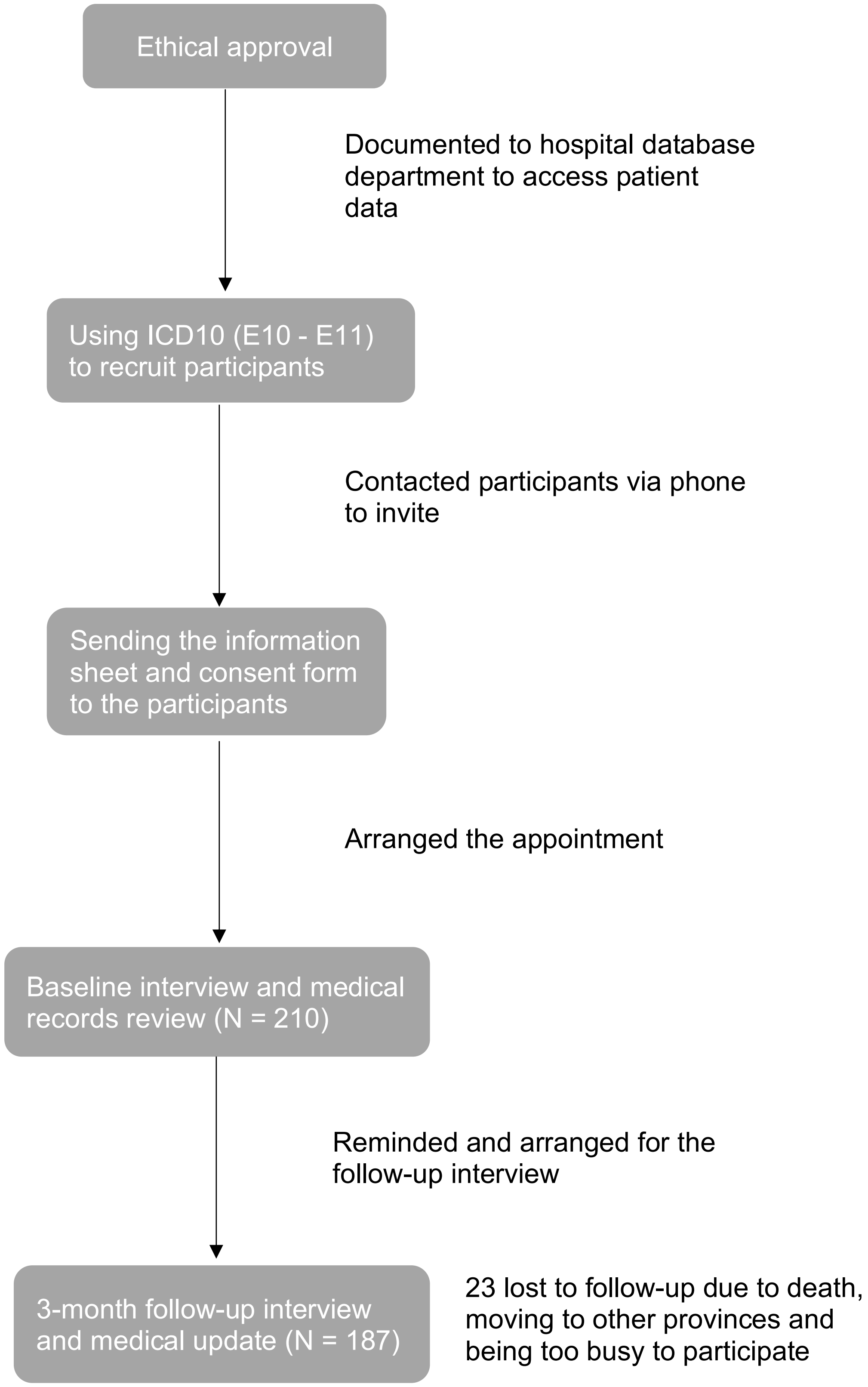


Figure 6: Participant flow through the study

3.4 Permission and Liaison

- Ethical approval was obtained from the University of Sheffield (038376), Hatyai hospital (HYH EC 061-64-02), and Faculty of Dentistry, Prince of Songkla University (EC6404-017) (Appendix A).
- All participants were contacted via phone and informed about the nature of the study.
- The information sheets, consent form and the questionnaire were sent to participants by post.
- Participants were asked to complete the consent form before taking part in the study and sent it back to the researcher.

3.5 Variables

This study is based on the Wilson and Cleary model (1995) (Figure 3). The model represents the proposed relationship among five main variables: biological and physiological variables, symptom status, functional status, general health perceptions as well as overall QoL. The model has been described in full in Chapter 2 (Page 82 - 85). This study aimed to examine the (inter)relationships among the five main and key individual variables documented in Figure 7.

Information was obtained from questionnaires and medical information from hospital medical records. This section will discuss the variables and how they were measured.

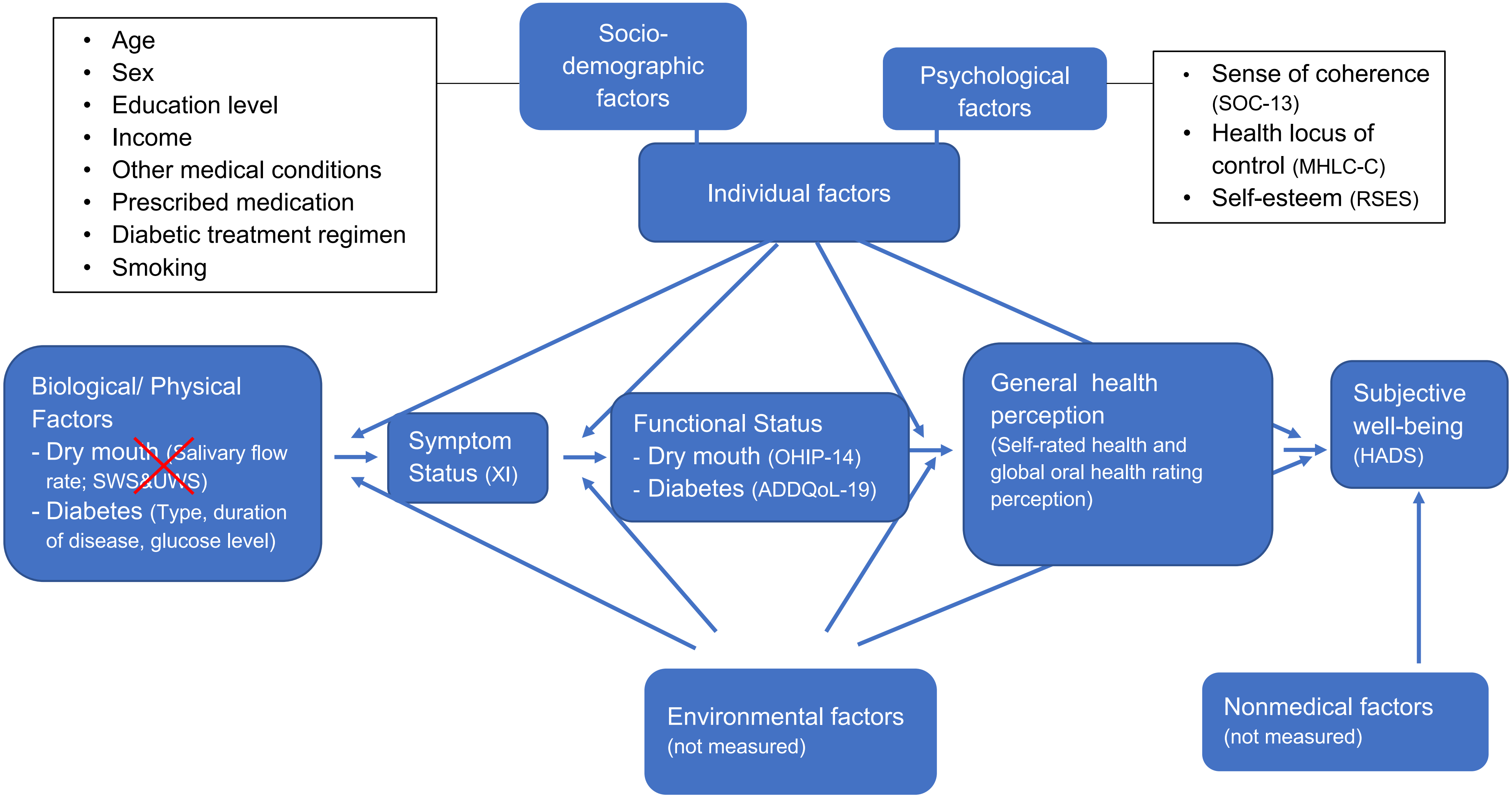


Figure 7: Selected variables and measurements used to operationalise the Wilson and Cleary model (1995)

Note: Salivary flow collection was not collected due to COVID-related changes to the hospital protocol during the pandemic

3.5.1 Biological and physiological variables

3.5.1.1 Dry mouth

In the initial protocol, pre-COVID pandemic, the biological and physiological assessment of dry mouth was planned to incorporate salivary flow rate. Both unstimulated and stimulated whole saliva were planned to be measured as they are secreted by different glands and have dissimilar compositions. Collecting salivary flow from both states would therefore ensure a comprehensive and accurate assessment. Cut-off values for SGH were based on previous literature: 0.1 ml/min for unstimulated whole salivary flow rate (Samnieng, 2015; Närhi, 1994; van der Putten et al., 2011; Dawes, 2008), and 0.5 ml/min for stimulated whole salivary flow rate (Samnieng, 2015; van der Putten et al., 2011).

Prior to the appointment and again before collecting salivary flow rate, participants were to be instructed to (Navazesh and Kumar, 2008):

1. Abstain from consuming food or beverages (except water), smoking, and chewing gum for one hour before salivary collection.
2. Sit in a forward head posture and relax position, remaining motionless during collection.
3. Rinse the mouth with water and swallow remaining saliva before the start of collection.
4. Avoid swallowing and keep eyes open during collection periods.

For unstimulated whole saliva, the passive (drain) method was to be used. Participants would be asked to let saliva drool into a pre-weighted container passively for five minutes, then spit any remaining saliva into the container.

For stimulated whole saliva, the active (spit) method was to be used. After unstimulated whole saliva collection, steps two through four would be repeated. Participants would then chew pre-weighted paraffin and spit saliva into a pre-weighted container every minute for five minutes. The first two-minute saliva would be discarded, and the next three-minute saliva would be examined. Paraffin would be removed from the container before analysis.

After collection, the container would be weighted to calculate salivary flow rate. The saliva collection form which would have been used in this study is detailed in Appendix B. Unfortunately, salivary collection was cancelled due to the COVID-19 situation in Thailand, as Hatyai hospital did not permit researchers to contact participants in person.

Other clinical signs related to dry mouth, such as dry or cracked lips, dry nose, dry skin, coated or fissured tongue, and dry, thin, or red mucous, were not originally planned to be collected in the study due to time limitations.

3.5.1.2 Diabetes mellitus

For diabetes information, the data collection was in accordance with recent studies (Sundaram et al., 2007; Azogui-Levy et al., 2018):

Three measures were taken: type of diabetes, duration of the disease, and glucose level (fasting blood sugar; FBS, haemoglobin A1c; HbA1c) were derived from the medical chart (Appendix D):

- Type of diabetes was categorised into two types: diabetes Type 1 and Type 2.
- The duration of diabetes was grouped into six groups: < 6 months, 6 - 12 months, > 1 - 3 years, > 3 - 5 years, > 5 - 10 years and 10+ years.
- Glucose level was recorded as FBS and HbA1c levels. FBS and HbA1c are grouped as treatment goals according to the ministry of public health. FBS was grouped into three groups; less than 70 mg/dL; 70 to 130 mg/dL; and 130 or more mg/dL. For HbA1c, the level was grouped into three groups; below 7% (below 53 mmol/mol); 7% to 9% (53 to 75 mmol/mol); 9% or more (75 or more mmol/mol).

3.5.2 Symptom status

Symptom status was assessed using the Xerostomia Inventory (XI) (Thomson et al., 1999), which was also employed in a previous study to determine relationships between clinical and non-clinical factors in xerostomia (Baker et al., 2007).

The XI is an 11-item summated rating scale that covers experiences and behaviour change due to xerostomia (Appendix E, Part 1). Participants were asked to score the frequency of each symptom in the previous four weeks on a scale; "never" (scoring 1); "hardly ever" (2); "occasionally" (3); "fairly often" (4); or "very often" (5). The higher score indicates greater severity of symptoms. The score was summed to give a single XI score.

The XI has shown acceptable validity, reliability, and responsiveness. Cronbach's alpha was 0.84, and correlation coefficients ranged from 0.39 to 0.74 (Thomson et al., 1999). The intra-class correlation coefficient was 0.92 (Thomson, 2007). In Thailand, there has been no application of XI-Thai version.

3.5.3 Functional status

3.5.3.1 Dry mouth

Functional status related to dry mouth was examined by using the short form oral health impact profile (OHIP-14) (Slade, 1997), which was also used in a previous study examining the relationships among main factors utilising the Wilson and Cleary model as a conceptual framework, similar to the present study (Baker et al., 2007).

OHIP-14 is a 14-item measure which covers seven dimensions: functional limitation; physical pain; psychological discomfort; physical disability; psychological disability; social disability; and handicap (Appendix E, Part 2). Participants were asked to score the frequency of impact in the previous four weeks on a scale; "never" (scoring 0); "hardly ever" (1); "occasionally" (2); "fairly often" (3); or "very often" (4). The scores were summed to give a single score. The higher score represents poorer OHRQoL.

The OHIP-14 has shown good internal reliability and validity (Slade, 1997; Robinson et al., 2003). Cronbach's alpha were 0.88 (Slade, 1997), and 0.92 (Robinson et al., 2003). The correlation coefficient with global oral rating scale and the severity of pain on a visual analogue scale were 0.51 and 0.49, respectively (Robinson et al., 2003).

The OHIP-14 has been translated into Thai and considered linguistic and cultural adaptation (Nammontri, 2017). The Thai version of OHIP-14 has shown good validity and reliability; Cronbach's alpha was 0.88 (Nammontri, 2017).

3.5.3.2 Diabetes mellitus

Functional status related to diabetes mellitus was examined using the audit of diabetes-dependent quality of life (ADDQoL-19) (Bradley et al., 1999). The ADDQoL-19 consists of two global and 19 diabetes-specific questions which cover social, physical, and emotional functioning (Appendix E, Part 3). The ADDQoL-19 allows participants to score impact of diabetes on a life aspect (-3 to 1) as well as rate the importance of the particular domain (0 to 3) (Bradley et al., 1999). The weight impact score is calculated from the impact score multiplied by the importance score (-9; maximum negative impact of diabetes to 3; maximum positive impact of diabetes) (Wee et al., 2006). To facilitate the analysis, the scales were reversed and recoded to 1 - 13, higher scores indicated poorer QoL. Participants may indicate not applicable (N/A) in five domains: family life, close personal relationship, sex life, work or employment, and holiday.

The ADDQoL-19 has shown acceptable reliability and validity (Bradley et al., 1999; Bradley and Speight, 2002). Cronbach's alpha ranged from 0.85 to 0.94; item-total correlations ranged from 0.37 to 0.67 (Bradley et al., 1999; Bradley and Speight, 2002; Wee et al., 2006).

The Thai version of ADDQoL-19 was developed and used in diabetic patients with mean age of 54.25 $\pm$ 9.87 years from a tertiary hospital in central Thailand. The study showed good reliability (Pongmesa et al., 2010). Cronbach's alpha was 0.90, also the factor loadings were above 0.4 for all items, except for sexual relationship (Pongmesa et al., 2010).

3.5.4 General health perceptions

General health perceptions were assessed by self-reported health assessment, and a global oral health rating scale (Appendix E, Part 4) (WHO, 2002b). Self-reported health was examined by asking "In general, how would you rate your health today?" with five response choices; very good (scoring 1); good (2); moderate (3); bad (4); and very bad (5). The question was utilised in the world health survey (2002), which surveyed in 70 countries (Subramanian et al., 2010).

For global oral health rating scale, the assessment is a single-item; Would you say that the health of your teeth, lips, jaws, or mouth is …..? (Nammontri, 2017). There have been five response choices; "poor" (scoring 0); "fair" (1); "good" (2); "very good" (3); and "excellent" (4). For the analysis, the scales were reversed (1 (excellent) – 5 (poor)). The global oral health rating scale has been used in previous studies (Atchison and Gift, 1997; Robinson et al., 2003; Baker et al., 2007; Baker et al., 2008; Nammontri, 2017).

3.5.5 Psychological distress

Psychological distress was assessed by the hospital and anxiety depression scale (HADS) (Zigmond and Snaith, 1983). The HADS was developed to assess psychological distress in non-psychiatric populations. The HADS consists of 14 items which cover two aspects: depression and anxiety (Appendix E, Part 5). Participants were asked to rate each item on five-point (0 - 3) scales, details in Appendix E, Part 5. The scores of seven or less indicate normal, 8 - 10 indicate doubtful depression or anxiety, and 11 or more indicate depression or anxiety (Zigmond and Snaith, 1983).

The HADS has shown acceptable internal reliability. The correlation coefficient ranged from 0.30 - 0.60 and 0.41 - 0.76 for depression and anxiety subscales respectively (Zigmond and Snaith, 1983). The HADS predicts the severity of depression and anxiety. The correlation was 0.70 and 0.74 for depression and anxiety, respectively (Zigmond and Snaith, 1983).

The Thai version of the HADS has been utilised with 60 cancer patients, mean aged 46 years. The study showed the scale to have good reliability and validity in this sample. Cronbach's alpha were 0.85 and 0.82 for depression and anxiety, respectively (Nilchaikovit et al., 1996).

3.5.6 Individual variables

Individual variables collected in the study were sociodemographic and psychological.

3.5.6.1 Socio-demographic variables

There were eight variables which were collected in this study: age, sex, education levels, income levels, smoking status, other medical conditions, prescribed medication, and diabetic treatment regimen (Appendix C and D). Age, education levels, income levels, and smoking status were collected by interview. Sex, other medical conditions, prescribed medication, and diabetic treatment regimen were collected by medical records.

The personal general questionnaire was adapted from the 2019 Household Socio-economic Survey whole kingdom (Ministry of Digital Economy and Society, 2020). The medical personal questionnaire was developed from the literature review.

- Age was measured as a continuous variable.
- Education levels were grouped as primary school, middle school, high school or equal, diploma, undergraduate, and postgraduate.
- Income levels were grouped based on the monthly income categorises as follow: no income, 1-5,000 baht, 5,001-15,000 baht, 15,001-30,000 baht, 30,001-50,000, and 50,001 or more. (1 GBP = 45 Baht; the daily minimum wage at Songkhla province is 325 baht)
- Smoking status (cigarettes, cigars, electronic cigarettes, tobacco, smokeless tobacco) was grouped as never smoked, former smoker, and current smoker.

- Other medical conditions and prescribed medication were recorded according to the medical record from the hospital.

3.5.6.2 Psychological variables

1) Sense of coherence (SOC)

Sense of coherence was assessed using the short form of Antonovsky's sense of coherence scale (SOC-13) which was developed by Antonovsky (1987). SOC-13 is 13-item scale which covers comprehensibility (tolerance vs. intolerance), manageability (trust vs. distrust), and meaningfulness (zest vs. depression) (Appendix E, Part 6) (Eriksson and Mittelmark, 2017). The responses are seven-point rating scale from one (never have this feeling) to seven (always have this feeling). The score of item one, two, three, five, and seven have to be reversed before summing the total (Holmefur et al., 2015). To facilitate the analysis, the sum scales were reversed, the higher scores indicated poorer SOC. The SOC-13 has shown acceptable reliability and validity (Eriksson and Lindstrom, 2005). Cronbach’s alpha ranged from 0.70 to 0.92 (Eriksson and Lindstrom, 2005). In Thailand, there has been application of SOC-13 in children (Nammontri, 2012), but no report of its reliability and validity.

2) Health locus of control

Health locus of control (HLOC) was measured by multidimensional health locus of control scale form C (MHLC-C) (Wallston et al., 1994). The MHLC-C is an 18-item questionnaire which contain four dimensions related to individual's belief about the cause of their health outcome, namely the internality (six items), chance (six items), doctor (three items), and other people (three items) (Appendix E, Part 8). Participants were asked to rate the agreement with each item from one (strongly disagree) to six (strongly agree). For the analysis, the scales were reversed, the higher scores indicated low belief. The MHLC-C has shown acceptable reliability and validity. Cronbach's alpha ranged from 0.70 to 0.87; stability coefficients ranged from 0.40 to 0.80 (Wallston et al., 1994). In Thailand, there has been no application of MHLC-C. The questionnaire was forward and back-translated as shown in Figure 8.

3) Self-esteem

Self-esteem was examined by Rosenberg self-esteem scale (RSES) (Rosenberg, 1965). RSES contains 10 items with four-point scale; one (strongly agree) to four (strongly disagree) (Appendix E, Part 7). The negative-wording items (item two, five, six, eight, and nine) have to invert the score before summing total score. The greater score indicates low self-esteem (Ciarrochi and Bilich, 2006). The RSES has shown excellent internal consistency; test-retest correlation ranged from 0.85 to 0.88. The measure has also been shown to significantly correlate with other self-esteem measurements indicating good construct validity (Ciarrochi and Bilich, 2006). A previous study in Thailand tested RSES in 664 university students in Northern province with a Cronbach's alpha of 0.86 (Wongpakaran and Wongpakaran, 2011).

3.6 Conduct of the study

3.6.1 Training and Calibration

A research assistant was trained by the researcher (AS) to conduct interviews and record information from the questionnaires.

3.6.2 Equipment

Interview form containing participant demographics and questionnaires: XI, OHIP-14, ADDQoL-19, health perceptions, HADS, SOC-13, HLOC, and RSES.

Medical forms comprising information on diabetes types, treatment regimen, duration of diabetes, FBS and HbA1c levels, medications, and comorbidities.

3.6.3 Translation

Seven of the questionnaires chosen for use in the study have Thai versions available: OHIP-14, ADDQoL-19, global oral health rating scale, HADS, SOC-13, and RSES. These have all been tested for their validity and reliability in previous studies. All authors were contacted and asked for their permission to apply the Thai translated versions in this study (unless the questionnaires are already available within the literature).

For the remaining questionnaires (XI, self-reported health assessment, MHLC-C) were translated into Thai by the researcher (AS), and back-translated into English by bilingual persons who have never seen the original English version. Any adaptations were made until the Thai version was analogous with the original. The translation process of the questionnaires used in the study is illustrated in Figure 8.

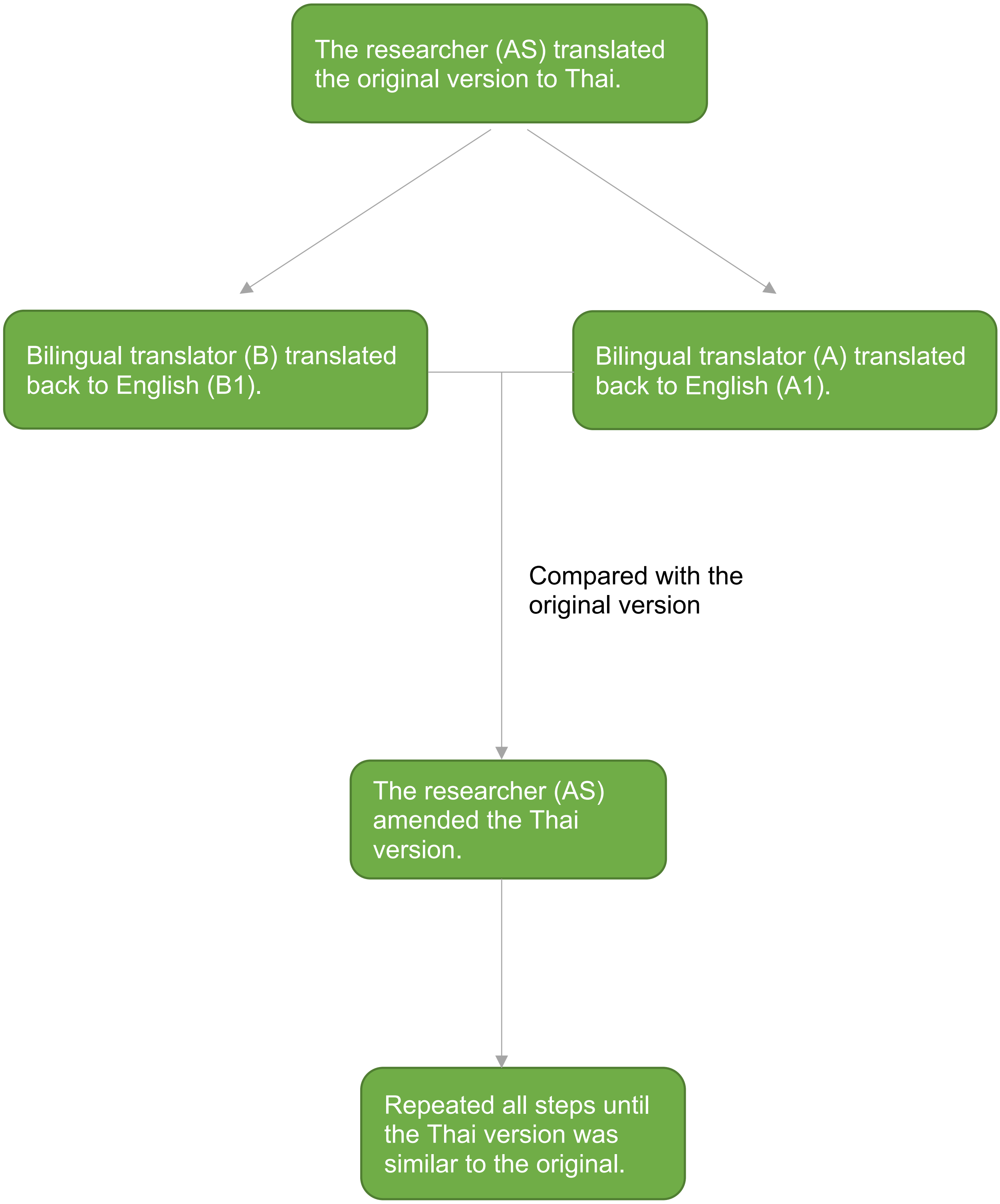


Figure 8: The translation process of the questionnaire used in the study

3.6.4 Personnel

- The researcher (AS) and research assistant interviewed participants.
- The researcher (AS) reviewed participant medical records.

3.6.5 Pilot study

The pilot study was conducted prior to data collection. All Thai questionnaire versions were tested for feasibility, time, reliability, validity, and management.

3.6.6 Reliability of all questionnaires

Cronbach's alpha reliability coefficients of all scales were assessed, the results as shown in Table 19.

Table 19: Cronbach's alpha reliability coefficients of all questionnaires

Questionnaires	Cronbach's alpha
XI	0.84
OHIP-14	0.91
ADDQoL-19	0.94
HADS	0.85
MHLC-C	0.79
SOC-13	0.56
RSES	0.81

As can be seen in Table 19, OHIP-14 and ADDQoL-19 showed excellent consistency. XI, HADS and RSES presented good consistency. MHLC-C had acceptable consistency. However, SOC-13 had poor consistency. The results will be discussed later in Chapter 5 (section 5.6).

3.6.7 Data collection

The questionnaire was distributed to participants via mail by a research assistant, with clear instructions to review it prior to a scheduled telephone interview. Data from the questionnaire were obtained during the telephone interviews, wherein trained interviewer (AS and research assistant) read each question aloud. Both AS and research assistant conducted independent interviews with the participants and recorded their responses.

Before the three-month follow up, participants were contacted via phone to schedule the follow-up interview. The questionnaire was subsequently mailed to those participants who still consented to participate in the study. Data were collected at two time points (Table 20): baseline and three-month follow up, with the exception of SOC, HLOC, and self-esteem. SOC typically develops during childhood and adolescence, stabilising around age 30. After this age, SOC tends to remain fairly stable and is unlikely to change significantly (Nilsson et al., 2010). Similarly, HLOC and self-esteem tend to increase with age and are influenced by various social, physical, and environmental factors (Pudrovska, 2015; Ogihara and Kusumi, 2020). Consequently, SOC, HLOC, and self-esteem were not expected to change over a three-month period and were not collected at the three-month follow up. A summary of data collection can be found in Table 20 below.

For the clinical record information, the researcher (AS) remotely accessed the necessary programs using a Virtual Private Network provided by Hatyai hospital (after obtaining ethics approval). Two programs were utilised: HN Find for reviewing medical records (including diabetic types, duration, treatment regimen, medications, and comorbidities), and iLabView for reviewing FBS and HbA1c levels. Medical information was extracted from participants' medical records by the researcher (AS).

Table 20: Summary of data collection

Variables collected at Time 1 (baseline)	Variables collected at Time 2 (3 months)
- Age, sex, income, and education level - Other medical conditions - Prescribed medication - Smoking status - Diabetic treatment regimen	- Other medical conditions - Prescribed medication
- Glucose level (FBS&HbA1C) - Type of diabetes - Duration of disease	- Glucose level (FBS&HbA1C)
- Symptom status (The Xerostomia Inventory) – 11 items - Functioning (OHIP-14) – 14 items - Functioning (ADDQoL-19) – 19 items - General health perception and Global oral health rating perception - Psychological distress (HADS) – 14 items	- Symptom status (The Xerostomia Inventory) – 11 items - Functioning (OHIP-14) – 14 items - Functioning (ADDQoL-19) – 19 items - General health perception and Global oral health rating perception - Psychological distress (HADS) – 14 items
- Sense of coherence (SOC-13) – 13 items - Health locus of control (MHLC scales) – 18 items - Self-esteem (RSES) – 10 items	Not collect at time 2

3.6.8 Data transfer

The telephone interview was audio recorded in order to check accuracy of data collection and response coding. All data were checked for completion by the interviewer and then transferred to an SPSS database by the researcher (AS). In order to check for accuracy, 10% of entries were checked by an independent researcher. The independent researcher listened to the interview record and entered data for each question in separate files. Then, the researcher (AS) checked the responses in the SPSS file.

For medical records, the researcher checked the data from the medical chart which could be accessed remotely via the hospital computer system. The data were transferred to an SPSS database by the researcher (AS). To check accuracy, 10% of entries were also checked by the research team (Hatyai hospital staff) and the data entered in separate files. Then, the researcher (AS) checked the responses in the SPSS file.

3.6.9 Data analysis

Data were coded and analysed by the researcher (AS) as summarised in Table 21. Three stages of data analysis were used:
Stage 1: Descriptive analysis of means, ranges, medians, and standard deviations for all variables at Time Points 1 and 2.
Stage 2: Bivariate analysis (Spearman or Pearson correlation coefficients) of all variables at baseline.
Stage 3: Structural equation modelling (SEM) to analyse the direct and indirect pathways between the variables according to the Wilson and Cleary model (1995), the analysis utilised only data of Type 2 diabetic patients at baseline.

Table 21: Summary of data analysis

Variables	Code	Analysis
Clinical variables		
➢ Type of diabetes	1 = Type 1 2 = Type 2	Descriptive
➢ Duration of diabetes	1 = less than 6 months 2 = 6-12 months 3 = more than 1 year - 3 years 4 = more than 3 years – 5 years 5 = more than 5 years – 10 years 6 = more than 10 years	Descriptive
Glucose level		Descriptive
➢ FBS	1 = ‘less than 70 mg/dL’ 2 = ‘70 to 130 mg/dL’ 3 = ‘130 or more mg/dL’	
➢ HbA1c	1 = ‘below 7%’ 2 = ‘7% to 9%’ 3 = ‘9% or more’	
Symptom status		
➢ Xerostomia Inventory	11 items on a 5-point scale	Total all items to generate raw scores of the XI
Functional status		
➢ Dry mouth (OHIP-14)	14 items on a 5-point scale	Total all items to generate raw scores of the OHIP-14
➢ Diabetes (ADDQoL-19)	19 items on a 5- impact point scale and 5-importat point scale	Total weight items to generate raw scores of the ADDQoL-19 (weight item = 'impact score' x 'important score') Sum scales were reversed in order to facilitate the analysis
General health perception		Descriptive
➢ Self-reported health scale	A question on a 5-point scale	
➢ Global oral health rating	A question on a 5-point scale	Global oral health rating scores were reversed in order to facilitate the analysis
Psychological distress		
➢ HADS	14 items on a 4-point scale	Total anxiety subscales (item 1, 3, 5, 7, 9, 11, 13) to generate raw scores of the anxiety Depression subscales (item 2, 4, 6, 8, 10, 12, 14) to generate raw scores of the depression

Table 21: Continued

Variables	Code	Analysis
Individual variables		
➢ Socio-demographic variables		Descriptive
- Age	Continuous data	
- Sex	1 = 'male' 2 = 'female'	
- Education level	0 = 'not attending school' 1 = 'primary school' 2 = 'middle school' 3 = 'high school or equal' 4 = 'Diploma' 5 = 'Undergraduate' 6 = 'Postgraduate'	
- Income level	0 = no income 1 = '1-5,000 baht' 2 = '5,001-15,000 baht' 3 = '15,001-30,000 baht' 4 = '30,001-50,000 baht' 5 = '50,001 or more baht'	
- Other medical conditions	Raw data	
- Prescribed medication	Raw data	
- Smoking status	0 = 'never smoked' 1 = 'former smoker' 2 = 'current smoker'	
- Diabetic treatment regimen	1 = 'diet only' 2 = 'tablets or insulin' 3 = 'insulin and tablets'	
➢ Psychological variables		
- Sense of coherence (SOC-13)	13 items on a 7-point scale	Total all items to generate raw scores of the SOC (1, 2, 3, 5, 7 were reversed scores) Sum scores were reversed in order to facilitate the analysis
- Health locus of control (MHLC-C)	18 items on a 6-point scale	Total each subscale to generate - internality (6 items) - chance (6 items) - doctor (3 items) - other people (3 items) Sum scores were reversed in order to facilitate the analysis
- Self-esteem (RSES)	10 items on a 4-point scale	Total all items to generate raw scores of the self-esteem (2, 5, 6, 8, 9 were reversed scores)

Table 21: Continued

Variables	Code	Analysis
Quality of life in general	1 = extremely good 2 = very good 3 = good 4 = neither good nor bad 5 = bad 6 = very bad 7 = extremely bad	Descriptive
Diabetic-related quality of life	1 = worse 2 = same 3 = a little better 4 = much better 5 = very much better	Descriptive

Chapter Four

Results

4.1 Introduction

There were 6,706 diabetic patients who received treatment at Hatyai hospital in 2019 who were eligible to take part in the study. Random sampling was applied to each group (diabetic type, sex, and age) and the patients were contacted to invite them to take part in the study. The process was repeated until the required sample size was reached. A total of 1,385 diabetic patients were contacted and invited to take part, of which 210 (15.2%) consented. The response rate was low owing largely to the ongoing COVID-19 pandemic, the closure of hospital services, and recruitment having to be conducted by telephone. The diabetic patients had never met the researcher (AS) (who was not a Hatyai hospital staff member) prior to recruitment. It was reported that many believed the call was a phone scammer; the incidence of which rose sharply during the pandemic in Thailand. As a result, many patients did not answer the recruitment telephone calls.

Baseline interviews were arranged from August 2021 to December 2021. Three-month follow-up data were collected from November 2021 to March 2022. There were 23 participants (11.0%) who were lost to follow-up due to death, moving to other provinces or being too busy to participate. The flow diagram for study participants is shown in Figure 9.

The results in this chapter will be presented in three sections:

Section 4.2 reports the results related to demographic data (age, sex, education level and income), clinical data, and self-reported questionnaire data. Descriptive data are reported for all variables at baseline and 3-month follow-up.

Section 4.3 reports the associations among variables using Pearson and Spearman's rank correlations. This section focuses only on the results of Type 2 diabetic patients at baseline.

Section 4.4 presents the results of the hypothesised associations between clinical, demographic, and person-reported questionnaires using structural equation modelling. This section again includes only the results of Type 2 diabetic patients at baseline.

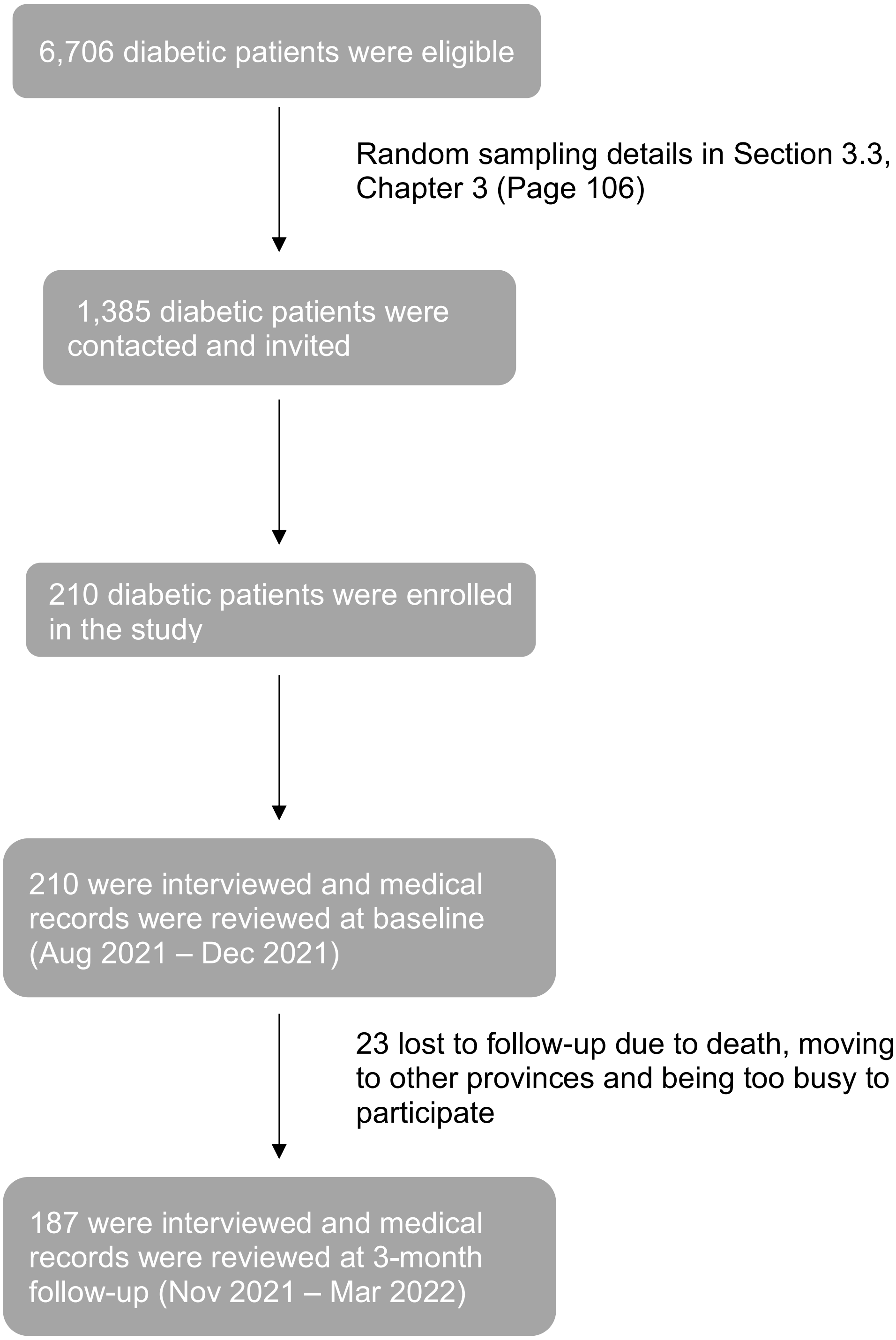


Figure 9: Flow diagram for study participants

4.2 Descriptive analysis

Descriptive data are presented separately for Type 1 and Type 2 diabetic patients. There were 23 (11.0%) Type 1 diabetic patients (T1DM), and 187 (89.0%) Type 2 diabetic patients (T2DM). The first section will report the demographic data. The next section will describe the clinical data. The last section will report the patient-reported outcome (questionnaire) data.

4.2.1 Demographic data

The mean age of Type 1 and Type 2 diabetic patients was 33.3 (SD 12.4) years (range 19-74 years) and 49.1 (SD 14.9) years (range 18 - 85 years) respectively. There were 14 (60.9%) and 88 (47.1%) T1DM and T2DM females respectively. For education level, 15 (65.2%) of T1DM had completed undergraduate or postgraduate careers. For those with T2DM, 54 had completed undergraduate or postgraduate (28.9%) careers. Eight (34.7%) of T1DM and 52 (27.8%) of T2DM had earned an income of more than 15,000 baht per month (≅ 350 GBP) as shown in Table 22.

Table 22: Demographic data

	T1DM (%)	T2DM (%)
Age [mean (SD)]	33.3 (12.4)	49.1 (14.9)
Sex		
- Female	14 (60.9)	88 (47.1)
- Male	9 (39.1)	99 (52.9)
Education level		
- Not attending the school	0	4 (2.1)
- Primary school	2 (8.7)	54 (28.9)
- Middle school	3 (13.0)	20 (10.7)
- High school	3 (13.0)	34 (18.2)
- Diploma	0	21 (11.2)
- Undergraduate	15 (65.2)	49 (26.2)
- Postgraduate	0	5 (2.7)
Income (baht; 1 GBP ≅ 43 baht)		
- No	7 (30.4)	43 (23.0)
- 1-5,000	1 (4.3)	22 (11.8)
- 5,001-15,000	7 (30.4)	70 (37.4)
- 15,001-30,000	5 (21.7)	30 (16.0)
- 30,001-50,000	2 (8.7)	17 (9.1)
- >50,001	1 (4.3)	5 (2.7)

4.2.2 Clinical data

Most participants never smoked, 19 (82.6%) and 128 (68.4%) for T1DM and T2DM respectively (Table 23). There were 22 (95.6%) and 118 (63.1%) T1DM and T2DM respectively who had been diagnosed with diabetes for more than five years. There were 20 (87.0%) T1DM who received insulin as treatment, and 142 (75.9%) T2DM were treated with oral medication. Thirteen (56.5%) and 163 (87.2%) T1DM and T2DM respectively had multimorbidity, for example, hypertension, kidney disease, and lipid disorders. In addition, there were six (26.1%) and 88 (47.1%) T1DM and T2DM respectively taking more than five drugs orally.

For blood sugar levels, the study included fasting blood sugar (FBS) and haemoglobin A1c (HbA1c). The normal range of FBS is 70 - 130 mg/dL. At baseline, 4 (17.4%) of T1DM and 71 (38.0%) of T2DM had FBS in the normal range respectively. For HbA1c, 1 (4.3%) of T1DM and 62 (33.2%) of T2DM had HbA1c in the normal range (<7 mg%) respectively. At 3-month follow-up, 20 (90.9%) T1DM had doctor appointments during the 3-month period. Twelve (52.2%) and 13 (56.5%) of which were for updated FBS and HbA1c respectively. One-hundred and thirty-eight (83.6%) T2DM got the appointment during the 3-month period. Seventy-one (38.4%) and 64 (35.4%) of which were updated FBS and HbA1c respectively. There were 2 (16.7%) of T1DM and 30

(42.3%) of T2DM who were reported FBS in the normal range (70 - 130 mg/dL) respectively. And there were 2 (15.4%) of T1DM and 22 (34.4%) of T2DM who had HbA1c in the normal range (<7 mg%) respectively.

Table 23: Clinical data

	T1DM (%)	T2DM (%)
Smoking status		
- Never smoked	19 (82.6)	128 (68.4)
- Former smoker	3 (13.0)	34 (18.2)
- Current smoker	1 (4.3)	25 (13.4)
Diabetes Duration		
- 6-12 mo	0	9 (4.8)
- >1-3 yr	0	30 (16.0)
- >3-5 yr	1 (4.3)	30 (16.0)
- >5-10 yr	9 (39.1)	54 (28.9)
- >10 yr	13 (56.5)	64 (34.2)
Tx regimen		
- Food	0	2 (1.1)
- Insulin or oral med	20 (87.0)	142 (75.9)
- Insulin and oral med	3 (13.0)	43 (23.0)
Multimorbidity (having diseases ≥ 2)	13 (56.5)	163 (87.2)
Polypharmacy (taking oral drugs ≥ 5)	6 (26.1)	88 (47.1)
Blood sugar level		
➢ At baseline		
FBS (mg/dL); normal range 70-130		
- <70	2 (8.7)	1 (0.5)
- 70-130	4 (17.4)	71 (38.4)
- >130	17 (73.9)	113 (61.1)
HbA1c (mg%); normal range <7		
- <7	1 (4.3)	62 (34.3)
- 7-9	12 (52.2)	70 (38.7)
- >9	10 (43.5)	49 (27.1)
Blood sugar level		
➢ At three-month follow up (N=187) *		
- Treatment update	20 (90.9)	138 (83.6)
- FBS update	12 (52.2)	71 (38.4)
- HbA1c update	13 (56.5)	64 (35.4)
FBS (mg/dL); normal range 70-130		
- <70	0	0
- 70-130	2 (16.7)	30 (42.3)
- >130	10 (83.3)	41 (57.7)
HbA1c (mg%); normal range <7		
- <7	2 (15.4)	22 (34.4)
- 7-9	4 (30.8)	23 (35.9)
- >9	7 (53.8)	19 (29.7)

*: At three-month follow up, some patients were recalled undergoing blood tests. It should be noted that the interview appointments for some patients might not align with their hospital appointments.

4.2.3 Other variables (self-reported questionnaire)

Symptom status, functional status, general health and oral health perceptions (GHP), overall QoL and psychological variables; SOC, HLOC, and self-esteem were collected by phone interview. The results can be seen in Table 24 and Table 25.

4.2.3.1 Symptom status

Symptom status was assessed using the XI. Xerostomia prevalence was evaluated using item four: “My mouth feels dry”. The participants who responded “yes” were counted as having xerostomia. The prevalence of xerostomia was 65.2% of T1DM and 41.2% of T2DM.

T1DM and T2DM mean sum scores at baseline and 3-month follow-up were 21.1 (SD = 6.6, median = 21.0), 18.9 (SD = 7.1, median = 17.0), 20.6 (SD = 6.8, median = 20.0) and 19.3 (SD = 6.9, median = 18.0) respectively (Table 24 and 25). The results showed that most of the participants had mild to moderate symptoms of dry mouth.

4.2.3.2 Functional status

1) Dry mouth

Functional status related to dry mouth was examined using the OHIP-14. Mean sum scores were 8.4 (SD = 6.7, median = 7.0), 7.8 (SD = 9.0, median = 5.0), 9.2 (SD = 9.9, median = 5.5) and 6.8 (SD = 8.6, median = 4.0) for T1DM and T2DM at Baseline and 3-month follow-up respectively (Table 24 and 25). The results suggested functional status related to dry mouth had very mild to mild impact on the participants.

2) Diabetes mellitus

Functional status related to diabetes mellitus was assessed using the ADDQoL-19. Mean average scores were 8.3 (SD = 2.2, median = 8.5) and 7.0 (SD = 2.1, median = 6.7) for T1DM and T2DM respectively (Table 24 and 25). The results showed functional status related to diabetes mellitus had moderate impact on the participants.

Moreover, ADDQoL-19 also includes two questions related to QoL: 1) general-related QoL and 2) diabetic-related QoL. The participants reported having good to extremely good QoL 73.9% and 67.8% for T1DM and T2DM, respectively. In contrast, the participants reported that they would have much better to very much better QoL if they did not have diabetes, 86.9% of T1DM and 71.6% of T2DM.

4.2.3.3 General health perceptions

General health perceptions were assessed by self-reported health assessment and a global oral health rating scale. Mean scores for self-reported health were 2.8 (SD = 0.8, median = 3.0), 2.6 (SD = 0.7, median = 3.0), 2.7 (SD = 0.8, median = 2.5) and 2.5 (SD = 0.7, median = 2.0) for T1DM and T2DM at Baseline and 3-month follow-up respectively (Table 24 and 25). The results indicated participants rated they had moderate to good health.

For global oral health rating scale, mean scores were 3.7 (SD = 1.0, median = 4.0), 3.5 (SD = 0.8, median = 3.0), 3.7 (SD = 0.9, median = 3.5) and 3.4 (SD = 0.8, median = 3.0) for T1DM and T2DM at Baseline and 3-month follow-up respectively (Table 24 and 25). The results indicated participants rated they had fair to good oral health.

4.2.3.4 Psychological distress

Psychological distress was assessed by the HADS. T1DM and T2DM anxiety mean sum scores at baseline and 3-month follow-up were 7.3 (SD = 3.2, median = 7.0), 4.6 (SD = 3.5, median = 4.0), 4.9 (SD = 3.2, median = 5.0) and 3.9 (SD = 3.1, median = 4.0) respectively (Table 24 and 25). The results showed most participants reported levels of anxiety within the normal range.

For depression, T1DM and T2DM mean sum scores at baseline and 3-month follow-up were 6.0 (SD = 3.5, median = 6.0), 3.7 (SD = 3.1, median = 3.0), 3.9 (SD = 3.1, median = 3.0) and 3.5 (SD = 3.3, median = 2.0) respectively (Table 24 and 25). The results showed most participants reported depression levels within the normal range.

Table 24: Data from the self-reported questionnaires at baseline and 3-month follow-up for Type 1 patients

Self-reported questionnaires [Possible score range]	Baseline (N=23)		3-month Follow-up (N=22)		p-value
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
XI [11-55]	21.1(6.6)	21.0 (11-33)	20.6 (6.8)	20.0 (11-33)	.71[1]
OHIP-14 [0-56]	8.4 (6.7)	7.0 (0-25)	9.2 (9.9)	5.5 (0-33)	.77[1]
ADDQoL-19 [1-13]	8.3 (2.2)	8.5 (4-12)	-	-	-
GHP					
- General health [1-5]	2.8 (0.8)	3.0 (1-5)	2.7 (0.8)	2.5 (2-4)	.21[2]
- Oral health [1-5]	3.7 (1.0)	4.0 (2-5)	3.7 (0.9)	3.5 (2-5)	.03[*,2]
HADS					
- Anxiety [0-21] (items 1, 3, 5, 7, 9, 11, 13)	7.3 (3.2)	7.0 (1-15)	4.9 (3.2)	5.0 (1-13)	.02[*,1]
- Depression [0-21] (items 2, 4, 6, 8, 10, 12, 14)	6.0 (3.5)	6.0 (0-12)	3.9 (3.1)	3.0 (0-10)	.05[*,1]
MHLC-C					
- Internality [6-36] (items 1-6)	28.6 (6.1)	29.0 (11-36)	-	-	-
- Chance [6-36] (items 7-12)	18.0 (7.6)	18.0 (6-36)	-	-	-
- Doctor [3-18] (items 13-15)	15.8 (2.3)	17.0 (11-18)	-	-	-
- Other people [3-18] (items 16-18)	10.7 (4.0)	11.0 (3-18)	-	-	-
- SOC [13-91]	59.2 (8.1)	61.0 (38-70)	-	-	-
- RSES [10-40]	20.9 (5.2)	21.0 (10-36)	-	-	-

[*]: Differences statistically significant $p < 0.05$

[1]: using t-test, [2]: using chi-square

Table 25: Data from the self-reported questionnaires at baseline and 3-month follow-up for Type 2 patients

Self-reported questionnaires [Possible score range]	Baseline (N=187)		3-month Follow-up (N=165)		p-value
	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
XI [11-55]	18.9 (7.1)	17.0 (11-52)	19.3 (6.9)	18.0 (11-42)	.60[1]
OHIP-14 [0-56]	7.8 (9.0)	5.0 (0-42)	6.8 (8.6)	4.0 (0-40)	.31[1]
ADDQoL-19 [1-13]	7.0 (2.1)	6.7 (4-12)	-	-	-
GHP					
- General health [1-5]	2.6 (0.7)	3.0 (1-5)	2.5 (0.7)	2.0 (1-4)	.09[2]
- Oral health [1-5]	3.5 (0.8)	3.0 (1-5)	3.4 (0.8)	3.0 (1-5)	<.00[*,2]
HADS					
- Anxiety [0-21] (items 1, 3, 5, 7, 9, 11, 13)	4.6 (3.5)	4.0 (0-16)	3.9 (3.1)	4.0 (0-15)	.04[*,1]
- Depression [0-21] (items 2, 4, 6, 8, 10, 12, 14)	3.7 (3.1)	3.0 (0-12)	3.5 (3.3)	2.0 (0-14)	.62[1]
MHLC-C					
- Internality [6-36] (items 1-6)	30.3 (5.1)	31.0 (16-36)	-	-	-
- Chance [6-36] (items 7-12)	20.9 (9.0)	20.0 (6-36)	-	-	-
- Doctor [3-18] (items 13-15)	16.8 (2.1)	18.0 (8-18)	-	-	-
- Other people [3-18] (items 16-18)	10.7 (4.9)	10.0 (3-18)	-	-	-
- SOC [13-91]	65.9 (8.8)	67.0 (36-80)	-	-	-
- RSES [10-40]	20.2 (3.2)	21.0 (11-28)	-	-	-

[*]: Differences statistically significant $p < 0.05$

[1]: using t-test, [2]: using chi-square

4.2.3.5 Psychological variables

1) Health locus of control

HLOC was examined by multidimensional health locus of control scale form C (MHLC-C). The questionnaire covered individual's beliefs in internality (items 1 - 6), chance (items 7 - 12), doctor (items 13 - 15) and other people (items 16 - 18). There are 6-point scales of agreement. The higher score indicated the higher belief in that dimension.

The possible range of internality, chance, doctor, and other people beliefs were 6 - 36, 6 - 36, 3 - 18 and 3 - 18 respectively. For internality belief, T1DM and T2DM mean sum scores were 28.6 (SD = 6.1, median = 29.0) and 30.3 (SD = 5.1, median = 31.0) respectively. T1DM and T2DM mean sum scores for chance belief were 18.0 (SD = 7.6, median = 18.0) and 20.9 (SD = 9.0, median = 20.0) respectively. T1DM and T2DM mean sum scores for doctor belief were 15.8 (SD = 2.3, median = 17.0) and 16.8 (SD = 2.1, median = 18.0) respectively. For other people belief, T1DM and T2DM mean sum scores were 10.7 (SD = 4.0, median = 11.0) and 10.7 (SD = 4.9, median = 10.0) respectively (Table 24 and 25). The results showed most participants had fairly high belief in internality and doctor. The participants also had moderate belief in chance and other people.

2) Sense of coherence (SOC)

SOC was examined using the short form of Antonovsky's sense of coherence scale (SOC-13). There were 7-point rating scales (possible range 13 - 91). The higher score indicated the greater sense of coherence. Mean scores were 59.2 (SD = 8.1, median = 61.0) and 65.9 (SD = 8.8, median = 67.0) respectively (Table 24 and 25). The results showed most participants had moderate sense of coherence.

3) Self-esteem

Self-esteem was assessed using Rosenberg self-esteem scale (RSES) with 4-point Likert scale (possible range 10 - 40). The higher score indicated the lower self-esteem. Mean scores were 20.9 (SD = 5.2, median = 21.0) and 20.2 (SD = 3.2, median = 21.0) respectively (Table 24 and 25). The results showed most participants had fairly high self-esteem.

4.2.4 Conclusions

In summary, 210 diabetic patients participated in this study: 23 (11.0%) had Type 1 diabetes, and 187 (89.0%) Type 2 diabetes, reflecting the prevalence of the conditions in the population (Banday et al., 2020). The mean age of T2DM was higher than that of T1DM. This difference may be because Type 1 diabetes mostly occurs during childhood, while Type 2 diabetes tends to increase with age (Skyler et al., 2017; Banday et al., 2020). The number of males and females was nearly equal. The study also found that individuals with Type 1 tended to have higher education levels. This might be a result of the establishment of loan funding in Thailand in 1995, which led the younger generation to have higher education levels. Those with higher education levels also had higher incomes.

For clinical data, most participants were non-smokers. Almost all of those with T1DM and over half of those with T2DM had been diagnosed for more than five years. Approximately three-quaters of T1DM were treated with insulin, whereas four-fifths of T2DM were treated with oral medications. Unsurprisingly, individuals with T2DM reported a higher prevalence of co-diseases due to age. Likewise, those with T2DM had more experience with polypharmacy.

Blood sugar levels were reviewed using two indicators: fasting blood sugar (FBS) and haemoglobin A1c (HbA1c). Less than 20% of T1DM had FBS and HbA1c within their normal range, while approximately 40% of T2DM had FBS and HbA1c within their normal range. The pandemic placed patients under greater stress, which may have resulted in more negative health behaviours such as, poor dietary control.

For patient-reported outcomes, xerostomia prevalence was 65.2% for T1DM and 41.2% for T2DM. Most participants experienced mild to moderate symptoms of dry mouth. In terms of functional status, participants reported very mild to mild impacts on oral functional status and moderate impacts on diabetic-related functional status. Approximately 70% of participants reported good to extremely good QoL. However, when considering diabetes, around 80% of the participants rated that their QoL would be better to very much better if they did not have diabetes.

For health perceptions, participants rated their overall health as moderate to good, and their oral health as fair to good. Most participants' psychological distress (anxiety and depression) were within normal range. It is interesting that T1DM had slightly higher levels of anxiety and depression. This might be due to the longer duration of diabetes among

T1DM, as well as the ability to deal with stress may possibly be lower in those in younger age groups.

Additionally, this study examined three psychological variables: HLOC; SOC; and self-esteem. Most participants had relatively high belief in internality and doctors, and moderate belief in chance and other people. The study also revealed that T2DM had higher beliefs in internality, chance, and doctors. This difference might be because T2DM participants were generally older than T1DM participants. Similarly, most had moderate coping abilities or SOC and T2DM also had higher SOC. Finally, most participants had fairly high level of self-esteem.

In the next section, the bivariate analyses will be reported.

4.3 Bivariate analyses

As can be seen in the previous section, the results between baseline and 3-month follow-up were very similar. Also, the number of the Type 1 diabetic patients was low. Moreover, Type 1 and Type 2 diabetes, have different pathogenesis which leads to differentiation of progression and prognosis (Skyler et al., 2017). As a result, and given the markedly different sample sizes, Type 1 and Type 2 were analysed separately. This section will report only on T2 diabetic patients at baseline (the analysis of the T1 diabetic patients can be found in Appendix F).

This section will report the associations among variables using Pearson correlation coefficient and Spearman's rank correlations.

There were variables for which higher scores previously indicated better conditions, namely ADDQoL-19, general oral health perceptions, HLOC, and SOC, but these did not correspond to the other variables. For ease of interpretation, these variables were recoded to have higher scores indicating worse conditions.

In addition, the treatment regime, FBS, and HbA1c were reclassified for the analysis (Table 26). The classification of other variables can be seen in Table 21 (Chapter 3, Section 3.6.9, Page 112).

Table 26: Re-classification coding

Variables	Original coding	Recoding
Diabetic-related biological status		
- Treatment regime	1 = diet only 2 = tablets or insulin 3 = insulin and tablets	1 = diet, tablets, or insulin 2 = insulin and tablets
- FBS	1 = less than 70 mg/dL 2 = 70 to 130 mg/dL 3 = 130 or more mg/dL	1 = normal range (70-130 mg/dL 2 = not in the normal range
- HbA1c	1 = below 7% 2 = 7% to 9% 3 = 9% or more	1 = normal range (< 7% mmol/mol) 2 = not in the normal range

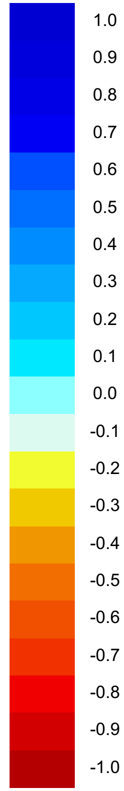
The results of the correlation coefficient among variables for Type 2 diabetic patients at baseline only is illustrated in Table 28. The correlation coefficient shows strength and direction between the variables. The strength of the correlation is between 0 (negligible correlation) to 1 (very high correlation). The positive relationships mean the variables related in the same direction, while the negative relationships indicate the opposite direction (Mukaka, 2012). The interpretation of the correlation coefficient is shown in the Table 27.

Table 27: Interpreting size of correlation coefficient (Mukaka, 2012)

Size of Correlation (*r*)	Interpretation
.90 to 1.00 (-.90 to -1.00)	Very high positive (negative) correlation
.70 to .90 (-.70 to -.90)	High positive (negative) correlation
.50 to .70 (-.50 to -.70)	Moderate positive (negative) correlation
.30 to .50 (-.30 to -.50)	Low positive (negative) correlation
.00 to .30 (-.00 to -.30)	Negligible correlation

Table 28: Correlation matrix among variables in T2 diabetic patients at baseline (N = 187)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1) Age	1																									
(2) Sex [1 = male, 2 = female]	.05	1																								
(3) Education level	.48**	.07	1																							
(4) Income	.31**	.22**	.52**	1																						
(5) Smoking status	.07	.56**	.03	.10	1																					
(6) Diagnosis Duration	.51**	.09	.34**	.20**	.04	1																				
(7) Treatment regime	.17*	.05	.15*	.10	.05	.10	1																			
(8) FBS	.26**	.08	.12	.09	.08	.04	.14	1																		
(9) HbA1c	.10	.00	.03	.05	.05	.09	.22**	.43**	1																	
(10) XI	.10	.03	.22**	.03	.03	.01	.06	.07	.05	1																
(11) OHIP-14	.00	.01	.07	.20**	.01	.00	.03	.02	.11	.63**	1															
(12) ADDQoL-19	.21**	.10	.07	.13	.00	.09	.05	.12	.05	.14	.30**	1														
(13) General Health Perception	.09	.01	.12	.04	.06	.03	.01	.05	.04	.24**	.10	.05	1													
(14) General Oral health Perception	.06	.00	.06	.09	.07	.10	.08	.04	.03	.31**	.42**	.05	.25**	1												
(15) QoL in general	.06	.09	.08	.13	.00	.16*	.01	.08	.03	.19**	.11	.12	.39**	.22**	1											
(16) Diabetic-related QoL	.23**	.09	.16*	.13	.02	.14	.07	.01	.06	.11	.13	.62**	.01	.01	.02	1										
(17) Anxiety	.15*	.03	.21**	.21**	.01	.11	.04	.02	.05	.46**	.56**	.43**	.26**	.24**	.26**	.28**	1									
(18) Depression	.10	.04	.09	.14	.08	.02	.01	.06	.04	.38**	.41**	.39**	.27**	.25**	.31**	.18*	.62**	1								
(19) SOC-13	.16*	.03	.16*	.13	.06	.13	.01	.05	.01	.32**	.33**	.27**	.25**	.20**	.23**	.18*	.51**	.48**	1							
(20) RSES	.23**	.01	.30**	.26**	.16	.16*	.08	.08	.05	.14	.06	.06	.27**	.01	.43**	.04	.18*	.19*	.27**	1						
(21) Internality beliefs	.00	.03	.06	.03	.08	.10	.06	.04	.07	.10	.09	.14	.14	.05	.00	.04	.17*	.08	.15*	.02	1					
(22) Chance beliefs	.34**	.01	.47**	.26**	.03	.23**	.11	.08	.04	.21**	.16*	.02	.19**	.14	.01	.11	.26**	.22**	.22**	.27**	.05	1				
(23) Doctor beliefs	.22**	.06	.19*	.13	.05	.13	.05	.01	.05	.30**	.22**	.03	.17*	.10	.02	.06	.18*	.17*	.20**	.01	.25**	.18*	1			
(24) Other people beliefs	.32**	.06	.37**	.25**	.07	.10	.12	.17*	.15*	.05	.03	.07	.15*	.08	.00	.06	.04	.02	.01	.23**	.05	.52**	.09	1		
(25) Multimorbidity	.42**	.06	.32**	.04	.15*	.39**	.13	.17*	.03	.12	.13	.09	.05	.09	.07	.11	.00	.10	.04	.17*	.08	.18*	.24**	.12	1	
(26) Polypharmacy	.37**	.03	.28**	.21**	.06	.33**	.05	.19**	.04	.04	.06	.09	.11	.01	.02	.11	.05	.06	.10	.02	.13	.11	.01	.10	.33**	1



*: Correlation statistically significant $p < 0.05$, **: Correlation statistically significant $p < 0.01$

(5) Smoking status: [0 = never smoked, 1 = former smoker, 2 = current smoker], (7) Treatment regime: [1 = diet, tablets, or insulin, 2 = insulin and tablets]

(8) FBS: [0 = not in the normal range, 1 = range between 70 to 130 mg/dL], (9) HbA1c : [0 = not in the normal range, 1 = below 7%]

(19)-(22) were assessed by MHLC-C, (23) Multimorbidity: [0 = having diseases <2, 1 = having diseases ≥ 2], (24) Polypharmacy: [0 = take oral medications <5, 1 = take oral medications ≥ 5]

4.3.1 Associations between demographic variables

As can be seen from Table 28, age was significantly negatively correlated with education level (r = -.48, p < 0.01) suggesting that older participants had lower education levels. In addition, older participants had lower incomes (r = -.31, p < 0.01). Unsurprisingly, those who had higher education levels had higher incomes (r = .52 at p < 0.01).

4.3.2 Associations within clinical variables and between clinical and demographic variables

The results of the correlational analysis (Table 28) demonstrated males were more likely to smoke than females (r = -.56, p < 0.01). The study results also showed a significant positive correlation between higher FBS and higher HbA1c (r = .43, p < 0.01).

Furthermore, the study found that individuals taking multiple medicines were more likely to have multimorbidity (r = .33, p < 0.01). Significant positive correlations were also found between polypharmacy and older participants (r = .37, p < 0.01), as well as between a higher number of medications and a longer duration of DM diagnosis (r = .33, p < 0.01). Older participants and those with longer duration of DM diagnosis were also more likely to have multimorbidity (r = .42 and .39, p < 0.01, respectively). In addition, higher prevalence of multimorbidity were more in those with lower education levels (r = -.32, p < 0.01). Those who had lower education levels and older participants were also more likely to have had a DM diagnosis for longer duration (r = -.34 and .51, p < 0.01, respectively).

4.3.3 Associations between symptoms, functioning and psychological variables

A significant positive correlation was found between xerostomia symptoms (XI) and oral functional status (OHIP-14) (r = .63, p < 0.01). The result indicated those who had more severe xerostomia symptoms also had poorer oral functional status. A similar pattern was found between xerostomia symptoms (XI) and general oral health perception (r = .31, p < 0.01), demonstrating that individuals with more severe xerostomia symptoms had poorer general oral health perceptions.

Moreover, it was found that xerostomia symptoms (XI) were significantly positively correlated with psychological distress (HADS) (r =.46, p < 0.01 for anxiety and .38, p < 0.01 for depression). This indicated that individuals with severe xerostomia symptoms reported poorer anxiety and depression. In addition, those who had more severe xerostomia symptoms had lower SOC (r = .32, $p < 0.01$) and were also found to have a lower belief in doctors (r = .30, $p < 0.01$).

Functional oral status (OHIP-14) was significantly positively correlated with diabetic-related functional status (ADDQoL-19) (r = .30, $p < 0.01$) such that those with poorer functional oral status had poorer diabetic-related functional status. There were also significant positive correlations between functional oral status and general oral health perception, psychological distress (anxiety and depression), and SOC. Correlation coefficients were .42, .56, .41, and .33 at $p < 0.01$ for general oral health perception, anxiety, depression, and SOC respectively. These indicate those with more severe functional oral status impacts had poorer general oral health perception, poorer anxiety and depression conditions, and lower SOC.

It was found that diabetic-related functional status (ADDQoL-19) was significantly positively correlated with psychological distress (anxiety and depression) (r = .43, $p < 0.01$ for anxiety and .39, $p < 0.01$ for depression). The results indicate those who had poorer diabetic-related functional status had poorer anxiety and depression conditions. The study also found SOC was significantly positively correlated with psychological distress (anxiety and depression), with correlation coefficients of .51, $p < 0.01$ for anxiety and .48, $p < 0.01$ for depression. These associations suggest that those with a lower SOC had worse anxiety and depression scores.

For QoL, the study found that diabetic-related QoL was significantly positively correlated with diabetic-related functional status (ADDQoL-19) (r = .62, $p < 0.01$). This suggests that higher diabetic-related functional status was, as would be expected, associated with better diabetic-related QoL.

In terms of general QoL, significant positive correlations were found between general QoL and general health perceptions (r = .39, $p < 0.01$), depression (r = .31, $p < 0.01$), and self-esteem (r = .43, $p < 0.01$). These indicate that better general health perceptions, lower levels of depression, and higher self-esteem were associated with higher levels of general QoL.

In addition, the results suggest an association between education levels and self-esteem (RSES), chance and other people beliefs. The result indicated those who had higher education levels had higher self-esteem (r = -.30, $p < 0.01$), lower beliefs in chance (r = .47, $p < 0.01$) and other people (r = .37, $p < 0.01$). Chance and other people beliefs were significantly negatively correlated with age, with correlation coefficients of -.34, $p < 0.01$ for chance belief and -.32, $p < 0.01$ for other people belief. These demonstrated that older participants tended to have more beliefs in chance and other people.

4.3.4 Conclusions

The bivariate analysis utilised the baseline data for Type 2 diabetic patients only. This was because the number of Type 1 diabetic participants recruited to the study was low (11.0%) meaning the two groups could not be compared, nor collapsed into one group due to substantial differences in the disease profile of Type 1 and Type 2 diabetes. In addition, the data for baseline and three-month follow-up were similar so it was decided not to assess changes over time but rather concentrate solely on the baseline dataset.

The data indicated several interesting findings in relation to older individuals. Firstly, older participants tended to have lower education levels, which were associated with lower incomes. Apart from education levels and incomes, older participants also had, unsurprisingly, longer duration of diabetes. In addition, this age group tended to have higher belief in chance and other people, and belief in chance and other people were also positively correlated. The study also revealed that older participants had higher rates of co-diseases and more experience of polypharmacy and there was a positive correlation between multimorbidity and polypharmacy.

Sex was found to be associated with smoking status; males tended to have a higher prevalence of smoking. For education levels, it was found that higher education levels were associated with higher incomes, shorter duration of diabetes, and lower prevalence of multimorbidity. Individuals with higher education levels had higher levels of self-esteem and lower belief in chance and other people.

Moreover, the study found that those with longer diabetes duration tended to have higher prevalence of multimorbidity and polypharmacy. Unsurprisingly, FBS was associated with HbA1c.

Individuals with worse dry mouth symptom status had worse oral functional status and lower general oral health perceptions. The study also found those with poorer dry mouth symptom status tended to have higher levels of anxiety and depression. Similarly, this group of participants had lower levels of SOC and a belief in doctors.

There was an association between oral functional status and diabetic-related functional status; individuals with worse oral functional status also had poorer diabetic-related functional status. In turn, those with worse oral functional status tended to have poorer general oral health perceptions. It is noteworthy that individuals with poorer oral functional status had higher levels of anxiety and depression, as well as lower levels of SOC.

In terms of diabetic-related functional status, the study found that individuals with worse diabetic-related functional status also had poorer diabetic-related QoL; poorer diabetic-related functional status was in turn, associated with higher levels of anxiety and depression. Anxiety and depression were also associated with one another.

Individuals with worse general QoL also had poorer general health perceptions and lower levels of depression. In addition, those with poorer general QoL tended to have lower levels of self-esteem. Interestingly, SOC was positively associated with anxiety and depression; those individuals with lower levels of SOC were more likely to experience higher levels of anxiety and depression.

A summary of the bivariate relationships in this study can be seen in Figure 10.

In the next section, the SEM analysis will be reported.

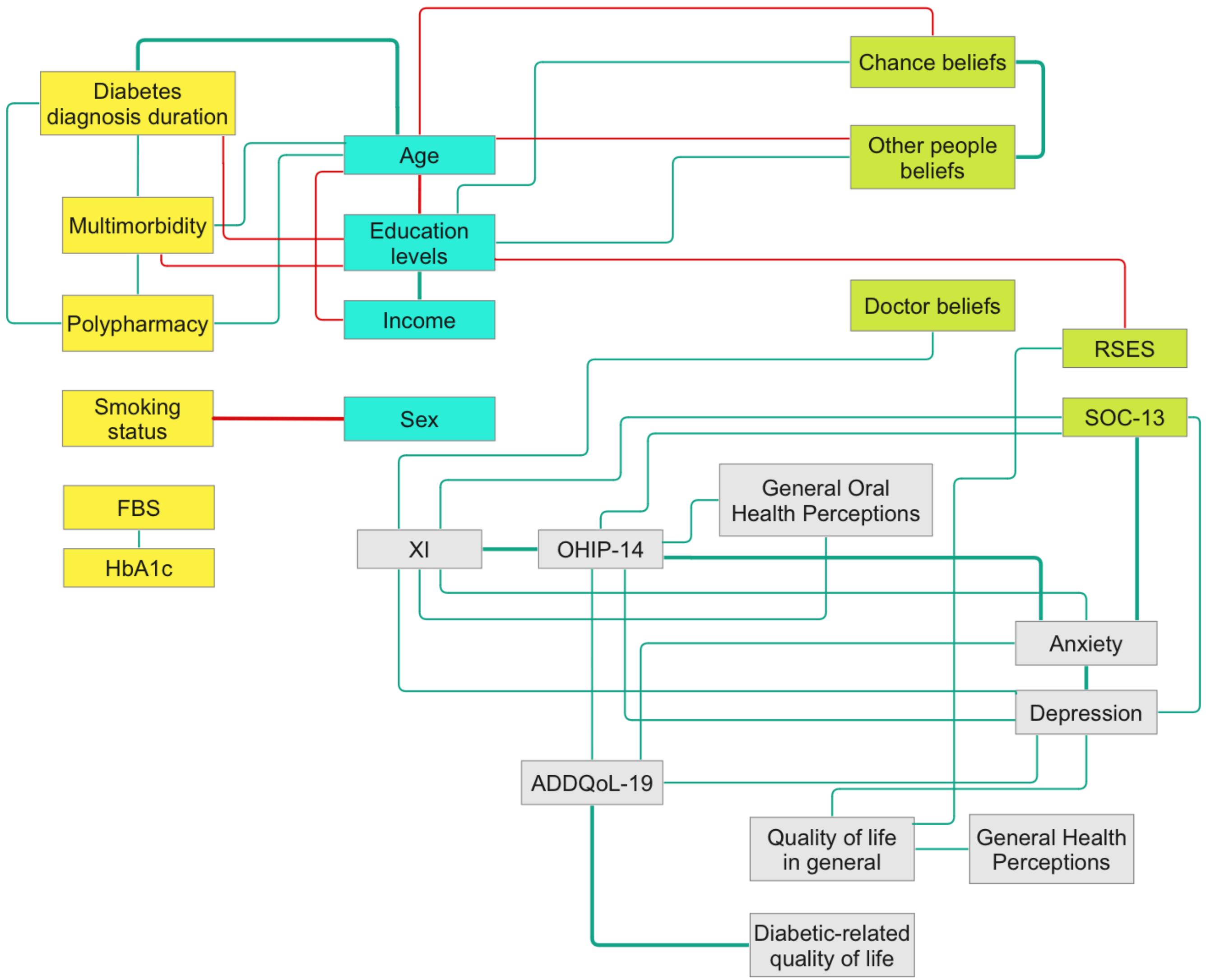


Figure 10: Summary of bivariate associations (green arrows = positive associations, red arrows = negative associations)

For coding, refer to Table 21 (Chapter 3, Section 3.6.9, Page 112) and Table 26 (Chapter 4, Section 4.3, Page 127), higher scores indicate poorer conditions.

4.4 Structural equation modelling

Structural equation modelling (SEM) is a powerful technique utilised to measure and analyse the correlations of the set of associations in an *a priori* hypothesised model (Beran and Violato, 2010; Ullman and Bentler, 2012). According to Anderson and Gerbing (1988), there are two steps recommended in SEM. First, Step 1, is confirmatory factor analysis (CFA) in which the measurement model for each latent variable is evaluated (see Section 4.4.1). Step 2 is testing the structural model which is developed based on *a priori* theory (for this study, the Wilson and Cleary model, 1995) (Section 4.4.2).

As mentioned earlier, the number of Type 1 diabetic participants was low, and the results between baseline and three-month follow-up were similar. Thus, as with the bivariate associations in the section above, the SEM analysis includes only baseline data for the Type 2 diabetic patients.

This section will report Step 1 CFA followed by Step 2, the structural model based on Wilson and Cleary (1995).

4.4.1 Confirmatory factor analysis (CFA)

CFA is the approach used to test measurement models. The measurement model is that which consists of the latent variable and the indicator (observed) variables. Since latent variables cannot be directly assessed, the observed variables are used as indicator items (variables) for the latent variable.

The analysis started by examining each latent variable to determine whether the indicator items were suitable representations of the latent variables. The fit indices criteria used to assess the model fit in SEM are as follows: Chi-square/degrees of freedom (CMIN/DF) should be less than 3, comparative fit index (CFI) should be close to 0.95, root mean square error of approximation (RMSEA) should be less than 0.06, and standardised root mean square residual (SRMR) should be less than 0.08 (Hu and Bentler, 1999; Baker, 2007b; Iacobucci, 2009; Kline, 2016).

In the present study, three latent variables were tested: individual (demographic), overall QoL, and HLOC. The individual (demographic) variable included age, sex, education level, income level, and smoking status. Age was grouped into 10-year intervals (10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89), while the other variables were grouped as described in the descriptive analysis section.

However, the results indicated that the latent variable demonstrated poor fit to the data, with the following fit indices: CMIN/DF = 14.491, CFI = 0.613, RMSEA (90% CIs) = 0.269 (0.216-0.326), and SRMR = 0.1473.

Given these findings, the demographic latent variable raised concerns. Due to the data being collected from a single hospital during the pandemic and the low response rate, it could be possible that the demographic group was fairly homogenous. Consequently, the individual (demographics) variable was excluded from the structural model and the model re-run (Step 2).

For HLOC, this variable comprised four indicator items: internality belief, chance belief, doctor belief, and other people belief. The modification indices suggested that allowing the error terms of internality and doctor beliefs to co-vary could potentially improve the model fit. Thus, internality and doctor beliefs were allowed to correlate.

The results indicated that the latent variable demonstrated an excellent fit to the data, with the following fit indices: CMIN/DF = 1.558, CFI = 0.992, RMSEA (90% CIs) = 0.055 (0.000-0.212), and SRMR = 0.0247. The bootstrap item loadings are illustrated in Figure 11. The latent variable is in an ellipse, indicator variables are in rectangles, and residual error terms are in circles.

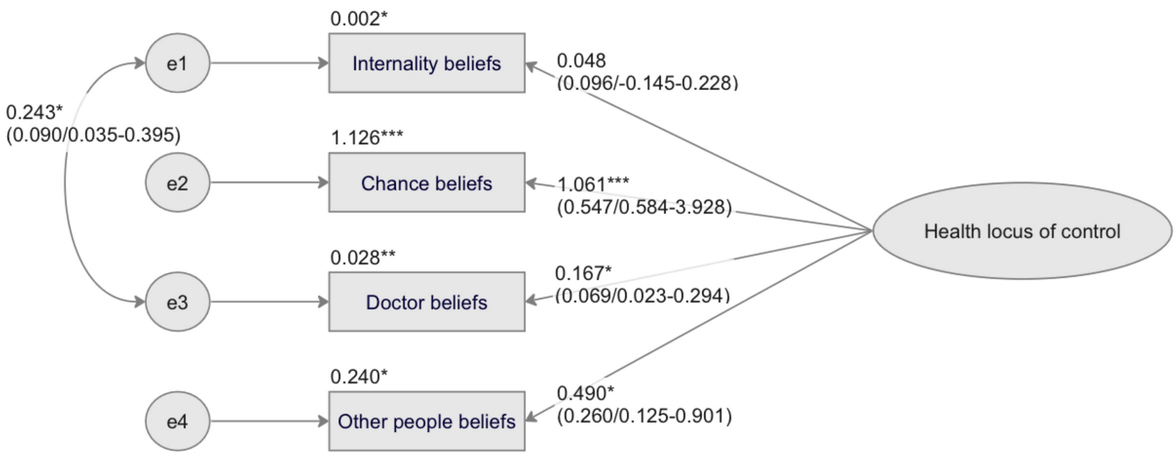


Figure 11: Bootstrap item loadings (SE/BC 95% CIs), squared multiple correlations, and covariances (SE/BC 95% CIs) of HLOC. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

As can be seen in Figure 11, the bootstrap loading of chance belief was notably high compared to the other items. Also, since the indicator items were derived from the same questionnaire, the loadings of each item should be equal. However, the results indicated that the items might not be representative of HLOC of Thai Type 2 diabetic patients in this study. As a result, the HLOC variable was excluded from the structural (Step 2) model (discussion of HLOC in the study is further explored in Chapter 5, Page 168 - 169).

In terms of the overall QoL latent variable, it included two indicator items: two general questions related to general QoL and diabetic-related QoL (derived from the general questions in ADDQoL-19 questionnaire), and two indicator items for anxiety and depression (from the HADS questionnaire). The results indicated that the latent variable showed an acceptable fit to the data, with the following fit indices: CMIN/DF = 2.914, CFI = 0.970, RMSEA (90% CIs) = 0.101 (0.000-0.202), and SRMR = 0.0376. The bootstrap item loadings are illustrated in Figure 12.

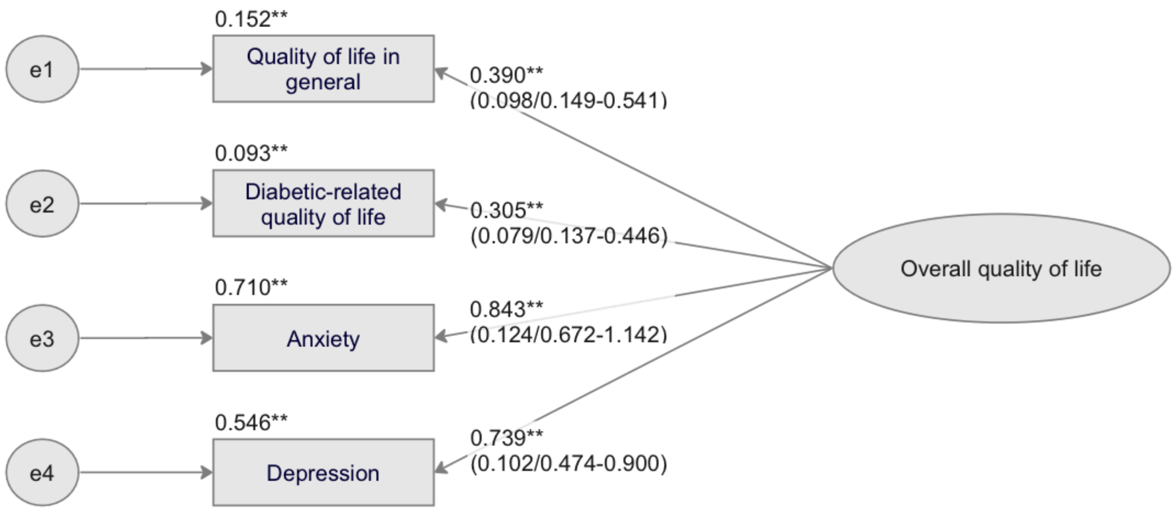


Figure 12: Bootstrap item loadings (SE/BC 95% CIs) and squared multiple correlations of overall QoL. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

As can be seen in Figure 12, the bootstrap loadings were approximately equivalent, and the study demonstrated that all loading factors were in the expected directions. These results demonstrated an acceptable overall QoL latent variable.

In addition, the results showed all loading factors were significant: QoL in general (β = .39, $p < 0.01$) with R^2 of .15, diabetic-related QoL (β = .31, $p < 0.01$) with R^2 of .09, anxiety (β = .84, $p < 0.01$) with R^2 of .71, and depression (β = .74, $p < 0.01$) with R^2 of .55.

4.4.2 Structural equation modelling

The structural model is the next step in SEM in which the hypothesised conceptual model is tested between observable (observed) and unobservable (latent) variables (Kline, 2016).

The proposed model in this study was based on the Wilson and Cleary model (1995). The Wilson and Cleary (1995) model (Chapter 2, Page 82) depicts association between five main factors: biological status, symptoms, functional status, general health perceptions and overall QoL. The model depicts both direct and indirect paths among these variables. Wilson and Cleary also suggest that there are a range of individual and environmental factors that are likely to be associated with these relationships.

The study hypotheses were that diabetic duration, treatment regime, blood sugar levels: FBS and HbA1c (diabetic-related health status) would predict dry mouth symptoms, dry mouth symptoms would predict oral and diabetic-related functional status, oral and diabetic-related functional status would predict oral and general health perceptions, as well as oral and general health perceptions would predict overall QoL. These relationships would also be associated with SOC, and self-esteem. Furthermore, multimorbidity would predict polypharmacy and diabetic duration, treatment regime, blood sugar levels: FBS and HbA1c (diabetic-related health status).

The psychological factors, namely SOC and self-esteem, were hypothesised to influence symptoms, functional status, general health perceptions and overall QoL. SOC refers to the capability to deal with problems and self-esteem is the beliefs in oneself or self-confidence. These two psychological factors can, in turn, influence health-related behaviours.

Furthermore, considering that dry mouth and diabetes are chronic conditions in which individuals' behaviour can either improve or worsen the conditions. Based on this understanding, the hypothesis was formulated that these two psychological factors might impact symptoms, functional status, general health perceptions and overall QoL.

For multimorbidity, it is evident that individuals with more disease are more likely to take multiple medications (polypharmacy). Additionally, the presence of multimorbidity was found to be correlated with the diabetic diagnosis duration. Also, those with multimorbidity might alter the diabetes treatment regime, which could potentially have an effect on blood sugar levels. The hypothesis that multimorbidity might have direct effects on polypharmacy and diabetic duration, treatment regime, blood sugar levels: FBS and HbA1c (diabetic-related health status) was also tested.

The hypothesised model is presented in Figure 13.

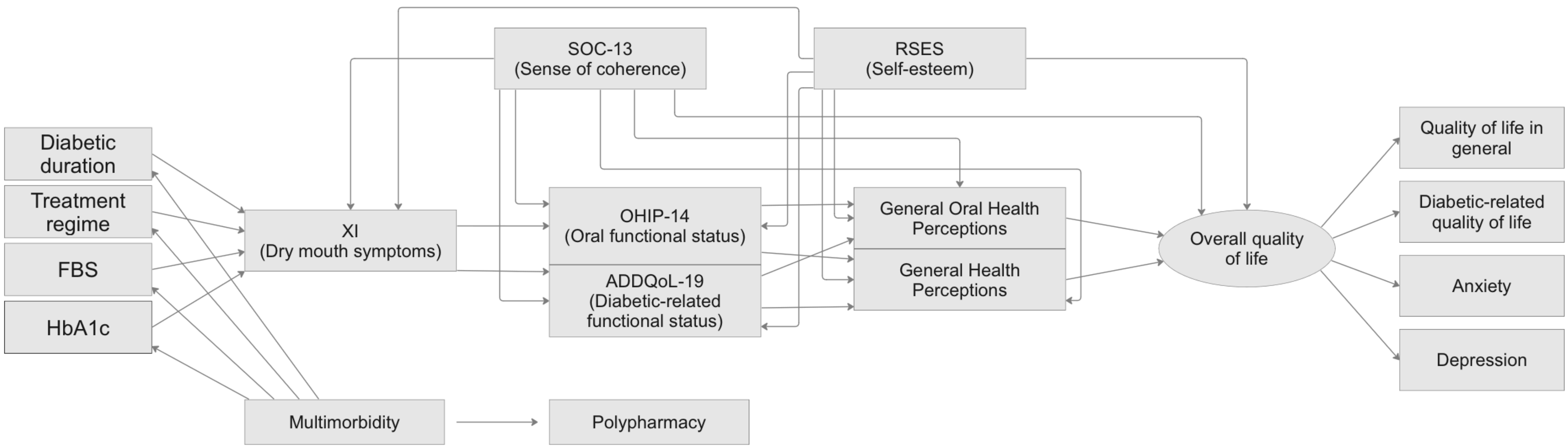


Figure 13: Modified hypothesised model based on the Wilson and Cleary model (1995)

Table 29: Structural model fit indices

Model	CMIN/DF	CFI	RMSEA (90% CIs)	SRMR
(1) Hypothesised model	3.765	0.609	0.122 (0.109-0.135)	0.1125
(2) Full model	2.533	0.853	0.091 (0.074-0.107)	0.0630

CMIN/DF: chi-square/degrees of freedom, CFI: comparative fit index, RMSEA: root mean square error of approximation, SRMR: standardised root mean square residual

The fit indices of the hypothesised model can be seen in Table 29. This indicated that this model did not fit the data well. The hypothesised model was then modified. The modification of the model was based on previous studies, justifications, and modification indices.

Bergdahl and Bergdahl (2000) studied the associations between unstimulated salivary flow, xerostomia, medication, anxiety, depression, and stress in lay people aged 20- to 69-year-old. The study reported direct associations among individuals with xerostomia along with having unstimulated salivary flow less than 0.1 mL/min and anxiety, depression as well as medication. A direct path between dry mouth symptoms and overall QoL thus was added to the model, as anxiety and depression were indicator variables of overall QoL.

Furthermore, Baker et al. (2006) aimed to evaluate the accurate measurements of OHRQoL, including OHIP-14, in xerostomia patients. They reported a direct relationship between OHIP-14 and depression. Similarly, the direct non-adjacent path between oral functional status (OHIP-14) and subjective well-being (anxiety and depression) were found in xerostomia patients (Baker et al., 2007). Therefore, the hypothesis of association between oral functional status (OHIP-14) and overall QoL (since depression and anxiety were part of the indicators) was considered. And for ease of interpretation, the direct path between diabetic-related functional status (ADDQoL-19) and overall QoL was also added to the model.

Moreover, in their systematic review, Ojelabi et al. (2017) determined the associations between variables within the Wilson and Cleary model (1995). Interestingly, they found associations between adjacent variables, and also non-adjacent factors which were: physiological factors and functional status, physiological factors and general health perceptions, physiological factors and overall QoL, symptom status and general health perceptions, as well as symptom status and overall QoL. Considering this finding along with modification indices, diabetic duration, treatment regime, blood sugar levels: FBS and HbA1c (diabetic-related health status) would predict (oral and diabetic-related) functional status, and symptom status would predict general and oral health perceptions were hypothesised.

As mentioned earlier, psychological factors might influence health-related behaviour. Therefore, it was hypothesised that psychological factors could also impact on multimorbidity and polypharmacy. Given the presence of multimorbidity and polypharmacy might impact on how individuals perceive their health and overall QoL, a path between multimorbidity and general oral health perceptions, general health perceptions, and overall QoL was included in the model. Also, a path between polypharmacy and general oral health perceptions, general health perceptions, and overall QoL was added.

Based on the modification indices, additional paths were also added between multimorbidity and diabetic diagnosis duration, treatment regime, HbA1c, and FBS (diabetic-related clinical status). In addition, paths between polypharmacy and diabetic diagnosis duration, treatment regime, HbA1c, and FBS (diabetic-related clinical status) were included.

Finally, covariances were added to take account of the associations between the two psychological factors, between oral and general health perceptions, between diabetic-related and oral functional status, between blood sugar levels: HbA1c and FBS, and treatment regime, and between multimorbidity and polypharmacy.

This modified full model is illustrated in Figure 14. The result showed model was acceptable fit (CMIN/DF = 2.533, CFI = 0.853, RMSEA (90% CIs) = 0.091 (0.074-0.107), and SRMR = 0.0630: Table 29).

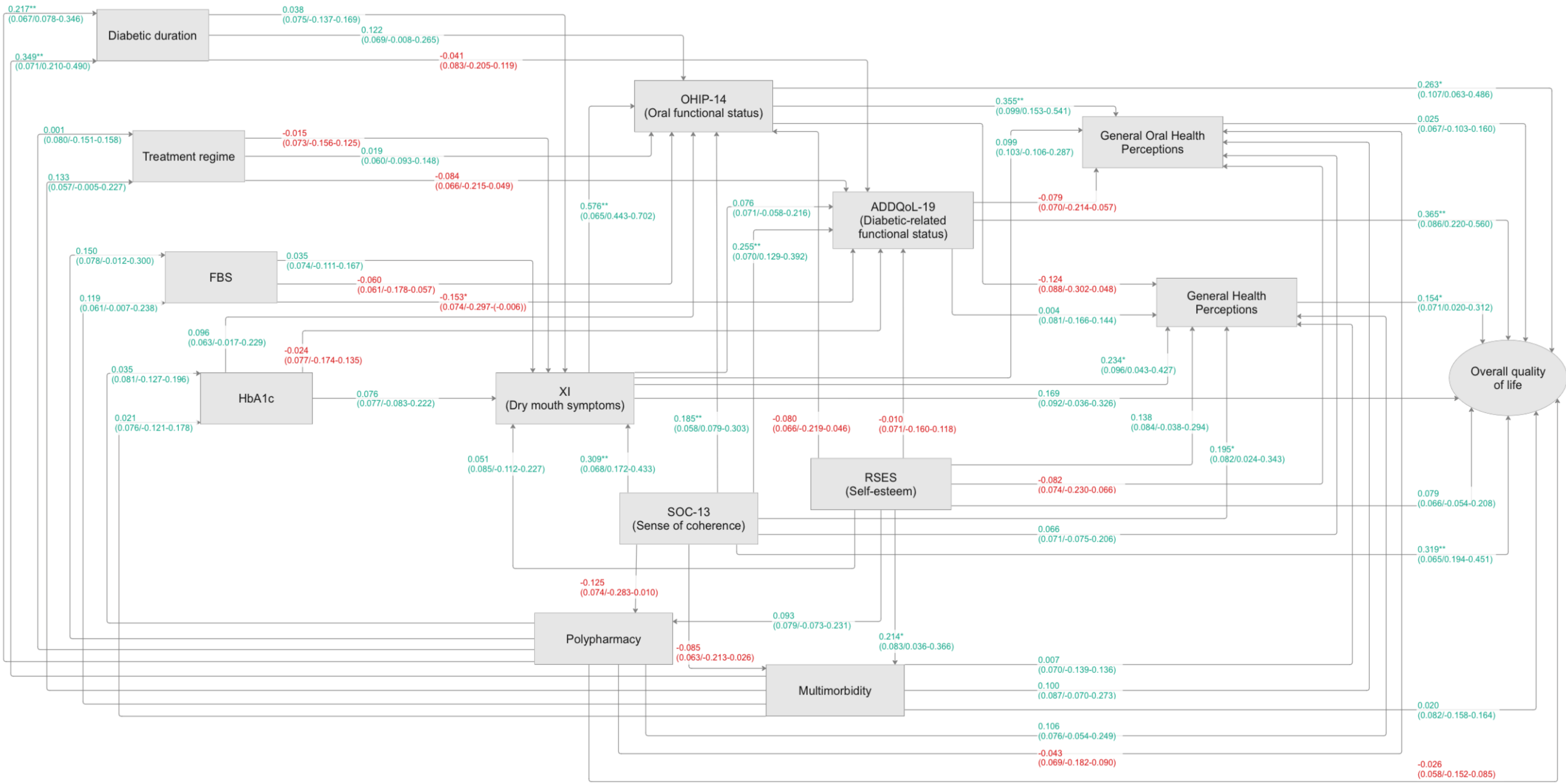


Figure 14: Bootstrap standardised estimates (SE/BC 95% CIs) for the full model. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.
Indicator variables, error terms and covariances are omitted for ease of interpretation. Green letters, positive associations; red letters, negative associations.

Table 30 below reports bootstrap standardised regression weights (β), SEs, and Bias-corrected 95% CI of the full model.

Table 30: Direct effects of the full model

Effects	β	Bootstrap SE	Bias-corrected 95% CI
Diabetic diagnosis duration			
- Symptom status	0.04	0.08	-0.14/0.17
- Oral functional status	0.12	0.07	-0.01/0.27
- Diabetic-related functional status	-0.04	0.08	-0.21/0.12
Treatment regime			
- Symptom status	-0.02	0.07	-0.16/0.13
- Oral functional status	0.02	0.06	-0.09/0.15
- Diabetic-related functional status	-0.08	0.07	-0.22/0.05
FBS			
- Symptom status	0.04	0.07	-0.11/0.17
- Oral functional status	-0.06	0.06	-0.18/0.06
- Diabetic-related functional status	-0.15	0.07	**-0.30/-0.01***
HbA1c			
- Symptom status	0.08	0.08	-0.08/0.22
- Oral functional status	0.10	0.06	-0.02/0.23
- Diabetic-related functional status	-0.02	0.08	-0.17/0.14
Symptom status			
- Oral functional status	0.58	0.07	**0.44/0.70****
- Diabetic-related functional status	0.08	0.07	-0.06/0.22
- General oral health perceptions	0.10	0.10	-0.11/0.29
- General health perceptions	0.23	0.10	**0.04/0.43***
- Overall QoL	0.17	0.09	-0.04/0.33
Oral functional status			
- General oral health perceptions	0.36	0.10	**0.15/0.54****
- General health perceptions	-0.12	0.09	-0.30/0.05
- Overall QoL	0.26	0.11	**0.06/0.49***
Diabetic-related functional status			
- General oral health perceptions	-0.08	0.07	-0.21/0.06
- General health perceptions	0.00	0.08	-0.17/0.14
- Overall QoL	0.37	0.09	**0.22/0.56****
General oral health perceptions			
- Overall QoL	0.03	0.07	-0.10/0.16
General health perceptions			
- Overall QoL	0.15	0.07	**0.02/0.31***
Multimorbidity			
- Diabetic diagnosis duration	0.35	0.07	**0.21/0.49****
- Treatment regime	0.13	0.06	-0.01/0.23
- FBS	0.12	0.06	-0.01/0.24
- HbA1c	0.02	0.08	-0.12/0.18
- General oral health perceptions	0.10	0.09	-0.07/0.27
- General health perceptions	0.01	0.07	-0.14/0.14
- Overall QoL	0.02	0.08	-0.16/0.16

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 30: Continued

Effects	β	Bootstrap SE	Bias-corrected 95% CI
Polypharmacy			
- Diabetic diagnosis duration	0.22	0.07	**0.08/0.35****
- Treatment regime	0.00	0.08	-0.15/0.16
- FBS	0.15	0.08	-0.01/0.30
- HbA1c	0.04	0.08	-0.13/0.20
- General oral health perceptions	-0.04	0.07	-0.18/0.09
- General health perceptions	0.11	0.08	-0.05/0.25
- Overall QoL	-0.03	0.06	-0.15/0.09
Sense of coherence			
- Symptom status	0.31	0.07	**0.17/0.43****
- Oral functional status	0.19	0.06	**0.08/0.30****
- Diabetic-related functional status	0.26	0.07	**0.13/0.39****
- General oral health perceptions	0.07	0.07	-0.08/0.21
- General health perceptions	0.20	0.08	**0.02/0.34***
- Overall QoL	0.32	0.07	**0.19/0.45****
- Multimorbidity	-0.09	0.06	-0.21/0.03
- Polypharmacy	-0.13	0.07	-0.28/0.01
Self-esteem			
- Symptom status	0.05	0.09	-0.11/0.23
- Oral functional status	-0.08	0.07	-0.22/0.05
- Diabetic-related functional status	-0.01	0.07	-0.16/0.12
- General oral health perceptions	-0.08	0.07	-0.23/0.07
- General health perceptions	0.14	0.08	-0.04/0.29
- Overall QoL	0.08	0.07	-0.05/0.21
- Multimorbidity	0.21	0.08	**0.04/0.37***
- Polypharmacy	0.09	0.08	-0.07/0.23

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

As can be seen from Figure 14 and Table 29 and 30, the full model demonstrated an acceptable fit to the data. The result showed adjacent associations between five main factors. Diabetic diagnosis duration, treatment regime, FBS, and HbA1c were found to be associated with dry mouth symptoms. Individuals with a longer duration of DM and those with FBS and HbA1c not in the normal range tended to experience worse dry mouth symptoms. Surprisingly, individuals with more complex treatment regimens were more likely to have better dry mouth symptoms.

Self-reported dry mouth symptoms were associated with oral and diabetic-related functional status. This suggests that people who report a greater severity of symptoms experienced worse oral and diabetic-related functioning in everyday life.

Regarding functional status, it was found to be associated with health perceptions. Individuals with better oral functional status tended to perceive better general oral health, but poorer general health. Conversely, those with better diabetic-related functional status tended to perceive better general health, but poorer general oral health.

In addition, the study found that general oral health perceptions and general health perceptions were linked with overall QoL. This indicates that individuals with more negative health perceptions also reported lower overall QoL.

Moreover, the study also found non-adjacent relationships among the main factors. Diabetic diagnosis duration, treatment regime, FBS, HbA1c were found to be associated with both oral and diabetic-related functional status. Individuals with a longer duration of DM, complex treatment regimens, and HbA1c not in the normal range tended to report poorer oral functional status, but better diabetic-related functional status. While those with FBS not in the normal range tended to report poorer oral and diabetic-related functional status.

In term of dry mouth symptoms, the study found links to both general oral health perceptions and general health perceptions, as well as overall QoL. This suggests that those experiencing worse dry mouth symptoms tended to have poorer perceptions of general oral health and general health and reported lower overall QoL.

Unsurprisingly, oral and diabetic-related functional status was found to be associated with overall QoL. The results indicate that individuals with poorer oral and diabetic-related functional status were more likely to report lower overall QoL.

Regarding multimorbidity and polypharmacy, the study found associations with diabetic diagnosis duration, treatment regime, FBS, and HbA1c. The results suggest that individuals experiencing multimorbidity and polypharmacy were more likely to have longer duration of DM, complex treatment regimens, as well as FBS and HbA1c levels that were not within the normal range.

Individuals with multimorbidity and polypharmacy tended to report poorer general health perceptions. Similarly, those with multimorbidity were more likely to report poorer oral general health perceptions. In contrast, those with polypharmacy were more likely to report better oral general health perceptions.

Indeed, findings regarding the impact of multimorbidity and polypharmacy on overall QoL were surprising. Although individuals with multimorbidity tended to report lower overall QoL, those with polypharmacy tended to report better overall QoL.

For psychological variables, SOC and self-esteem, those with lower levels tended to report poorer dry mouth symptoms.

Unsurprisingly, individuals with lower levels of SOC tended to report poorer oral and diabetic-related functional status. Similarly, individuals with lower levels of SOC also tended to perceive poorer general oral health and general health, as well as lower overall QoL.

Interestingly, individuals with lower levels of SOC were more likely to report a lower prevalence of multimorbidity and polypharmacy.

In terms of self-esteem, it was found that individuals with lower levels tended to have better oral and diabetic-related functional status, as well as better general oral health status. However, those with lower levels of self-esteem were more likely to have poorer general health perceptions and lower overall QoL.

Unsurprisingly, individuals with lower levels of self-esteem were more likely to report a higher prevalence of multimorbidity and polypharmacy.

The bootstrap standardised direct, indirect, and total effects (β) of the full model are presented in Table 31.

Table 31: Total effects of the full model

Effects	Direct	Indirect	Total
Diabetic diagnosis duration			
- Symptom status	0.04	0.00	0.04
- Oral functional status	0.12	0.02	0.14
- Diabetic-related functional status	-0.04	0.00	-0.04
- General oral health perceptions	0.00	0.06	0.06
- General health perceptions	0.00	-0.01	-0.01
- Overall QoL	0.00	0.03	0.03
Treatment regime			
- Symptom status	-0.02	0.00	-0.02
- Oral functional status	0.02	-0.01	0.01
- Diabetic-related functional status	-0.08	-0.00	-0.09
- General oral health perceptions	0.00	0.01	0.01
- General health perceptions	0.00	-0.01	-0.01
- Overall QoL	0.00	-0.03	-0.03
FBS			
- Symptom status	0.04	0.00	0.04
- Oral functional status	-0.06	0.02	-0.04
- Diabetic-related functional status	**-0.15***	0.00	**-0.15***
- General oral health perceptions	0.00	0.00	0.00
- General health perceptions	0.00	0.01	0.01
- Overall QoL	0.00	-0.06	-0.06

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 31: Continued

Effects	Direct	Indirect	Total
HbA1c			
- Symptom status	0.08	0.00	0.08
- Oral functional status	0.10	0.04	0.14
- Diabetic-related functional status	-0.02	0.01	-0.02
- General oral health perceptions	0.00	0.06	0.06
- General health perceptions	0.00	0.00	0.00
- Overall QoL	0.00	0.05	0.05
Symptom status			
- Oral functional status	**0.58****	0.00	**0.58****
- Diabetic-related functional status	0.08	0.00	0.08
- General oral health perceptions	0.10	**0.20****	**0.30****
- General health perceptions	**0.23***	-0.07	**0.16***
- Overall QoL	0.17	**0.21****	**0.38****
Oral functional status			
- General oral health perceptions	**0.36****	0.00	**0.36****
- General health perceptions	-0.12	0.00	-0.12
- Overall QoL	**0.26***	-0.01	**0.25***
Diabetic-related functional status			
- General oral health perceptions	-0.08	0.00	-0.08
- General health perceptions	0.00	0.00	0.00
- Overall QoL	**0.37****	-0.00	**0.36****
General oral health perceptions			
- Overall QoL	0.03	0.00	0.03
General health perceptions			
- Overall QoL	**0.15***	0.00	**0.15***
Multimorbidity			
- Diabetic diagnosis duration	**0.35****	0.00	**0.35****
- Treatment regime	0.13	0.00	0.13
- FBS	0.12	0.00	0.12
- HbA1c	0.02	0.00	0.02
- Symptom status	0.00	0.02	0.02
- Oral functional status	0.00	0.05	0.05
- Diabetic-related functional status	0.00	-0.04	-0.04
- General oral health perceptions	0.10	0.02	0.12
- General health perceptions	0.01	-0.00	0.01
- Overall QoL	0.02	0.00	0.02
Polypharmacy			
- Diabetic diagnosis duration	**0.22****	0.00	**0.22****
- Treatment regime	0.00	0.00	0.00
- FBS	0.15	0.00	0.15
- HbA1c	0.04	0.00	0.04
- Symptom status	0.00	0.02	0.02
- Oral functional status	0.00	0.03	0.03
- Diabetic-related functional status	0.00	-0.03	-0.03
- General oral health perceptions	-0.04	0.02	-0.03
- General health perceptions	0.11	0.00	0.11
- Overall QoL	-0.03	0.02	-0.01

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 31: Continued

Effects	Direct	Indirect	Total
Sense of coherence			
- Diabetic diagnosis duration	0.00	**-0.06***	**-0.06***
- Treatment regime	0.00	-0.01	-0.01
- FBS	0.00	**-0.03***	**-0.03***
- HbA1c	0.00	-0.01	-0.01
- Symptom status	**0.31****	-0.00	**0.31****
- Oral functional status	**0.19****	**0.17****	**0.36****
- Diabetic-related functional status	**0.26****	0.03	**0.29****
- General oral health perceptions	0.07	**0.13****	**0.20***
- General health perceptions	**0.20***	0.02	**0.21***
- Overall QoL	**0.32****	**0.29****	**0.61****
- Multimorbidity	-0.09	0.00	-0.09
- Polypharmacy	-0.13	0.00	-0.13
Self-esteem			
- Diabetic diagnosis duration	0.00	**0.10****	**0.10****
- Treatment regime	0.00	**0.03***	**0.03***
- FBS	0.00	0.04	0.04
- HbA1c	0.00	0.01	0.01
- Symptom status	0.05	0.01	0.06
- Oral functional status	-0.08	0.04	-0.04
- Diabetic-related functional status	-0.01	-0.01	-0.02
- General oral health perceptions	-0.08	0.01	-0.07
- General health perceptions	0.14	0.03	0.17
- Overall QoL	0.08	0.02	0.10
- Multimorbidity	**0.21***	0.00	**0.21***
- Polypharmacy	0.09	0.00	0.09

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Based on Table 31, the study showed several indirect effects in the model, there were a total of nine significant indirect paths. It was found that dry mouth symptoms had indirect effect on general oral health perceptions through functional status (β = .20, p < .01). This implies that individuals who self-reported worse dry mouth symptoms also had poorer functional status which, in turn, was associated with poorer perceptions of their oral health. In addition, dry mouth symptoms also indirectly related to overall QoL via functional status and health perceptions (β = .21, p < .01), indicating that those with more severe dry mouth symptom status tended to have poorer functional status and health perceptions which was associated with individuals having lower overall QoL.

SOC showed indirect relationships with diabetic diagnosis duration (β = -.06, p < .05), and FBS (β = -.03, p < .05). This suggests that those with lower levels of SOC tended to have lower prevalence of multimorbidity and polypharmacy, which in turn was associated with those who had a shorter duration of diabetes and FBS within the normal range.

Furthermore, the study also found indirect associations between SOC and oral functional status (β = .17, $p < .01$), general oral health perceptions (β = .13, $p < .01$), and overall QoL (β = .29, $p < .01$). This indicates that those with lower levels of SOC tended to have poorer symptom status which, was associated with poorer oral functioning, lower general oral health perceptions, and decreased overall QoL.

Additionally, the study found that self-esteem was indirectly related to diabetic diagnosis duration (β = .10, $p < .01$), and treatment regime (β = .03, $p < .05$). This suggests that individuals with lower levels of self-esteem were more likely to have higher prevalence of multimorbidity and polypharmacy, which in turn was associated with those who had a longer duration of diabetes and more complex treatment regimens.

Figure 15 below shows the significant direct and indirect paths of the full model.

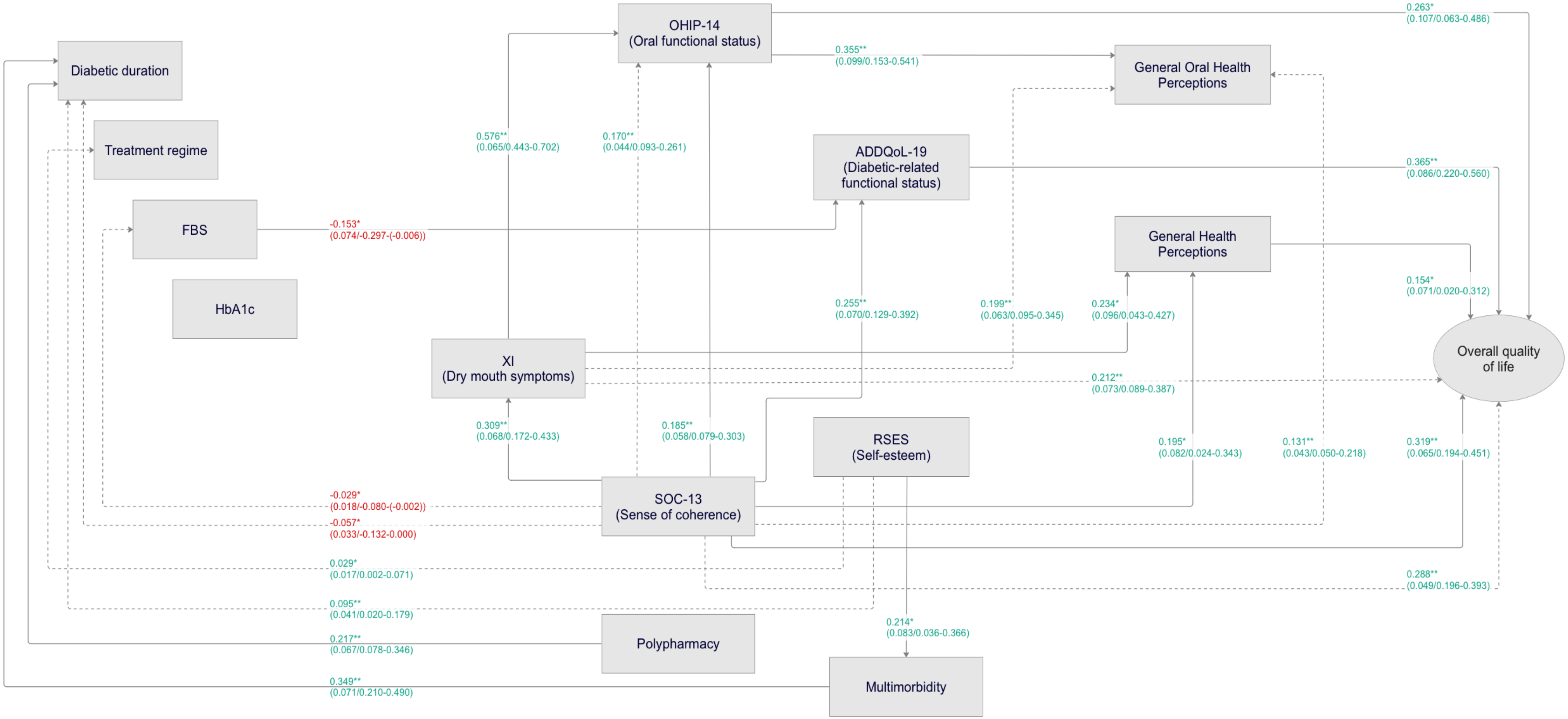


Figure 15: Significant direct and indirect paths of the full model [Bootstrap standardised estimates (SE/BC 95% CIs)]
Indicator variables, error terms and covariances are omitted to ease interpretation. Solid lines, direct paths; dashed lines, indirect paths. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

4.4.3 Conclusions

To sum, findings from this study support the Wilson and Cleary model, showing significant associations between the adjacent five main factors in the model. It is noteworthy that SOC and self-esteem (psychological factors) were associated with dry mouth symptom status, oral and diabetic-related functional status, general oral health and general health perceptions, overall QoL, including multimorbidity and polypharmacy.

The study also found non-adjacent relationships among the five main factors. Diabetic diagnosis duration, treatment regime, FBS, and HbA1c (diabetic-related health status) were found to be associated with oral and diabetic-related functional status, dry mouth symptoms were linked to general oral health and general health perceptions and overall QoL, as well as oral and diabetic-related functional status was associated with overall QoL.

Moreover, the study found nine significant indirect paths, indicating the potential mediating effects of certain variables. It was found that dry mouth symptoms had an indirect effect on general oral health perceptions through functional status. Dry mouth symptoms were also indirectly related to overall QoL via functional status and health perceptions.

SOC showed indirect relationships with diabetic diagnosis duration, FBS, oral functional status, general oral health perceptions, and overall QoL. Additionally, the study found that self-esteem was indirectly related to diabetic diagnosis duration and treatment regime.

Chapter Five

Discussion

5.1 Introduction

The aim of this PhD was to examine the associations between dry mouth and OHRQoL in diabetic patients in Songkhla province, Thailand. The study was observational, with a three-month follow-up period. Type 1 and Type 2 diabetic patients were interviewed, and the medical records were reviewed to collect clinical data. The statistical analysis focused primarily on Type 2 diabetic patients at baseline, due to the number of Type 1 diabetic patients (11%) and the similarity between baseline and follow-up scores.

The study hypothesised that the severity of dry mouth in diabetic patients was associated with overall QoL and utilised the Wilson and Cleary model (Figure 3, Chapter two, Page 83) to elucidate the associations among the main variables (diabetic duration, treatment regime, FBS, HbA1c, dry mouth symptom status, oral and diabetic-related functional status, general oral health and general health perceptions, and overall QoL). Additionally, it was hypothesised that these associations were mediated by multimorbidity, polypharmacy, SOC, and self-esteem. The modified hypothesised model based on the Wilson and Cleary model can be seen in Figure 13 (Chapter four, Page 138), with the final (full) model presented in Figure 14 and 15 (Chapter four, Page 141 and 149).

The findings lend support to Wilson and Cleary's conceptual framework. The results demonstrated both adjacent and non-adjacent direct associations between the main variables. Indeed, indirect paths were also found among the variables.

Interestingly, two individual factors, SOC, and self-esteem, were found to be associated with symptom status, oral and diabetic-related functional status, general oral health and general health perceptions, and overall QoL, including multimorbidity and polypharmacy.

Furthermore, the study demonstrated that multimorbidity and polypharmacy showed an association with diabetic duration, treatment regime, FBS, and HbA1c, general oral health and general health perceptions, and overall QoL.

These findings will be discussed more fully as follows:

- Prevalence and impact of dry mouth and diabetes
- Research Question 1: Is dry mouth associated with OHRQoL in diabetic patients?
- Research Question 2: What is the association between clinical, and individual factors in dry mouth patients with diabetes?
- Limitations of the study

5.2 Prevalence and impact of dry mouth and diabetes

As stated in Chapter 2, Section 2.2.1, there has been no general agreement on the definition of xerostomia, resulting in varied measurement methods and prevalence reported in previous studies. In this study, xerostomia was defined as the subjective symptoms or feeling of oral dryness. As stated earlier, the study evaluated xerostomia using the xerostomia inventory (XI), and utilised item four: "My mouth feels dry" to assess xerostomia prevalence. Those who responded occasionally, fairly often, and very often were counted as having xerostomia. The study found a xerostomia prevalence of 65.2% in Type 1 diabetic patients (T1DM) and 41.2% in Type 2 diabetic patients (T2DM).

The observed prevalence of xerostomia in T1DM was notably higher than that in T2DM. This disparity might be because of the autoimmune nature of T1DM, which predominantly emerges during childhood (Skyler et al., 2017; Banday et al., 2020; ElSayed et al., 2023). In addition, this study also found a higher prevalence of T1DM cases that had been diagnosed with diabetes for more than five years. This extended duration of diabetes might have contributed to a higher incidence of complications, including xerostomia.

Since there are no standardised measurement tools to assess xerostomia, comparing prevalence across studies becomes challenging. Nonetheless, this study is consistent with previous studies that reported the prevalence of xerostomia in diabetic patients ranging from 20% to 76.4% (Sreebny et al., 1992; Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Busato et al., 2009; Khovidhunkit et al., 2009; Borges et al., 2010; Malicka et al., 2014). This study also reported a higher prevalence of xerostomia than previous studies that examined prevalence in population-based samples, with a range of 0.4% to 64.8% (Osterberg et al., 1984; Locker, 1993; Narhi, 1994; Nederfors et al., 1997; Anttila et al., 1998; Thomson et al., 1999; Field et al., 2001; Jansson et al., 2003; Orellana et al., 2006; Thomson et al., 2006; Ikebe et al., 2007; Flink et al., 2008; Hopcraft and Tan, 2010; Agostini et al., 2018).

In Thailand, Yookhum (2022) reported xerostomia prevalence of 24.4% in Thai older adults. Notably, the study found that participants with diabetes or hypertension tended to experience more subjective dry mouth symptoms compared to those without. These findings were consistent with previous studies that also found individuals with diabetes reported a higher prevalence of xerostomia (Ben-Aryeh et al., 1993; Moore et al., 2001; Carda et al., 2006; Khovidhunkit et al., 2009; Malicka et al., 2014).

In addition, Yookhum (2022) study also utilised XI questionnaire to evaluate xerostomia. However, the criteria to determine xerostomia were different from this study. Here “My mouth feels dry” was used to assess xerostomia prevalence, and those who responded occasionally, fairly often, and very often were counted as having xerostomia. Whereas, Yookhum (2022) used a cut-point of summed scores of XI at 11 to determine xerostomia. This might be a weakness of the XI questionnaire since there are no diagnostic criteria for xerostomia. Considering the difference in diagnosis, using summed scores of XI might lead to a lower likelihood of including individuals who would be diagnosed with xerostomia, compared to using just one item. However, the prevalence reported in this study was almost three times higher for Type 1 and two times higher for Type 2 diabetic patients than by Yookhum (2022).

The xerostomia prevalence in this study was consistent with Khovidhunkit et al. (2009), who investigated xerostomia prevalence in Type 2 diabetic patients in Thailand and found a prevalence of 62%. Their study used similar questions to this to determine xerostomia. Khovidhunkit et al. (2009) counted participants having xerostomia if they responded yes to at least one of these questions: “Do you feel that your mouth is dry?”, “Do you have any difficulty eating dry food?”, and “Do you feel that your tongue sticks to the palate when you wake up in the morning?”. As there were more questions to evaluate xerostomia, this might have led Khovidhunkit et al. (2009) to diagnose participants with xerostomia at a higher rate compared to the present study (41.2%).

Furthermore, similar findings have been reported in another study conducted in Thailand. A xerostomia prevalence of 38.4% among individuals with T2DM aged over 50 years was reported (Sonpanao et al., 2023). In their study, xerostomia was evaluated by asking the following questions, namely “Do you feel you have too little saliva in your mouth?”, “Do you have a dry mouth when you eat meals?”, “Do you often have a dry mouth at night or when you wake up in the morning?”, “Do you feel that swallowing your food is difficult?”, and “Do you sip water all the time while swallowing food?”. Those who responded positively to at least one of these questions were considered to have xerostomia (Sonpanao et al., 2023). Using more specific questions related to dry mouth symptoms could account for the lower prevalence of xerostomia observed in this earlier study, despite its focus on an older demographic than this present study.

It is worth noting that the severity of xerostomia in diabetic patients in the present study appeared to be higher than the findings of a previous study in Thailand, where the mean sum scores of the XI was reported as 14.59 (Yookhum, 2022). Interestingly, the study by Yookhum (2022) specifically focused on individuals aged over 60 years, whereas the present study encompassed participants ranging in age from 18 to 85 years. This difference underscores the possibility that individuals with diabetes might experience more substantial repercussions from dry mouth in comparison to those without the condition. Similarly, Khongsirisombat et al. (2022) reported average sum XI scores of 17.0 in Thai older adult participants. Once again, the study primarily focused on older adult individuals aged over 60 years; however, the severity of xerostomia scores was slightly lower than those observed here.

This utilised the OHIP-14 questionnaire, which encompasses seven dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap, to assess oral functional status. The findings indicated that participants rated their oral conditions, including xerostomia, to have very mild to mild impact on their oral functioning. These results were in line with an earlier study involving T2DM patients in Thailand, which showed that patients experienced difficulties in speaking, tasting, swallowing, and chewing. Notably, these problems were more pronounced among patients with xerostomia (Sonpanao et al., 2023). However, participants did not rate the severity of these impacts. Furthermore, the findings were in line with a study involving T2DM patients in the Netherlands, which revealed that oral conditions such as mouth pain, xerostomia, bad breath, periodontitis, and edentulism had a very mild impact on their oral functioning (Verhulst et al., 2019).

The present study showed diabetes had moderate impact on participants' daily social, physical, and emotional functioning. These findings are consistent with a study conducted in the Netherlands, which found that T2DM patients experienced a greater impact on physical, social, role limitations due to physical and emotional problems, vigour, and general health perceptions compared to the general population (Verhulst et al., 2019).

In addition, approximately three-quarters of the participants reported having a good to extremely good QoL. However, they also reported that their QoL would be much better to very much better if they did not have diabetes. These might be due to the participants included here did not exhibit severe diabetes-related conditions or complications. Nonetheless, the experience of living with diabetes might restrict certain lifestyle choices or behaviours, such as eating, drinking, or working. Consequently, a majority of those with T2DM expressed that their QoL would substantially improve if they did not have diabetes.

Regarding health perceptions, the present study indicates that participants reported having moderate to good overall health and fair to good oral health. As mentioned earlier, participants included in this study did not have severe cases of diabetes. This might have influenced their ratings of oral health and general health as being relatively positive.

For psychological distress, the majority of participants reported anxiety and depression levels within the normal range. These results are in concordance with an earlier study conducted in Thailand (Tunsuchart et al., 2020), which focused on individuals diagnosed with T2DM. They found a significant proportion of T2DM participants (91.1%) reported experiencing either no or mild diabetes-related distress. In addition, most T2DM participants reported experiencing no or mild emotional, physician-related, regimen-related, and diabetes-related interpersonal distress (Tunsuchart et al., 2020). Additionally, the findings of the present study align with a previous study involving diabetic patients in Ireland, demonstrating that approximately three-quarters (68.0% for anxiety and 77.6% for depression) of participants exhibited anxiety and depression levels within the normal range (Collins et al., 2009).

5.3 Research question 1: Is dry mouth associated with OHRQoL in diabetic patients?

The findings of this study support the Wilson and Cleary model. Greater dry mouth symptoms were associated with overall QoL. However, it is important to note that this study did not include the measurement of salivary flow rate, a biological factor often associated with dry mouth. This omission was due to limitations imposed by the pandemic context. Instead, the study focused only on collecting data related to diabetic-specific biological factors, which were extracted from patient charts (as discussed on page 162). The association between dry mouth symptoms and overall QoL was mediated by functional status and health perceptions. The study found that worse subjective dry mouth symptoms status was linked to poorer oral functional status. Poorer oral functional status was associated with lower oral general health perceptions. Poorer general health perceptions were associated with lower overall QoL. However, the association between xerostomia and diabetic-related functional status was not statistically significant. This might be due to using the ADDQoL-19 to examine diabetic-related functional status. The ADDQoL-19 questionnaire covers social, physical, and emotional functioning that mainly focus on diabetic-related health and does not include questions related to oral health. As a result, participants might not associate the impact of xerostomia on their diabetic-related health, leading to a lack of significant association between xerostomia and diabetic-related functional status in the present study.

As the present study utilised OHIP-14 to assess oral functional status, it is important to note that some previous studies have also used OHIP-14 and referred to the results as OHRQoL. For easy of interpretation and understanding, the present study will discuss the results from those previous studies as oral functional status.

The present study's findings were in line with the previous studies that found those who reported having worse xerostomia were more likely to report poorer oral functional status (Locker, 2003; Gerdin et al., 2005; Ikebe et al., 2005; Baker et al., 2006; Thomson et al., 2006; Baker et al., 2007; Ikebe et al., 2007; Busato et al., 2009; Enoki et al., 2014; Niklander et al., 2017; Khongsirisombat et al., 2022).

The consistent findings were also reported by Busato et al. (2009), who examined the impact of xerostomia on oral functional status in Type 1 diabetic patients. The study found that those with xerostomia tended to exhibit poorer oral functioning compared to those without this condition. However, given the difference in the type of diabetes between the present study and that of Busato et al. (2009), caution must be applied. The participants in their study were adolescents with a mean age of 17.2 ($\pm$ 1.36) years (Busato et al., 2009). Consequently, younger participants might not have experienced factors that could impact subjective oral dryness symptoms to the same extent as adults or the older adults, such as other systemic diseases or medication usage.

Furthermore, Molania et al. (2017) examined the impact of xerostomia and hyposalivation on oral functional status in Type 2 diabetic patients. They found an association between xerostomia and hyposalivation. Also, hyposalivation correlated with swallowing problems, and the need for aids to help swallowing. Conversely, they did not find a statistically significant difference in the severity of oral functional status between those with and without hyposalivation. However, other than hyposalivation, the authors did not consider the associations between xerostomia and other variables in the study, despite xerostomia and hyposalivation not always occurring together (Joanna and Thomson, 2015; Agostini et al., 2018; Sonpanao et al., 2023).

The association between poorer symptom status and reduced functioning has also been identified in patients with edentulism, HIV, chronic obstructive pulmonary disease, chronic heart failure, coronary artery disease, asthma or bronchitis, hypertension, back problems, rheumatoid arthritis or joint problems, migraine, and dermatologic conditions (Sullivan et al., 2000; Arnold et al., 2005; Sousa and Kwok, 2006; Baker et al., 2008; Krethong et al., 2008; Saengsiri et al., 2014), as well as in studies with diabetic patients (Chia, 2007; Shiu et al., 2014).

The finding of an association between oral functional status and general oral health perceptions - indicating that individuals with poorer oral functional status had lower general oral health perceptions – also corresponds with previous studies involving dry mouth symptoms; lower oral functional status was associated with lower general oral health perceptions or self-rated general health (Baker et al., 2006; Baker et al., 2007; Ikebe et al., 2007).

In addition, the study identified non-significant paths between oral functional status and general health perceptions, and between diabetic-related functional status and both general oral health and general health perceptions. Poorer diabetic-related functional status was associated with lower general health perceptions. However, there were unexpected findings. Poorer oral functional status was associated with better general health perceptions and poorer diabetic-related functional status predicted better general oral health perceptions. This seemingly contradictory outcome might stem from the mild functional impairment of participants in this study, implying that these factors may not have significantly influenced health perceptions. Additionally, as suggested by Wilson and Cleary (1995), individual and environmental factors can also influence the main variables. Moreover, circumstances associated with the pandemic, there could have been other confounding factors or influences impacting health perceptions.

The link between lower functional status and diminished general health perceptions has been found in studies involving patients with edentulism, HIV, chronic obstructive pulmonary disease, chronic heart failure, diabetes, asthma or bronchitis, hypertension, back problems, rheumatoid arthritis or joint problems, migraine, and dermatologic conditions (Sullivan et al., 2000; Arnold et al., 2005; Sousa and Kwok, 2006; Chia, 2007; Baker et al., 2008; Krethong et al., 2008; Shiu et al., 2014; Santos et al., 2015).

In this study, lower general health perceptions were associated with reduced overall QoL. However, no significant association was found between general oral health perceptions and overall QoL. This discrepancy might be attributed to the fact that most participants in the study experienced only mild to very mild impacts from their oral conditions. As a result, they rated their oral health as fair to good, indicating that they might not have given as much attention to oral health aspects compared to general health aspects.

Additionally, no association was found between global oral health perceptions and subjective well-being. These might be attributed to the utilisation of the Hospital Anxiety and Depression Scale (HADS) in previous studies (Baker et al., 2006; Baker et al., 2007). The HADS primarily focuses on assessing anxiety and depression aspects. This might suggest that this questionnaire may not comprehensively encompass all relevant aspects for participants' overall well-being.

This study incorporated questions allowing participants to rate their general QoL and diabetic-related QoL, combined with HADS, to assess overall QoL. Despite this comprehensive approach, no association was observed between general oral health perceptions and overall QoL. This outcome highlights the potential impact of various other variables on this association.

In terms of a link between general health perception and overall QoL, this finding might suggest that individuals primarily focus on general health rather than oral health. In addition, earlier studies have demonstrated links between optimistic orientation, positive health behaviours, and improved health-related perceptions (including physical functioning and subjective perceptions) (Baker, 2007a; Pais-Ribeiro et al., 2007). These factors, in turn, contribute to an enhanced QoL (Pais-Ribeiro et al., 2007). Conversely, negative emotions such as worries, anxiety, and depressive feelings can shape individuals' negative self-perception, including aspects related to health (Langeveld et al., 2004; Warner et al., 2010; Rassart et al., 2014). These psychological factors and the fact that anxiety and depression were parts of the overall QoL variable in the present study may provide an explanation for the observed association between general health perceptions and overall QoL.

In support of this, previous studies in patients with HIV, diabetes, asthma or bronchitis, hypertension, back problems, rheumatoid arthritis or joint problems, migraine, and dermatologic conditions have also demonstrated that lower health perceptions predict reduced overall QoL (Sullivan et al., 2000; Sousa and Kwok, 2006; Chia, 2007; Krethong et al., 2008; Shiu et al., 2014; Verhulst et al., 2019).

Interestingly, subjective dry mouth symptom status was associated with general health perceptions, and oral and diabetic-related functional status were associated with overall QoL.

This corresponds with previous studies that found that subjective dry mouth symptoms had a negative impact on OHRQoL (Thomson et al., 2006; Khongsirisombat et al., 2022). The study found that individuals with worse subjective dry mouth symptoms experienced higher levels of negative emotions (such as stress and anxiety) and lower levels of positive emotions (such as well-being and self-efficacy), potentially leading to an overall reduction in their QoL (Thomson et al., 2006).

Additionally, earlier research has reported findings consistent with the present study, where clinical status, such as severe salivary gland conditions and hyposalivation, are predictive of poorer functional status, for example, difficulties with swallowing and chewing (Baker et al., 2006; Samnieng, 2015). In addition, an association between subjective dry mouth symptoms and general oral health perceptions was also found in earlier research which indicated that worse dry mouth symptoms were linked to poorer perceptions of general oral health (Locker, 2003). Moreover, previous studies have shown that poorer functional status predicts negative emotions, or depressive symptoms, which in turn might impact subjective well-being (Baker et al., 2006; Thomson et al., 2006; Baker et al., 2007).

Furthermore, worse symptom status predicting lower health perceptions has been reported by previous studies in relation to edentulism, oral symptoms in school children, diabetes, HIV, chronic obstructive pulmonary disease, heart failure, asthma or bronchitis, hypertension, back problems, rheumatoid arthritis or joint problems, migraine, and dermatologic conditions (Sullivan et al., 2000; Arnold et al., 2005; Sousa and Kwok, 2006; Krethong et al., 2008; Nammontri et al., 2013; Shiu et al., 2014; Santos et al., 2015).

The association between poorer functioning and lower overall QoL has also been found in previous studies involving edentulism, heart failure, asthma or bronchitis, hypertension, back problems, rheumatoid arthritis or joint problems, migraine, and dermatologic conditions (Sullivan et al., 2000; Krethong et al., 2008; Santos et al., 2015).

This study also identified indirect associations among variables. It found that worse subjective dry mouth symptoms predicted lower general oral health perceptions and lower overall QoL. These findings are consistent with a study conducted in the UK by Baker et al. (2007). It also indicated indirect links between xerostomia and global oral health perceptions, and between xerostomia and subjective well-being.

For the path between symptom status and subjective well-being, this study suggested it was mediated through oral functional status. Individuals with worse symptoms were associated with poorer functioning, resulting in diminished subjective well-being. However, for the path between symptoms and global oral health perceptions, caution in interpretation should be exercised, as the study found difference in direction between direct and indirect effects. This divergence could indicate that the association between symptoms and oral health perceptions was mediated by other variables not included in the present study.

Variables found to be important in previous studies for understanding the impact of oral health conditions on OHRQoL, include individual factors such as self-esteem (Benyamini et al., 2004), health beliefs (Cheng et al., 2016; Pudrovska, 2015; Bashian and Caskie, 2021), SOC (Elheeny, 2020), as well as environmental factors like income, education levels, and occupation (Zimmer and Amornsirisomboon, 2001; Midao et al., 2018; Ruengorn et al., 2021). In this study, three individual factors were included; however, only two were subsequently analysed (detailed in the section below).

As mentioned earlier, there were no associations found between diabetic diagnosis duration, treatment regime, blood sugar levels (FBS and HbA1c) (diabetic-related clinical status), and other variables, except for FBS and diabetic-related functional status.

Surprisingly, it was found that having FBS levels outside the normal range was associated with better diabetic-related functional status. This unexpected finding could be explained by participants with FBS levels outside the normal range in this study did not exhibit extremely high or low levels. However, it is important to note that this study did not include other clinical signs of diabetes complications. As participants rated diabetes mellitus as having a moderate impact on their daily functioning, this might suggest that they still fell within the range of controlled diabetes management. Consequently, the prediction of better diabetic-related functional status for individuals with FBS levels outside the normal range, as observed in the final model, becomes plausible.

In addition, previous studies have reported the association between clinical or biological status with functioning in patients with chronic heart failure, and chronic obstructive pulmonary disease (Arnold et al., 2005; Krethong et al., 2008). Moreover, a longitudinal study demonstrated a link between clinical status and overall QoL in paediatric patients with dental caries (Gururatana et al., 2014).

Of note, the study did not observe an association between diabetic-related clinical status and symptom status, which is in line with previous studies that did not find associations between glycaemic control and dry mouth symptoms in diabetic patients (Chia, 2007; Chomkhakhai et al., 2009; Shiu et al., 2014). Interestingly, this absence of association was also found by Baker et al. (2006), who reported no link between dry mouth-related clinical status and dry mouth symptom status. These results emphasise the possible impact of other key variables on the association that might not have been included in the study.

Conversely, a distinct study identified a link between improved clinical status and worse symptoms in edentulous patients (Santos et al., 2015). Notably, Santos et al. (2015) employed questions related to teeth appearance and denture satisfaction to assess symptoms status, potentially capturing those with favourable oral health but unsatisfactory conditions. The use of a single question related to patient oral health satisfaction may not encompass symptoms associated edentulism, thus limiting its representation of symptom status.

In addition, earlier studies that demonstrated poorer clinical status or marked biological variables predict worse symptom status in conditions like HIV and coronary artery disease (Sousa and Kwok, 2006; Saengsiri et al., 2014).

5.4 Research question 2: What is the association between clinical, and individual factors in dry mouth patients with diabetes?

According to Wilson and Cleary's (1995) conceptual framework, individual and environmental variables play a key role in the associations between the clinical condition (e.g. dry mouth) and symptoms, functioning, health perceptions, and QoL. In the present study, five individual factors were included: SOC, self-esteem, HLOC, multimorbidity, and polypharmacy. However, given difficulties in fitting the structural equation models with HLOC included, this variable had to be deleted from the analysis (see Section 5.6 for discussion of limitations). The findings indicated that SOC had an impact on symptom status, functional status (oral and diabetes), general health perceptions, and overall QoL. Lower levels of SOC were linked to worse symptom status, poorer functioning, lower general health perceptions, and lower overall QoL. Additionally, the present study found that SOC had indirect effects on oral functional status, general oral health perceptions, overall QoL, FBS, and diabetic duration.

These findings are in line with a previous studies assessing the role of SOC in oral health. For example, a longitudinal study in paediatric patients found that SOC had impact on OHRQoL at baseline and at three, six, and nine-month follow-ups (Gururatana et al., 2014). Moreover, Savolainen et al. (2005) studied the association between SOC and OHIP-14 and identified a strong link between SOC and OHIP-14. This study suggested that higher SOC was associated with better health behaviour, leading to an improved health condition and consequently better OHRQoL (Savolainen et al., 2005). These reflections align with the present – cross-sectional – study's findings, suggesting that higher SOC levels might lead to healthier behaviour, resulting in fewer problems, and subsequently lower symptom severity, better functioning, improved health perceptions, and enhanced overall QoL.

Nammontri et al. (2013), for example, stated that SOC might promote health in three ways: firstly, through its components of comprehensibility, manageability, and meaningfulness (Antonovsky, 1993), enhancing an individuals' ability to cope with stress or depression (Kövi et al., 2017), therefore, reducing the impact of adverse conditions. Secondly, SOC might lead individuals to perform better health-related behaviour. Thirdly, higher SOC might mitigate stress and lead individuals perceive better subjective aspects such as symptoms, health perceptions, and overall QoL. In her study, Nammontri et al. (2013) demonstrated that higher levels of SOC were associated with positive health beliefs, lower symptoms, and interestingly, SOC was found to predict functional status through symptoms in school children. The present results, and those of Nammontri et al. (2013) are in line with a study involving Type 1 diabetic patients, which also found that individuals with higher levels of SOC experienced lower levels of oral symptoms and better oral functioning (Elheeny, 2020). Supporting these findings, Lindmark et al. (2011) found that individuals with higher SOC exhibited better health-related behaviour, such as lower sweet consumption and fewer snacks between meals. The study also found that those with higher SOC had more knowledge about oral health and displayed a more positive attitude toward self-care and dental treatment. This consistency in findings across different populations, oral health measures, settings and countries underscores the important potential role of SOC in shaping (oral) health beliefs, symptom experiences, functional outcomes and overall QoL.

The second individual psychological variable analysed in the present model - self-esteem - was directly associated with multimorbidity and, indirectly, with treatment regime and diabetic duration. This outcome could be attributed to self-esteem's role in shaping an individual's sense of self-worth and self-perception. Consequently, self-esteem might impact an individual's capacity to cope with and manage health conditions, potentially leading those with lower self-esteem to have a higher prevalence of multimorbidity and polypharmacy, along with more complex treatment requirement and longer diabetes diagnosis duration.

The findings of the present study are aligned with the results of Littlefield et al. (1992), who studied the associations among treatment adherence, self-efficacy, depression, self-esteem, and binge behaviour in patients with diabetes. They reported strong associations between self-esteem and depression, as well as links between self-esteem, treatment adherence, self-efficacy, and binge eating disorder. The findings indicated that individuals with lower self-esteem were more likely to report lower adherence to diabetic treatment regimens and engage in higher levels of binge behaviour. This underscores the impact of self-esteem on health-related behaviour, a pattern also observed in previous oral health studies (Kallestal et al., 2000; Kallestal et al., 2006; Pazos et al., 2019). These behaviours may subsequently influence an individual's health outcomes.

Similar results have been reported in studies involving cancer and diabetes patients, indicating that lower self-esteem predicted higher levels of worry or depression (Langeveld et al., 2004; Warner et al., 2010; Rassart et al., 2014), and lower QoL (Langeveld et al., 2004). In addition, a previous study related to Rheumatoid Arthritis showed corresponding pattern with the present study, indicating that those with longer diagnosis duration tended to have lower self-esteem (Krol et al., 1994).

In the context of oral health, previous studies have reported associations between self-esteem and OHRQoL in patients undergoing orthodontic treatment, experiencing partial tooth loss, wearing dentures, expressing aesthetic concerns, and in paediatric patients (Agou et al., 2008; Ozhayat, 2013; Özhayat, 2013; Benson et al., 2015; Clijmans et al., 2015; Grecu et al., 2019; Alharbi et al., 2023). These highlighted that individuals with higher self-esteem experienced less impact from their conditions, leading to improved functioning and enhanced OHRQoL. This might be because those with higher self-esteem were focusing less on their problems and had a stronger belief in treatment efficacy, leading to reduced perceived impact and improved overall QoL (Benyamini et al., 2004).

Given that dry mouth can result from chronic conditions and/or medication use, these were both included in the model tested. It was hypothesised that these factors would impact on clinical status, health perceptions, and overall QoL. However, in the final model, polypharmacy and multimorbidity were only directly associated with duration of diabetes. The lack of expected associations may be due to the limited measurement of both variables in the study. That is, only the number of co-existing diseases and medications were recorded, rather than a more detailed assessment of the severity of co-morbid conditions or specific types/categories of drugs. It may be that a more detailed assessment of multi-morbidity and/or polypharmacy, the expected associations might have been observed.

In terms of multimorbidity, previous studies in the older adults found associations between those with chronic diseases and health outcomes such as self-rated health, life satisfaction, mobility limitation, and loneliness (Sullivan et al., 2000; Wister et al., 2016). These associations might be because multimorbidity is linked to depressive symptoms, diminished functioning, lower self-esteem, and reduced control beliefs all of which can contribute to a lower QoL (Warner et al., 2010; Tomasdottir et al., 2016).

Regarding polypharmacy, previous studies have indicated that individuals with multimorbidity are at a higher risk of polypharmacy (Vatcharavongvan and Puttawanchai, 2017; Midao et al., 2018; Wongpakaran et al., 2018), and polypharmacy itself has been associated with detrimental effects on HRQoL (Montiel-Luque et al., 2017; Wilder et al., 2022; Ye et al., 2022). In support of these findings, Schenker et al. (2019) highlighted that individuals with polypharmacy often face more severe symptoms, reduced functioning, and lower QoL. This aligns with consistent findings in patients with exacerbated subjective dry mouth symptoms, who exhibit a higher prevalence of polypharmacy (Storbeck et al., 2022; Cannon et al., 2023).

5.5 Summary of the findings

The findings of this study in a sample of Type 2 diabetic patients in Songkhla province, Thailand, support the proposed of Wilson and Cleary conceptual model. The results show associations among the main variables, indicating that dry mouth has an impact on symptom status, functioning, health perceptions, and overall QoL. Worse dry mouth predicted poorer symptoms, poorer functioning, lower health perceptions, and lower overall QoL. However, the present study did not observe an association between diabetic-related clinical status and dry mouth symptoms.

Furthermore, as proposed by Wilson and Cleary (1995), there are other factors that might influence these associations. In the present study, individual psychological factors, including SOC and self-esteem, had impacts on the main variables. The study demonstrated that those with higher SOC and self-esteem tended to report better health conditions.

Additionally, the study found links between multimorbidity and polypharmacy and the main variables. It indicated that those with a higher prevalence of multimorbidity and polypharmacy were more likely to predict worse health conditions. Unsurprisingly, the study found associations between individual factors, SOC, and self-esteem, and multimorbidity and polypharmacy.

5.6 Limitations of the current study

There were a number of limitations in the present study, including changes to the protocol due to the COVID-19 pandemic and considerations regarding the cultural appropriateness of the questionnaires. Each of these limitations will be discussed in turn.

Firstly, the original protocol for the study included the assessment of salivary flow as an indicator of clinical status. However, given the restrictions at Hatyai Hospital in response to the pandemic – in-person patient contact was not permitted. As a result, the collection of salivary flow rate data was cancelled. This cancellation meant that an important aspect of the Wilson and Cleary model could not be assessed, including the association between biological factors and symptom status. This importantly limited the methodological triangulation, and ability to compare findings with some previous studies in the area.

In addition, all data had to be collected via phone interviews. This change in data collection method posed a number of additional challenges, particularly among older adult participants who were unaccustomed to phone interviews. The length of questionnaires, which took approximately 45 minutes to complete, occasionally resulted in participant disengagement. The complexity of certain questionnaires, notably the SOC-13 used to assess sense of coherence, which included negative questions, led to participant confusion. Therefore, more time had to be spent explaining these, contributing to interviews lasting one to two hours per participant. This extended duration might have affected response accuracy, particularly for questions towards the end of the interview. Notably, the SOC-13 assessment was positioned as the second last questionnaire, which could have further impacted participant fatigue and the overall reliability of the SOC-13 results in the study. The reliability of the SOC-13 in this study was lower than desired (0.56), despite the remaining questionnaires demonstrating acceptable and good reliability.

Whilst the data collection had to be conducted online, a number of studies have reported that this method of data collection during the pandemic was increasingly used due to its accessibility. Specifically, it was accessible to those with a phone (Saarijarvi and Bratt, 2021). However, as phone interviews can take longer, explanations are often required, participants might become distracted during the interview. Therefore, the questionnaire should not be too long, should be clear, and should not contain sensitive questions (Kalaycioglu, 2020; Saarijarvi and Bratt, 2021). In addition, participants being interviewed via phone should not have hearing problems, which is more likely to be an issue with the older adults (Saarijarvi and Bratt, 2021). As questionnaires in this study were relatively long and contained some sensitive questions, along with the fact that some older adults that might have hearing problems, the validity of the questionnaires might have been impacted, especially SOC-13, which comprises complex questions as mentioned earlier.

Furthermore, low response rates (possibly due to concerns about phone scams) and the use of phone interviews may have both introduced selection bias, as only individuals with access to phones were able to participate. This could have resulted in a more homogenous sample suggesting caution when generalising the findings to diabetes patients in Thailand.

In addition to changes to the method of data collection, the follow-up period also had to be reduced due to the ongoing impact of the pandemic. In the original protocol, the follow-up period was six months, but in the study as conducted the follow-up period was reduced to three months. It may be that due to the reduced time between baseline and follow-up, there was little change in the key variables – and this was what was found. Many of the variables had similar scores at baseline and three-month follow-up (e.g., XI, OHIP-14, HADS). Given there was little change between the two time points, it was decided to only utilise the baseline data in the structural equation modelling, especially as no intervention had been delivered. As a result of the cross-sectional data, it is not possible to ascertain any cause-and-effect relationships within the Wilson and Cleary model.

Furthermore, the intention in the original protocol was to recruit a similar number of T1DM and T2DM patients. However, again, due to changes in the data collection method – and particularly the lack of in person contact, the sampling frame had to be 'loosened' and more Type 2 patients were recruited. This meant that it was not possible in the modelling to analyse the Wilson and Cleary model for Type 1 and Type 2 diabetes patients separately. As a result, the study SEM findings can only be applied to Type 2 diabetes patients in Thailand. Moreover, quarantine measures led to difficulties in examining blood sugar level, resulting in a low number of the patients who underwent blood sugar level examinations, especially at the three-month follow-up (52.2% for T1DM, 38.4% for T2DM).

A further limitation was that some of the questionnaires employed in the study were developed and tested in Western settings, potentially introducing a number of difficulties due to cultural differences. For example, the ADDQoL-19 contains questions related to sex life, a topic that is not openly discussed in Thai culture. However, the questionnaire allowed participants not to respond to those questions. In cases where a Thai version of the questionnaire was not available (XI, self-reported health assessment, MHLC-C), the questionnaires were translated into Thai by the researcher (AS) and then back-translated into English by bilingual persons who had never seen the original English version. Any necessary adaptations were made to ensure that the Thai version was analogous with the original version.

Moreover, the study included participants from one hospital, this might lead participants' characteristics being homogeneous and potentially omitting influential individual factors such as education levels and incomes, which could have enriched the analysis.

The cross-cultural utility of some of the questionnaires may also be relevant to difficulties observed with the HLOC data. As mentioned above (Section 4.4.1), HLOC was not included in the modelling as an individual variable, as there were problems in fitting the model. Contrary to previous studies, there were low correlations between the four construct domains in the confirmatory factor analysis, namely internality, chance, doctor influence, and the influence of others. This suggests that these indicators may not accurately represent the latent variable of HLOC. It may be that there were cross-cultural difficulties with the measure. There are many differences in health beliefs, deeply rooted in Thai culture, which might not align well with the composite structure of HLOC. For example, even though patients may know the cause of diabetes, such as high sugar dietary consumption, genetics, or lack of exercise, they may still believe that diabetes is related to karma or fate, and that making merit or praying could help them control blood sugar levels (Ratanasuwan et al., 2005; Sowattanangoon et al., 2009). A review of literature suggests that there has been no previous use of the HLOC measure among adults in Thailand, which suggests that further work is necessary before applying such a measure in health research.

It is worth noting that earlier studies have demonstrated that health control beliefs, including HLOC, can exert both direct and indirect effects on oral health and health related QoL through symptom experiences, functioning, and health perceptions (Gururatana et al., 2014; Pudrovska, 2015; Cheng et al., 2016; Elheeny, 2020). Interestingly, an overlap in the effects of internal factors like SOC and HLOC on an individual’s health, despite their distinct conceptual underpinnings, has been reported (Elheeny, 2020). Therefore, while health beliefs are important considerations, researchers should select and utilise measurement tools that best align with the specific characteristics of their study population.

Chapter Six

Conclusions and Recommendations

The present study aimed to examine whether dry mouth was associated with oral health-related quality of life (OHRQoL) in diabetic patients in Songkhla, Thailand. The present study was observational, with a three-month follow-up period.

The findings supported the Wilson and Cleary model (1995). The results indicated that worse dry mouth symptoms predicted a lower overall QoL through poorer functioning and poorer health perceptions. Additionally, psychological factors such as sense of coherence (SOC) and self-esteem, along with individual factors like multimorbidity and polypharmacy, were found to be important in these relationships.

The present study emphasises the potential complexity of the impacts of dry mouth on OHRQoL in diabetic patients, encompassing both clinical and non-clinical aspects. The study also underscores the necessity of holistic care that combines both physical and psychological aspects to improve individual's QoL.

This chapter summarises strengths, recommendations, and conclusions of the study.

6.1 Strengths of the study

The present study investigated the impacts of dry mouth on OHRQoL through the lens of the Wilson and Cleary conceptual framework. This study uniquely incorporated both oral health and diabetic-related conditions. To the best of the authors knowledge, this study is the first to examine the implications of dry mouth within diabetic patients using this model, which encompasses both clinical and non-clinical dimensions. Moreover, the study incorporated individual factors, including psychological factors such as SOC and self-esteem, alongside considerations of multimorbidity and polypharmacy, to comprehensively explore their associations with the key variables.

6.2 Recommendations

There are a number of recommendations that can be made based on the study findings reported here. These recommendations are both for clinical practice, health promotion, and for future research.

6.2.1 Recommendations for clinical practice

Given the pivotal role of SOC and self-esteem in the current findings, dental professionals need to embrace a holistic approach moving beyond clinical aspects. Dental professionals may instruct patients in managing their subjective symptoms, enhancing their coping skills and their beliefs in manageability of the condition. For example, research in school settings in Thailand has shown that increasing SOC – one important individual difference factor - can lead to improved health outcomes (Nammontri et al., 2013).

Furthermore, this study underscores the inseparable and interacting nature of oral and general health (in this case diabetes). Therefore, dental professionals should consider discussion of general heath alongside dental advice and treatment, taking into account concurrent medical conditions and medication usage when providing care and striving to enhance individual health for diabetic patients.

Additionally, dental professionals should educate patients and raise awareness about how controlling their diabetes can potentially impact on their oral health, and how diabetes can also worsen oral health conditions (Leite et al., 2013; Kudiyirickal and Pappachan, 2015; Suttagul, 2018).

6.2.2 Recommendations for health promotion in diabetic settings

In the context of Thailand, it is imperative for the government to provide systematic record-keeping of clinical status and dry mouth symptoms to gain a better understanding of patients' needs and tailor care strategies accordingly. While Thailand already has a system in place where diabetic patients are automatically referred to dentists for regular dental check-ups (Bureau of Dental Health), the program primarily focuses on periodontitis treatment due to the large number of diabetic patients. To address the comprehensive oral health needs of diabetic patients, there should be a program that encompass all possible oral health complications. This program should also include an efficient system for monitoring and recalling diabetic patients for dental check-ups.

Given Thailand's transition into an aging society, this study emphasises the imperative for systematic record-keeping, holistic care approaches, and increased collaboration among oral health professionals, diabetes clinicians and public and health authorities (in hospital secondary care settings but also including primary care personnel and services). These future measures are crucial for the enhancement of the overall health, well-being QoL of the diabetic population.

6.2.3 Recommendations for future research

Future longitudinal studies are crucial for gaining deeper insights into the evolving effects of dry mouth on functioning and QoL over time. These studies can provide a more comprehensive understanding of the temporal associations, causal links, and bidirectional relationships. To achieve this, researchers should encompass salivary flow and clinical signs as 'objective' indicators of dry mouth clinical status, clinical assessment of dry mouth, alongside self-reports.

To further understanding of dry mouth for both T1DM and T2DM patients, future studies should incorporate an adequate sample size for both groups such that separate analyses can be conducted. Given their likely distinct clinical profiles, the impact of dry mouth may vary between these patient groups over time, influenced by a host of factors including co-morbidity and polypharmacy.

Recognising the significance of psychological factors, particularly SOC, future studies could, as has been seen in related areas in oral health, develop and evaluate psychosocial intervention strategies/tools for diabetic patients (e.g., a salutogenic intervention based on SOC). Such salutogenic interventions might be aimed at helping diabetic patients manage their symptoms and its impact in daily life, enhance their coping skills, and health-related behaviours. Such interventions have been found to be successful in oral health, although in a very different context (school based oral health promotion with school children, Nammontri et al. (2013)). These SOC interventions have also been developed in other contexts and could be applied within the diabetic clinic setting (Kahonen et al., 2012; Foureur et al., 2013; Super et al., 2016).

It is important to note that this study included patients from one hospital in one geographical region of Thailand due to pandemic restrictions. Future research should aim to sample patients from diabetic clinics in various locations across the country where possible. In addition, in such studies, the validity of key measures should be psychometrically evaluated for their cross-cultural appropriateness and assess in far greater detail the role of differing co-morbidities and polypharmacy on dry mouth and its impact. In addition, careful consideration should be given to determining the optimal length of the questionnaire and interview duration.

6.3 Conclusions

This study found a xerostomia prevalence of 65.2% in Type 1 diabetic patients and 41.2% in Type 2 diabetic patients. The study supported the Wilson and Cleary model (1995) and demonstrated links between variables (symptoms, functioning, health perceptions, and overall QoL), but not clinical status.

The study showed that dry mouth symptoms directly impacted on oral functional status and general health perceptions, and indirectly impacted on general oral health perceptions and overall QoL. Oral functional status predicted general oral health perceptions and overall QoL. Diabetic-related functional status predicted overall QoL, also general health perception associated with overall QoL.

Interestingly, psychological factors like SOC played a crucial role in this study. It was found that SOC was associated with symptom status, functioning, health perceptions, and overall QoL.

References

Aekplakorn W, Abbott-Klafter J, Premgamone A, et al. (2007) Prevalence and management of diabetes and associated risk factors by regions of Thailand: Third National Health Examination Survey 2004. *Diabetes Care* 30(8): 2007-2012.

Aekplakorn W, Chariyalertsak S, Kessomboon P, et al. (2018) Prevalence of Diabetes and Relationship with Socioeconomic Status in the Thai Population: National Health Examination Survey, 2004-2014. *J Diabetes Res* 2018: 1654530.

Aekplakorn W, Chariyalertsak S, Kessomboon P, et al. (2011) Prevalence and management of diabetes and metabolic risk factors in Thai adults: the Thai National Health Examination Survey IV, 2009. *Diabetes Care* 34(9): 1980-1985.

Affoo RH, Foley N, Garrick R, et al. (2015) Meta-Analysis of Salivary Flow Rates in Young and Older Adults. *J Am Geriatr Soc* 63(10): 2142-2151.

Agostini BA, Cericato GO, Silveira ERD, et al. (2018) How Common is Dry Mouth? Systematic Review and Meta-Regression Analysis of Prevalence Estimates. *Braz Dent J* 29(6): 606-618.

Agou S, Locker D, Streiner DL, et al. (2008) Impact of self-esteem on the oral-health-related quality of life of children with malocclusion. *Am J Orthod Dentofacial Orthop* 134(4): 484-489.

Alharbi A, Humphris G and Freeman R (2023) The Associations among Dental Anxiety, Self-Esteem, and Oral Health-Related Quality of Life in Children: A Cross-Sectional Study. *Dent J (Basel)* 11(7).

Allen PF (2003) Assessment of Oral Health Related Quality of Life. *Health and Quality of Life Outcomes* 8(40): 1-8.

Altarawneh S, Bencharit S, Mendoza L, et al. (2013) Clinical and histological findings of denture stomatitis as related to intraoral colonization patterns of Candida albicans, salivary flow, and dry mouth. *J Prosthodont* 22(1): 13-22.

Amaral J, Marques D, Thomson WM, et al. (2018) Validity and reliability of a Portuguese version of the Summated Xerostomia Inventory-5. *Gerodontology* 35(1): 33-37.

Anderson JC and Gerbing DW (1988) Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. *Psychological Bulletin* 103(3): 411-423.

Antonovsky A (1993) The structure and properties of the sense of coherence scale. *Soc. Sci. Med.* 36(6): 725-733.

Anttila SS, Knuuttila MLE and Sakki TK (1998) Depressive symptoms as an underlying factor of the sensation of dry mouth. *Psychosomatic Medicine* 60(2): 215-218.

Arany S, Kopycka-Kedzierawski DT, Caprio TV, et al. (2021) Anticholinergic medication: Related dry mouth and effects on the salivary glands. *Oral Surg Oral Med Oral Pathol Oral Radiol* 132(6): 662-670.

Arnold R, Ranchor AV, Koeter GH, et al. (2005) Consequences of chronic obstructive pulmonary disease and chronic heart failure: the relationship between objective and subjective health. *Soc Sci Med* 61(10): 2144-2154.

Association AD (2014) Diagnosis and classification of diabetes mellitus. *Diabetes Care* 37 Suppl 1: S81-90.

Association AD (2020) 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2020. *Diabetes Care* 43(Suppl 1): S14-S31.

Atchison KA and Gift HC (1997) Perceived oral health in a diverse sample. *Adv Dent Res* 11(2): 272-280.

Azogui-Levy S, Dray-Spira R, Attal S, et al. (2018) Factors associated with oral health-related quality of life in patients with diabetes. *Aust Dent J* 63(2): 163-169.

Baiju RM, Peter E, Varghese NO, et al. (2017) Oral Health and Quality of Life: Current Concepts. *J Clin Diagn Res* 11(6): ZE21-ZE26.

Baker SR (2007a) Dispositional optimism and health status, symptoms and behaviours: Assessing idiothetic relationships using a prospective daily diary approach. *Psychology & Health* 22(4): 431-455.

Baker SR (2007b) Testing a Conceptual Model of Oral Health: a Structural Equation Modeling Approach. *J Dent Res* 86(8): 708-712.

Baker SR, Mat A and Robinson PG (2010) What psychosocial factors influence adolescents' oral health? *J Dent Res* 89(11): 1230-1235.

Baker SR, Pankhurst CL and Robinson PG (2006) Utility of two oral health-related quality-of-life measures in patients with xerostomia. *Community Dent Oral Epidemiol* 34(5): 351-362.

Baker SR, Pankhurst CL and Robinson PG (2007) Testing relationships between clinical and non-clinical variables in xerostomia: a structural equation model of oral health-related quality of life. *Qual Life Res* 16(2): 297-308.

Baker SR, Pearson NK and Robinson PG (2008) Testing the applicability of a conceptual model of oral health in housebound edentulous older people. *Community Dent Oral Epidemiol* 36(3): 237-248.

Banday MZ, Sameer AS and Nissar S (2020) Pathophysiology of diabetes: An overview. *Avicenna J Med* 10(4): 174-188.

Barbe AG, Heinzler A, Derman S, et al. (2017) Hyposalivation and xerostomia among Parkinson's disease patients and its impact on quality of life. *Oral Dis* 23(4): 464-470.

Bashian H and Caskie G (2021) The Role of Aging Anxiety, Ageism, and Health Locus of Control on Middle-Aged Adults Health Outcomes and Behaviors. *Innov Aging* 5(1): 604-605.

Ben-Aryeh H, Serouya R, Kanter Y, et al. (1993) Oral Health and Salivary Composition in Diabetic Patients. *J Diab Comp* 7: 57-62.

Benson PE, Da'as T, Johal A, et al. (2015) Relationships between dental appearance, self-esteem, socio-economic status, and oral health-related quality of life in UK schoolchildren: A 3-year cohort study. *Eur J Orthod* 37(5): 481-490.

Benyamini Y, Leventhal H and Leventhal EA (2004) Self-rated oral health as an independent predictor of self-rated general health, self-esteem and life satisfaction. *Soc Sci Med* 59(5): 1109-1116.

Beran TN and Violato C (2010) Structural equation modeling in medical research: a prime. *BMC Res Notes* 267(3): 1-10.

Bergdahl M and Bergdahl J (2000) Low unstimulated salivary flow and subjective oral dryness: association with medication, anxiety, depression, and stress. *J Dent Res* 79(9): 1652-1658.

Borges BCD, Fulco GM, Souza AJC, et al. (2010) Xerostomia and Hyposalivation: A Preliminary Report of Their Prevalence and Associated Factors in Brazilian Elderly Diabetic Patients. *Oral health & preventive dentistry* 8(2): 153-158.

Bradley C and Speight J (2002) Patient perceptions of diabetes and diabetes therapy: assessing quality of life. *Diabetes Metab Res Rev* 18 Suppl 3: S64-69.

Bradley C, Todd C, Gorton T, et al. (1999) The development of an individualized questionnaire measure of perceived impact of diabetes on quality of life: The ADDQoL. *Quality of Life Research* 8(1-2): 79-91.

Bulthuis MS, Jan Jager DH and Brand HS (2018) Relationship among perceived stress, xerostomia, and salivary flow rate in patients visiting a saliva clinic. *Clin Oral Investig* 22(9): 3121-3127.

Bultzingslowen I, Sollecito TP, Fox PC, et al. (2007) Salivary dysfunction associated with systemic diseases: systematic review and clinical management recommendations. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 103 Suppl: S57 e51-15.

Busato IM, Ignacio SA, Brancher JA, et al. (2009) Impact of xerostomia on the quality of life of adolescents with type 1 diabetes mellitus. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 108(3): 376-382.

Busato IM, Ignacio SA, Brancher JA, et al. (2012) Impact of clinical status and salivary conditions on xerostomia and oral health-related quality of life of adolescents with type 1 diabetes mellitus. *Community Dent Oral Epidemiol* 40(1): 62-69.

Cannon I, Robinson-Barella A, McLellan G, et al. (2023) From Drugs to Dry Mouth: A Systematic Review Exploring Oral and Psychological Health Conditions Associated with Dry Mouth in Older Adults with Polypharmacy. *Drugs Aging* 40(4): 307-316.

Carda C, Mosquera-Lloreda N, Salom L, et al. (2006) Structural and functional salivary disorders in type 2 diabetic patients. *Med Oral Patol Oral Cir Bucal* 11: E309-314.

Cassolato SF and Turnbull RS (2003) Xerostomia: clinical aspects and treatment. *Gerodontology* 20(2): 64-77.

Cella DF (1994) Quality of life: Concept and definition. *Journal of Pain and Symptom Management* 9(3): 186-192.

Chávez EM, Borrell LN, Taylor GW, et al. (2001) A longitudinal analysis of salivary flow in control subjects and older adults with type 2 diabetes. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 91(2): 166-173.

Cheng C, Cheung MW and Lo BC (2016) Relationship of health locus of control with specific health behaviours and global health appraisal: a meta-analysis and effects of moderators. *Health Psychol Rev* 10(4): 460-477.

Chia L (2007) *The characteristics that associate with health related quality of life in patients with type -2 diabetes*. University of Pittsburgh, ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global.

Chomkhakhai U, Thanakun S, Khovidhunkit S-oP, et al. (2009) Oral health in Thai patients with metabolic syndrome. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews* 3(4): 192-197.

Ciarrochi J and Bilich L (2006) Process measures of potential relevance
to ACT. 1-162.

Clijmans M, Lemiere J, Fieuws S, et al. (2015) Impact of self-esteem and personality traits on the association between orthodontic treatment need and oral health-related quality of life in adults seeking orthodontic treatment. *Eur J Orthod* 37(6): 643-650.

Collins MM, Corcoran P and Perry IJ (2009) Anxiety and depression symptoms in patients with diabetes. *Diabet Med* 26(2): 153-161.

DAT (2017) *Clinical Practice Guideline for Diabetes 2017.* Romyen Media Company Limited.

Dawes C (1987) Physiological Factors Affecting Salivary Flow Rate, Oral Sugar Clearance, and the Sensation of Dry Mouth in Man. *Journal of Dental Research* 66: 648-653.

Dawes C (2008) Salivary flow patterns and the health of hard and soft oral tissues. *J Am Dent Assoc* 139 Suppl: 18S-24S.

Dawes C, Pedersen AM, Villa A, et al. (2015) The functions of human saliva: A review sponsored by the World Workshop on Oral Medicine VI. *Arch Oral Biol* 60(6): 863-874.

Deerochanawong C and Ferrario A (2013) Diabetes management in Thailand: a literature review of the burden, costs, and outcomes. *Globalization and Health* 9(11): 1-18.

Deshpande AD, Harris-Hayes M and Schootman M (2008) Epidemiology of Diabetes and Diabetes-Related Complications. *Phys Ther* 88(11): 1254-1264.

Dijkema T, Raaijmakers CP, Braam PM, et al. (2012) Xerostomia: a day and night difference. *Radiother Oncol* 104(2): 219-223.
Dodds M, Roland S, Edgar M, et al. (2015) Saliva A review of its role in maintaining oral health and preventing dental disease. *BDJ Team* 2(1-8).
Donaldson M and Goodchild JH (2019) A Systematic Approach to Xerostomia A Systematic Approach to Xerostomia. *CEU* 2.
Elheeny AAH (2020) Determinants of oral-health related quality of life and overall quality of life among early adolescents with type-1 diabetes. *Community Dent Health* 37(3): 199-204.
ElSayed NA, Aleppo G, Aroda VR, et al. (2023) 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care* 46(Suppl 1): S19-S40.
Enoki K, Matsuda KI, Ikebe K, et al. (2014) Influence of xerostomia on oral health-related quality of life in the elderly: a 5-year longitudinal study. *Oral Surg Oral Med Oral Pathol Oral Radiol* 117(6): 716-721.
Eriksson M and Lindstrom B (2005) Validity of Antonovsky's sense of coherence scale: a systematic review. *J Epidemiol Community Health* 59(6): 460-466.
Eriksson M and Mittelmark MB (2017) The Sense of Coherence and Its Measurement. In: Mittelmark MB, Sagy S, Eriksson M, et al. (eds) *The Handbook of Salutogenesis*. Cham (CH), pp.97-106.
Falcão DP, Mota LMH, Pires AL, et al. (2013) Sialometry: aspects of clinical interest. *Revista Brasileira de Reumatologia (English Edition)* 53(6): 525-531.
Fan WF, Zhang Q, Luo LH, et al. (2013) Study on the clinical significance and related factors of thirst and xerostomia in maintenance hemodialysis patients. *Kidney Blood Press Res* 37(4-5): 464-474.
Ferrans CE, Zerwic JJ, Wilbur JE, et al. (2005) Conceptual Model of Health-Related Quality of Life. *Journal of Nursing Scholarship* 37(4): 336-342.
Field EA, Fear S, Higham SM, et al. (2001) Age and medication are significant risk factors for xerostomia in an English population, attending general dental practice. *Gerodontology* 18(1): 21-24.
Flink H, Bergdahl M, Tegelberg A, et al. (2008) Prevalence of hyposalivation in relation to general health, body mass index and remaining teeth in different age groups of adults. *Community Dent Oral Epidemiol* 36(6): 523-531.
Flink H, Tegelberg A, Arnetz JE, et al. (2020) Self-reported oral and general health related to xerostomia, hyposalivation, and quality of life among caries active younger adults. *Acta Odontol Scand* 78(3): 229-235.
Folke S, Paulsson G, Fridlund B, et al. (2009) The subjective meaning of xerostomia—an aggravating misery. *International Journal of Qualitative Studies on Health and Well-being* 4(4): 245-255.
Forouhi NG and Wareham NJ (2014) Epidemiology of diabetes. *Medicine (Abingdon)* 42(12): 698-702.
Foureur M, Besley K, Burton G, et al. (2013) Enhancing the resilience of nurses and midwives: pilot of a mindfulness-based program for increased health, sense of coherence and decreased depression, anxiety and stress. *Contemp Nurse* 45(1): 114-125.
Fox PC, Busch KA and Baum BJ (1987) Subjective reports of xerostomia and objective measures of salivary gland performance. *J Am Dent Assoc* 115(4): 581-584.
Fure S and Zickert I (1989) Salivary conditions and cariogenic microorganisms in 55, 65, and 75-year-old Swedish individuals. *European Journal of Oral Sciences* 98(3): 197-210.
Gerdin EW, Einarson S, Jonsson M, et al. (2005) Impact of dry mouth conditions on oral health-related quality of life in older people. *Gerodontology* 22(4): 219-226.

Gibson B, Periyakaruppiah K, Thornhill MH, et al. (2020) Measuring the symptomatic, physical, emotional and social impacts of dry mouth: A qualitative study. *Gerodontology* 37(2): 132-142.

Gilbert GH, Heft MW and Duncan RP (1993) Mouth dryness as reported by older Floridians. *Community Dentistry and Oral Epidemiology* 21: 390-397.

Glasgow RE, Ruggiero L, Eakin EG, et al. (1997) Quality of life and associated characteristics in a large national sample of adults with diabetes. *Diabetes Care* 20(4): 562-567.

Goldney RD, Phillips PJ, Fisher LJ, et al. (2004) Diabetes, Depression, and Quality of Life: A population study. *Diabetes Care* 27(5): 1066-1070.

Grecu AG, Balazsi R, Dudea D, et al. (2019) Oral health related quality of life and self-esteem in a general population. *Med Pharm Rep* 92(Suppl No 3): S65-S72.

Gueiros LA, Soares MS and Leao JC (2009) Impact of ageing and drug consumption on oral health. *Gerodontology* 26(4): 297-301.

Guggenheimer J and Moore PA (2003) Xerostomia: etiology, recognition and treatment. *J Am Dent Assoc* 134(1): 61-69; quiz 118-119.

Gururatana O, Baker SR and Robinson PG (2014) Determinants of children's oral-health-related quality of life over time. *Community Dent Oral Epidemiol* 42(3): 206-215.

Guthrie RA and Guthrie DW (2004) Pathophysiology of Diabetes Mellitus. *Critical Care Nursing Quarterly* 27(2): 113-125.

Hahnel S, Schwarz S, Zeman F, et al. (2014) Prevalence of xerostomia and hyposalivation and their association with quality of life in elderly patients in dependence on dental status and prosthetic rehabilitation: a pilot study. *J Dent* 42(6): 664-670.

Health BoD *Dental Guidelines for Diabetic Patients in Thailand.*

Holmefur M, Sundberg K, Wettergren L, et al. (2015) Measurement properties of the 13-item sense of coherence scale using Rasch analysis. *Qual Life Res* 24(6): 1455-1463.

Hopcraft MS and Tan C (2010) Xerostomia: an update for clinicians. *Aust Dent J* 55(3): 238-244; quiz 353.

Hu Lt and Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal* 6(1): 1-55.

Humphrey SP and Williamson RT (2001) A review of saliva Normal composition, flow, and function. *The Journal of Prosthetic Dentistry* 85(2): 162-169.

Iacobucci D (2009) Structural equations modeling: Fit Indices, sample size, and advanced topics. *Journal of Consumer Psychology* 20(1): 90-98.

Ikebe K, Matsuda K, Morii K, et al. (2007) Impact of dry mouth and hyposalivation on oral health-related quality of life of elderly Japanese. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 103(2): 216-222.

Ikebe K, Morii K, Kashiwagi J, et al. (2005) Impact of dry mouth on oral symptoms and function in removable denture wearers in Japan. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 99(6): 704-710.

Inoue H, Ono K, Masuda W, et al. (2006) Gender difference in unstimulated whole saliva flow rate and salivary gland sizes. *Arch Oral Biol* 51(12): 1055-1060.

Islas-Granillo H, Borges-Yanez A, Fernandez-Barrera MA, et al. (2017) Relationship of hyposalivation and xerostomia in Mexican elderly with socioeconomic, sociodemographic and dental factors. *Sci Rep* 7: 40686.

Ivanovski K, Naumovski V, Kostadinova M, et al. (2012) Xerostomia and salivary levels of glucose and urea in patients with diabetes. *Contributions, Sec. Biol. Med. Sci.* 33(2): 219-229.

Jansson C, Johansson S, Lindh-Astrand L, et al. (2003) The prevalence of symptoms possibly related to the climacteric in pre- and postmenopausal women in Linkoping, Sweden. *Maturitas* 45(2): 129-135.

Jensen SB, Vissink A, Limesand KH, et al. (2019) Salivary Gland Hypofunction and Xerostomia in Head and Neck Radiation Patients. *J Natl Cancer Inst Monogr* 2019(53).

Joanna NDY and Thomson WM (2015) Dry mouth - An overview. *Singapore Dent J* 36: 12-17.

Johnstone PAS, Peng YP, May BC, et al. (2001) Acupuncture for pilocarpine-resistant xerostomia following radiotherapy for head and neck malignancies. *International Journal of Radiation Oncology Biology Physics* 50(2): 353-357.

Kahonen K, Naatanen P, Tolvanen A, et al. (2012) Development of sense of coherence during two group interventions. *Scand J Psychol* 53(6): 523-527.

Kalaycioglu O (2020) Guidance for research on the Covid-19 disease in times of pandemic. *Journal of Health and Social Sciences* 5(2): 177-186.

Kallestal C, Dahlgren L and Stenlund H (2006) Oral health behavior and self-esteem in Swedish adolescents over four years. *J Adolesc Health* 38(5): 583-590.

Kallestal C, Dahlgrena L and Stenlund H (2000) Oral health behaviour and self-esteem in Swedish children. *Social Science & Medicine* 51(12): 1841-1849.

Khongsirisombat N, Kiattavorncharoen S and Thanakun S (2022) Increased Oral Dryness and Negative Oral Health-Related Quality of Life in Older People with Overweight or Obesity. *Dent J (Basel)* 10(12).

Khovidhunkit SOP, Suwantuntula T, Thaweboon S, et al. (2009) Xerostomia, hyposalivation, and oral microbiota in type 2 diabetic patients: a preliminary study. *J Med Assoc Thai* 92(9): 1220-1228.

Kline RB (2016) Global Fit Testing. *Principles and Practice of Structural Equation Modeling*. 4 ed. the United States of America: The Guilford Press, pp.262-299.

Kövi Z, Odler V, Gacsályi S, et al. (2017) Sense of coherence as a mediator between personality and depression. *Personality and Individual Differences* 114: 119-124.

Krethong P, Jirapaet V, Jitpanya C, et al. (2008) A causal model of health-related quality of life in Thai patients with heart-failure. *J Nurs Scholarsh* 40(3): 254-260.

Krol B, Sanderman R, Suurmeijer T, et al. (1994) Disease characteristics, level of self-esteem and psychological well-being in rheumatoid arthritis patients. *Scand J Rheumatol* 23(1): 8-12.

Kudiyirickal MG and Pappachan JM (2015) Diabetes mellitus and oral health. *Endocrine* 49(1): 27-34.

Lamster IB, Lalla E, Borgnakke WS, et al. (2008) The relationship between oral health and diabetes mellitus. *J Am Dent Assoc* 139 Suppl: 19S-24S.

Langeveld NE, Grootenhuis MA, Voute PA, et al. (2004) Quality of life, self-esteem and worries in young adult survivors of childhood cancer. *Psychooncology* 13(12): 867-881.

Leite RS, Marlow NM, Fernandes JK, et al. (2013) Oral health and type 2 diabetes. *Am J Med Sci* 345(4): 271-273.

Leoncini E, Ricciardi W, Cadoni G, et al. (2014) Adult height and head and neck cancer: a pooled analysis within the INHANCE Consortium. *Eur J Epidemiol* 29(1): 35-48.

Lindmark U, Hakeberg M and Hugoson A (2011) Sense of coherence and its relationship with oral health-related behaviour and knowledge of and attitudes towards oral health. *Community Dent Oral Epidemiol* 39(6): 542-553.

Littlefield CH, Craven JL, Rodin GM, et al. (1992) Relationship of Self-efficacy and Binging to Adherence to Diabetes Regimen Among Adolescents. *Diabetes Care* 15(1): 90-94.

Liu B, Dion MR, Jurasic MM, et al. (2012) Xerostomia and salivary hypofunction in vulnerable elders: prevalence and etiology. *Oral Surg Oral Med Oral Pathol Oral Radiol* 114(1): 52-60.
Locker D (1993) Subjective reports of oral dryness in an older adult population. *Community Dentistry and Oral Epidemiology* 21(3): 165-168.
Locker D (2003) Dental status, xerostomia and the oral health-related quality of life of an elderly institutionalized population. *Special Care in Dentistry* 23(3): 86-93.
Locker D and Allen F (2007) What do measures of 'oral health-related quality of life' measure? *Community Dent Oral Epidemiol* 35(6): 401-411.
Locker D and Quinonez C (2011) To what extent do oral disorders compromise the quality of life? *Community Dent Oral Epidemiol* 39(1): 3-11.
Lone MA, Shaikh S, Lone MM, et al. (2017) Association of salivary gland hypofunction with diabetes mellitus and drugs among the elderly in Karachi, Pakistan. *J Investig Clin Dent* 8(2).
Malicka B, Kaczmarek U and K. S-M (2014) Prevalence of xerostomia and the salivary flow rate in diabetic patients. *Adv Clin Exp Med* 23(2): 225-233.
Manthrope R, Oxholm P, Prause J, et al. (1986) The Copenhagen Criteria for SjÖgren's syndrome. *Scandinavian journal of rheumatology* 61: 19-21.
Mauri-Obradors E, Estrugo-Devesa A, Jane-Salas E, et al. (2017) Oral manifestations of Diabetes Mellitus. A systematic review. *Med Oral Patol Oral Cir Bucal* 22(5): e586-e594.
Midao L, Giardini A, Menditto E, et al. (2018) Polypharmacy prevalence among older adults based on the survey of health, ageing and retirement in Europe. *Arch Gerontol Geriatr* 78: 213-220.
Millsop JW, Wang EA and Fazel N (2017) Etiology, evaluation, and management of xerostomia. *Clin Dermatol* 35(5): 468-476.
Molania T, Alimohammadi M, Akha O, et al. (2017) The effect of xerostomia and hyposalivation on the quality of life of patients with type II diabetes mellitus. *Electron Physician* 9(11): 5814-5819.
Montiel-Luque A, Nunez-Montenegro AJ, Martin-Aurioles E, et al. (2017) Medication-related factors associated with health-related quality of life in patients older than 65 years with polypharmacy. *PLoS One* 12(2): e0171320.
Moore PA, Guggenheimer J, Etzel KR, et al. (2001) Type 1 diabetes mellitus, xerostomia, and salivary flow rates. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 92(3): 281-291.
Mortazavi H, Baharvand M, Movahhedian A, et al. (2014) Xerostomia due to systemic disease: A review of 20 conditions and mechanisms. *Annals of Medical and Health Sciences Research* 4(4).
Mukaka MM (2012) Statistics Corner: A guide to appropriate use of Correlation coefficient in medical research. *Malawi Medical Journal* 24(3): 69-71.
Nammontri O (2012) *The Effect of an Intervention to Enhance Sense of Coherence on Oral Health Related Quality of Life: A Cluster Randomised Controlled Trial*. The University of Sheffield.
Nammontri O (2017) Validation of the Thai version of the 14-item oral health impact profile (Thai OHIP-14) amongst the general Thai adult population in a community setting. *J Health Res* 31(6): 481-486.
Nammontri O, Robinson PG and Baker SR (2013) Enhancing oral health via sense of coherence: a cluster-randomized trial. *J Dent Res* 92(1): 26-31.
Narhi TO (1994) Prevalence of subjective feelings of dry mouth in the elderly. *J Dent Res* 73(1): 20-25.

Navazesh M and Kumar SK (2008) Measuring salivary flow: challenges and opportunities. *J Am Dent Assoc* 139 Suppl: 35S-40S.

Nederfors T (2000) Xerostomia and Hyposalivation. *Advances in Dental Research* 14: 48-56.

Nederfors T, Isaksson R, Mörnstad H, et al. (1997) Prevalence of perceived symptoms of dry mouth in an adult Swedish population - relation to age, sex and pharmacotherapy. *Community Dentistry and Oral Epidemiology* 25(3): 211-216.

Niklander S, Veas L, Barrera C, et al. (2017) Risk factors, hyposalivation and impact of xerostomia on oral health-related quality of life. *Braz Oral Res* 31: e14.

Nilchaikovit T, Lotrakul M and Phisansuthideth U (1996) Development of Thai version of hospital anxiety and depression scale in cancer patients. *J Psychiatr Assoc Thailand* 41(1): 18-30.

Nilsson KW, Leppert J, Simonsson B, et al. (2010) Sense of coherence and psychological well-being: improvement with age. *Journal of Epidemiology & Community Health* 64(4): 347-352.

Nittayananta W, Chanowanna N, Jealae S, et al. (2010) Hyposalivation, xerostomia and oral health status of HIV-infected subjects in Thailand before HAART era. *J Oral Pathol Med* 39(1): 28-34.

Nittayananta W, Chanowanna N, Pruphetkaew N, et al. (2013) Relationship between xerostomia and salivary flow rates in HIV-infected individuals. *J Investig Clin Dent* 4(3): 164-171.

Ogihara Y and Kusumi T (2020) The Developmental Trajectory of Self-Esteem Across the Life Span in Japan: Age Differences in Scores on the Rosenberg Self-Esteem Scale From Adolescence to Old Age. *Front Public Health* 8: 132.

Ojelabi AO, Graham Y, Haighton C, et al. (2017) A systematic review of the application of Wilson and Cleary health-related quality of life model in chronic diseases. *Health Qual Life Outcomes* 15(1): 241.

Orellana MF, Lagravere MO, Boychuk DGJ, et al. (2006) Prevalence of Xerostomia in Population-based Samples: A Systematic Review. *Journal of Public Health Dentistry* 66(2): 152-158.

Osterberg T, Birkhed D, Johansson C, et al. (1992) Longitudinal study of stimulated whole saliva in an elderly population. *Scand J dent Res* 100: 340-345.

Osterberg T, Landahl S and Hedegard B (1984) Salivary flow, saliva, pH and buffering capacity in 70-year-old men and women. *Journal of Oral Rehabilitation* 11: 157-170.

Ozhayat EB (2013) Influence of self-esteem and negative affectivity on oral health-related quality of life in patients with partial tooth loss. *Community Dent Oral Epidemiol* 41(5): 466-472.

Özhayat EB (2013) Influence of negative affectivity and self-esteem on the oral health related quality of life in patients receiving oral rehabilitation. *Health Qual Life Outcomes* 11(178): 1-7.

Pais-Ribeiro J, da Silva AM, Meneses RF, et al. (2007) Relationship between optimism, disease variables, and health perception and quality of life in individuals with epilepsy. *Epilepsy Behav* 11(1): 33-38.

Pazos CTC, Austregesilo SC and Goes PSA (2019) Self-esteem and oral health behavior in adolescents. *Cien Saude Colet* 24(11): 4083-4092.

Pedersen AM, Bardow A, Jensen SB, et al. (2002) Saliva and gastrointestinal functions of taste, mastication, swallowing and digestion. *Oral Diseases* 8(3): 117-129.

Pongmesa T, Li SC and Wee HL (2010) Development of a Thai Version of the Audit of Diabetesdependent Quality of Life (Addqol-19) Questionnaire: Linguistic and Psychometric Evaluation. *Value in Health* 13(7).

Porter SR, Scully C and Hegarty AM (2004) An update of the etiology and management of xerostomia. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 97(1): 28-46.
Proctor GB (2016) The physiology of salivary secretion. *Periodontology 2000* 70(1): 11-25.
Puangpet T, Pongkunakorn T, Chulkarat N, et al. (2022) Control and complications of diabetes in urban primary care units in Thailand: a cross-sectional study. *BMC Prim Care* 23(1): 212.
Pudrovska T (2015) Gender and health control beliefs among middle-aged and older adults. *J Aging Health* 27(2): 284-303.
Putten GJ, Brand HS, Schols JM, et al. (2011) The diagnostic suitability of a xerostomia questionnaire and the association between xerostomia, hyposalivation and medication use in a group of nursing home residents. *Clin Oral Investig* 15(2): 185-192.
Rad M, Kakoie S, Brojeni FN, et al. (2010) Effect of Long-term Smoking on Whole-mouth Salivary Flow Rate and Oral Health. *Journal of dental research, dental clinics, dental prospects* 4(4): 110-114.
Rassart J, Luyckx K, Moons P, et al. (2014) Personality and self-esteem in emerging adults with Type 1 diabetes. *J Psychosom Res* 76(2): 139-145.
Ratanasuwan T, Indharapakdi S, Promrerk R, et al. (2005) Health Belief Model about Diabetes Mellitus in Thailand: The Culture Consensus Analysis. *J Med Assoc Thai* 88(5): 623-631.
Rebelo MA, Cardoso EM, Robinson PG, et al. (2016) Demographics, social position, dental status and oral health-related quality of life in community-dwelling older adults. *Qual Life Res* 25(7): 1735-1742.
Reichart PA (2000) Oral mucosal lesions in a representative cross-sectional study of aging Germans. *Community Dentistry and Oral Epidemiology* 28(5): 390-398.
Reutrakul S and Deerochanawong C (2016) Diabetes in Thailand: Status and Policy. *Curr Diab Rep* 16(3): 28.
Robinson PG (2016) Choosing a measure of health related quality of life. *Community Dental Health* 33(2): 107-115.
Robinson PG, Baker SR and Gibson BJ (2015) Introduction. *Dentine Hypersensitivity*. pp.3-20.
Robinson PG, Gibson BJ, Khan FA, et al. (2003) Validity of two oral health-related quality of life measures. *Community Dentistry and Oral Epidemiology* 31(2): 90-99.
Rohani B (2019) Oral manifestations in patients with diabetes mellitus. *World J Diabetes* 10(9): 485-489.
Rubin RR and Peyrot M (1999) Quality of life and diabetes. *Diabetes/Metabolism Research and Reviews* 15(3): 205-218.
Ruengorn C, Awiphan R, Wongpakaran N, et al. (2021) Association of job loss, income loss, and financial burden with adverse mental health outcomes during coronavirus disease 2019 pandemic in Thailand: A nationwide cross-sectional study. *Depress Anxiety* 38(6): 648-660.
Saarijarvi M and Bratt EL (2021) When face-to-face interviews are not possible: tips and tricks for video, telephone, online chat, and email interviews in qualitative research. *Eur J Cardiovasc Nurs* 20(4): 392-396.
Saeedi P, Petersohn I, Salpea P, et al. (2019) Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9(th) edition. *Diabetes Res Clin Pract* 157: 107843.
Saengsiri A, Thanasilp S and Preechawong S (2014) Factors predicting quality of life for coronary artery disease patients after percutaneous coronary intervention. *Asian Biomedicine* 8(1): 31-42.

Sakboonyarat B, Pima W, Chokbumrungsuk C, et al. (2021) National trends in the prevalence of glycemic control among patients with type 2 diabetes receiving continuous care in Thailand from 2011 to 2018. *Sci Rep* 11(1): 14260.

Sakboonyarat B, Sangkool T, Poovieng J, et al. (2023) Trends in the Prevalence of Type 2 Diabetes among Royal Thai Army Personnel and Associated Factors from 2017 to 2021. *Journal of Southeast Asian Medical Research* 7.

Samnieng P (2015) Association of Hyposalivation with Oral Function, Nutrition, and Oral Health in Visual Impaired Patient. *International Journal of Clinical Preventive Dentistry* 11(1): 15-20.

Santos CM, Celeste RK, Hilgert JB, et al. (2015) Testing the applicability of a model of oral health-related quality of life. *Cad Saude Publica* 31(9): 1871-1880.

Savolainen J, Suominen-Taipale AL, Hausen H, et al. (2005) Sense of coherence as a determinant of the oral health-related quality of life: a national study in Finnish adults. *Eur J Oral Sci* 113(2): 121-127.

Schenker Y, Park SY, Jeong K, et al. (2019) Associations Between Polypharmacy, Symptom Burden, and Quality of Life in Patients with Advanced, Life-Limiting Illness. *J Gen Intern Med* 34(4): 559-566.

Schram MT, Baan CA and Pouwer F (2009) Depression and Quality of Life in Patients with Diabetes: A Systematic Review from the European Depression in Diabetes (EDID) Research Consortium. *Current Diabetes Reviews* 5(2): 112-119.

Ship JA (2003) Diabetes and oral health: an overview. *J Am Dent Assoc* 134 Spec No: 4S-10S.

Ship JA, Pillemer SR and Baum BJ (2002) Xerostomia and the Geriatric Patient. *JAGS* 50(3): 535-543.

Shirlaw PJ and Khan A (2017) Oral dryness and Sjogren's: an update. *Br Dent J* 223(9): 649-654.

Shiu AT, Choi KC, Lee DT, et al. (2014) Application of a health-related quality of life conceptual model in community-dwelling older Chinese people with diabetes to understand the relationships among clinical and psychological outcomes. *J Diabetes Investig* 5(6): 677-686.

Skyler JS, Bakris GL, Bonifacio E, et al. (2017) Differentiation of Diabetes by Pathophysiology, Natural History, and Prognosis. *Diabetes* 66(2): 241-255.

Slade GD (1997) Derivation and validation of a short-form oral health impact profile. *Community Dentistry and Oral Epidemiology* 25(4): 284-290.

Sonpanao P, Janebodin K, Namvichaisirikul N, et al. (2023) The Prevalence of Xerostomia in Older Thai Individuals with Type II Diabetes Mellitus and Its Association with Type of Toothpaste and Oral Functions: A Cross-Sectional Study Using Questionnaires. *Geriatrics (Basel)* 8(4).

Soper DS (2020) *A-priori Sample Size Calculator for Structural Equation Models [Software]*. Available at: https://www.danielsoper.com/statcalc.

Sousa KH and Kwok OM (2006) Putting Wilson and Cleary to the test: analysis of a HRQOL conceptual model using structural equation modeling. *Qual Life Res* 15(4): 725-737.

Sowattanangoon N, Kotchabhakdi N and Petrie KJ (2009) The influence of Thai culture on diabetes perceptions and management. *Diabetes Res Clin Pract* 84(3): 245-251.

Sreebny LM, Yu A, Green A, et al. (1992) Xerostomia in Diabetes Mellitus. *Diabetes Care* 15(7): 900-904.

Storbeck T, Qian F, Marek C, et al. (2022) Dose-dependent association between xerostomia and number of medications among older adults. *Spec Care Dentist* 42(3): 225-231.

Subramanian SV, Huijts T and Avendano M (2010) Self-reported health assessments in the 2002 World Health Survey: how do they correlate with education? *Bull World Health Organ* 88(2): 131-138.
Sullivan MD, Kempen GI, E. VS, et al. (2000) Models of health-related quality of life in a population of community-dwelling Dutch elderly. *Qual Life Res* 9(7): 801-810.
Sundaram M, Kavookjian J, Patrick JH, et al. (2007) Quality of life, health status and clinical outcomes in Type 2 diabetes patients. *Qual Life Res* 16(2): 165-177.
Super S, Wagemakers MA, Picavet HS, et al. (2016) Strengthening sense of coherence: opportunities for theory building in health promotion. *Health Promot Int* 31(4): 869-878.
Suttagul K (2018) Diabetes Mellitus Type 2 and Oral Health in Context to Thailand: An Updated Overview. *J Int Dent Med Res* 11(1): 342-347.
Tan ECK, Lexomboon D, Sandborgh-Englund G, et al. (2018) Medications That Cause Dry Mouth As an Adverse Effect in Older People: A Systematic Review and Metaanalysis. *J Am Geriatr Soc* 66(1): 76-84.
Tanasiewicz M, Hildebrandt T and Obersztyn I (2016) Xerostomia of Various Etiologies: A Review of the Literature. *Adv Clin Exp Med* 25(1): 199-206.
Thatreenaranon S (2018) The efficacy of oral moisturizing jelly in alleviating symptoms of xerostomia in psychiatric patients. *Journal of Mental Health of Thailand* 26(2): 129-141.
Thomson WM (2005) Issues in the epidemiological investigation of dry mouth. *Gerodontology* 22(2): 65-76.
Thomson WM (2007) Measuring change in dry-mouth symptoms over time using the Xerostomia Inventory. *Gerodontology* 24(1): 30-35.
Thomson WM (2015) Dry mouth and older people. *Aust Dent J* 60 Suppl 1: 54-63.
Thomson WM, Brown RH and Williams SM (1993) Medication and perception of dry mouth in a population of institutionalised elderly people. *New Zealand Medical Journal* 106(957): 219-221.
Thomson WM, Chalmers JM, Spencer AJ, et al. (1999) The Xerostomia Inventory: A multi-item approach to measuring dry mouth. *Community Dent Health* 16(1): 12-17.
Thomson WM, Lawrence HP, Broadbent JM, et al. (2006) The impact of xerostomia on oral-health-related quality of life among younger adults. *Health Qual Life Outcomes* 4: 86.
Thomson WM, van der Putten GJ, de Baat C, et al. (2011) Shortening the xerostomia inventory. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 112(3): 322-327.
Thomson WM and Williams SM (2000) Further testing of the xerostomia inventory. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 89(1): 46-50.
Tomasdottir MO, Sigurdsson JA, Petursson H, et al. (2016) Does 'existential unease' predict adult multimorbidity? Analytical cohort study on embodiment based on the Norwegian HUNT population. *BMJ Open* 6(11): e012602.
Tunsuchart K, Lerttrakarnnon P, Srithanaviboonchai K, et al. (2020) Type 2 Diabetes Mellitus Related Distress in Thailand. *Int J Environ Res Public Health* 17(7).
Turner M, Jahangiri L and Ship JA (2008) Hyposalivation, xerostomia and the complete denture: a systematic review. *J Am Dent Assoc* 139(2): 146-150.
Turner MD and Ship JA (2007) Dry mouth and its effects on the oral health of elderly people. *J Am Dent Assoc* 138 Suppl: 15S-20S.
Ullman JB and Bentler PM (2012) Structural Equation Modeling. *Handbook of Psychology, Second Edition*. John Wiley & Sons, Ltd, pp.661-690.

Vatcharavongvan P and Puttawanchai V (2017) Polypharmacy, medication adherence and medication management at home in elderly patients with multiple non-communicable diseases in Thai primary care. *Family Medicine & Primary Care Review* 19(4): 412-416.

Vathanophas V (2019) Factors Associated with Xerostomia in Non-Radiated Patients. *Siriraj Medical Journal* 71(5): 377-384.

Verhulst MJ, Teeuw WJ, Gerdes VE, et al. (2019) Self-reported oral health and quality of life in patients with type 2 diabetes mellitus in primary care: a multi-center cross-sectional study. *Diabetes Metab Syndr Obes* 12: 883-899.

Villa A, Wolff A, Narayana N, et al. (2016) World Workshop on Oral Medicine VI: a systematic review of medication-induced salivary gland dysfunction. *Oral Dis* 22(5): 365-382.

Vitali C, Bombardieri S, Jonsson R, et al. (2002) Classification criteria for Sjögren's syndrome: A revised version of the European criteria proposed by the American-European Consensus Group. *Annals of the Rheumatic Diseases* 61(6): 554-558.

Vitali C, Bombardieri S, Moutsopoulos H, et al. (1996) Assessment of the European classification criteria for Sjögren's syndrome in a series of clinically defined cases: Results of a prospective multicentre study. *Annals of the Rheumatic Diseases* 55(2): 116-121.

Wallston KA, Stein MJ and Smith CA (1994) Form C of the MHLC scales: a condition-specific measure of locus of control. *J Pers Assess* 63(3): 534-553.

Warner LM, Schuz B, Wurm S, et al. (2010) Giving and taking--differential effects of providing, receiving and anticipating emotional support on quality of life in adults with multiple illnesses. *J Health Psychol* 15(5): 660-670.

Wee HL, Tan CE, Goh SY, et al. (2006) Usefulness of the Audit of Diabetes-Dependent Quality-of-Life (ADDQoL) questionnaire in patients with diabetes in a multi-ethnic Asian country. *PharmacoEconomics* 24(7): 673-682.

WHO (2001) Editorial: ICF approved as the successor of ICIDH. *Journal of Rehabilitation Medicine*. 193-194.

WHO (2002a) Towards a common language for functioning, disability and health: ICF. *International Classification* 1149: 1-22.

WHO (2002b) WORLD HEALTH SURVEY 2002.

Wilder L, Devleesschauwer B, Clays E, et al. (2022) Polypharmacy and Health-Related Quality of Life/Psychological Distress Among Patients With Chronic Disease. *Prev Chronic Dis* 19: E50.

Wilson IB and Cleary PD (1995) Linking clinical variables with health-related quality of life. A conceptual model of patient outcomes. *JAMA: The Journal of the American Medical Association* 273(1): 59-65.

Wister A, Kendig H, Mitchell B, et al. (2016) Multimorbidity, health and aging in Canada and Australia: a tale of two countries. *BMC Geriatr* 16(1): 163.

Wolff A, Joshi RK, Ekstrom J, et al. (2017) A Guide to Medications Inducing Salivary Gland Dysfunction, Xerostomia, and Subjective Sialorrhea: A Systematic Review Sponsored by the World Workshop on Oral Medicine VI. *Drugs R D* 17(1): 1-28.

Wongpakaran N, Wongpakaran T, Sirirak T, et al. (2018) Predictors of polypharmacy among elderly Thais with depressive and anxiety disorders: findings from the DAS study. *BMC Geriatr* 18(1): 309.

Wongpakaran T and Wongpakaran N (2011) Confirmatory factor analysis of Rosenberg Self-Esteem Scale: A study of Thai student sample. *J Psychiatr Assoc Thailand* 56(1): 59-70.

Ye L, Yang-Huang J, Franse CB, et al. (2022) Factors associated with polypharmacy and the high risk of medication-related problems among older community-dwelling adults in European countries: a longitudinal study. *BMC Geriatr* 22(1): 841.
Yookhum N (2022) Prevalence of Xerostomia in The Elderly at Mueang Roiet District. *Research and Development Health System Journal* 15(1): 129-141.
Zigmond AS and Snaith RP (1983) The Hospital Anxiety and Depression Scale. *Acta Psychiatr. Scand.* 67: 361-370.
Zimmer Z and Amornsirisomboon P (2001) Socioeconomic status and health among older adults in Thailand: an examination using multiple indicators. *Social Science & Medicine* 52(8): 1277-1311.
Zunzunegui MV, Beland F and Gutierrez-Cuadra P (2001) Loss to follow-up in a longitudinal study on aging in Spain. *Journal of Clinical Epidemiology* 54: 501-510.

Appendices

Appendix A: Ethical Approval

- Hatyai hospital

	คณะกรรมการจริยธรรมการวิจัยในมนุษย์ โรงพยาบาลหาดใหญ่	AP 14-04/V.3
	แบบฟอร์มการโหวตให้คะแนน	เริ่มใช้ 10 มีนาคม 2564

รหัสโครงการ	061-64-02
ชื่อโครงการวิจัย	The impacts of dry mouth on oral health-related quality of life in diabetic patients in Songkhla, Thailand
ชื่อผู้วิจัยหลัก	ทันตแพทย์หญิงอริศา ศรีคง
ผลการพิจารณาลงมติ	☑ 1 เห็นชอบให้ทำการวิจัยได้โดยไม่มีเงื่อนไข (Approved)
	☐ 2 ปรับปรุงแก้ไขเพื่อเห็นชอบ (Modification for Approval)
	☐ 3 ปรับปรุงแก้ไขแล้วเข้าพิจารณาใหม่ (Modification for Full Board Review)
	☐ 4 ไม่เห็นชอบให้ดำเนินการวิจัย (Disapproved)

ข้อเสนอแนะ :

....

....

....

....

....

....

ลงนาม

(นายเจริญ เกียรติวัชรชัย)

วันที่ 31 เดือนพฤษภาคม พ.ศ. 2564

- Prince of Songkla University

HUMAN RESEARCH ETHICS COMMITTEE (HREC)
BUILDING 1 5TH FLOOR
TEL. 66-74-287734

FACULTY OF DENTISTRY
PRINCE OF SONGKLA UNIVERSITY
HADYAI, SONGKHLA 90112, THAILAND
TEL. 66-74-287500

Documentary Proof of Ethical Clearance
Human Research Ethics Committee (HREC)
Faculty of Dentistry, Prince of Songkla University

The Project Entitled	The impacts of dry mouth on oral health-related quality of life in diabetic patients in Songkhla, Thailand
EC Project No.	EC6404-017
Principal Investigator	Asst.Prof.Samerchit Pithpornchaikul
Affiliation	Department of Preventive Dentistry Faculty of Dentistry, PSU
Co-Principal Investigator	Miss Arisa Srikong / Miss Rungsinee Techawitoonwong
Affiliation	Department of Preventive Dentistry Faculty of Dentistry, PSU / Hatyai Hospital

Approved Documents :

- ☑ Submission Form
- ☑ Research Proposal
- ☑ Information Sheet
- ☑ Consent Form
- ☑ Other ...
  - ☑ Questionnaire Form

Approved by Human Research Ethics Committee (HREC), Faculty of Dentistry, Prince of Songkla University.

This is to certify that HREC is in full compliance with International Guidelines for Human Research Protection such as the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

This review is documented in the meeting minutes of the meeting 5/2564
Agenda 3.6.2 **on** 27 MAY 2021

Please submit the Progress Report every 12 **months. (Renewal must be submitted at least 30 days prior to expired date.)**

(Assoc.Prof.Dr.Chairat Charoemratrote)
Chairman of Research Ethics Committee
Faculty of Dentistry, Prince of Songkla University

Date of Approval : 28 April 2021
Date of Expiration : 27 April 2022

- The University of Sheffield

The University Of Sheffield.

Downloaded: 13/07/2021
Approved: 13/07/2021

Arisa Srikong
Registration number: 190188090
School of Clinical Dentistry
Programme: Dentistry (Science) (PhD/ Dentistry (Science) FT)

Dear Arisa

PROJECT TITLE: The impacts of dry mouth on oral health-related quality of life in diabetic patients in Songkhla, Thailand
APPLICATION: Reference Number 038376

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 13/07/2021 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 038376 (form submission date: 27/06/2021); (expected project end date: 01/12/2022).
- Participant information sheet 1093878 version 1 (21/06/2021).
- Participant consent form 1093879 version 1 (21/06/2021).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Paul Hatton
Ethics Administrator
School of Clinical Dentistry

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix B: Salivary collection form

-
-

Time (Minutes)	Saliva	Container No.	Post-weight (Grams)	Pre-weight (Grams)	Flow rate/ Minute	Hyposalivation	
5	Unstimulated					N (0)	Y (1)
3	Stimulated					N (0)	Y (1)

- *N: No, Y: Yes

Unstimulated salivary flow rate = $\frac{\text{(Post-weight)} - \text{(Pre-weight)}}{\text{Collection period}} = \frac{\quad - \quad}{5} =$ g/min

-

Stimulated salivary flow rate = $\frac{\text{(Post-weight)} - \text{(Pre-weight)}}{\text{Collection period}} = \frac{\quad - \quad}{3} =$ g/min

-

Hyposalivation is considered as ≤ 0.1 g/min (ml/ min) for unstimulated whole salivary flow rate, and ≤ 0.5 g/min (ml/min) for stimulated whole salivary flow rate.

Appendix C: Participant demographic form

	Code
Age:	
Date of birth (dd/mm/yy):	
Sex: (1) Male (2) Female	
Education level: (1) Primary school (2) Middle school (3) High school or equal (4) Diploma (5) Undergraduate (6) Postgraduate	
Income level: (1) No income (2) 1-5,000 baht (3) 5,001-15,000 baht (4) 15,001-30,000 baht (5) 30,001-50,000 baht (6) 50,001 or more baht	
Smoking status: (1) Never smoked (2) Former smoker (3) Current smoker	
Date of DM diagnosis (dd/mm/yy):	

Appendix D: Participant medical form

Diabetic type: (1) Type 1 (2) Type 2	DMType [ ]
Duration of the disease: (1) less than 6 months (2) 6-12 months (3) More than 1 year – 3 years (4) More than 3 year – 5 years (5) More than 5 year – 10 years (6) More than 10 years	DMDur [ ]
Diabetic treatment regimen: (1) Insulin and diet (2) Insulin and tablets (3) Tablets and diet (4) Diet only	DMRegimen [ ]
Glucose level: FBS:________________________ Date: ______________________ (1) less than 70 mg/dL (2) 70 to 130 mg/dL (3) 130 or more mg/dL	FBS [ ]
HbA1c:________________________ Date: ______________________ (1) below 7% (below 53 mmol/mol) (2) 7% to 9% (53 to 75 mmol/mol) (3) 9% or more (75 or more mmol/mol)	HbA1c [ ]
Other medical conditions: (0) No (1) Yes ____ ____	Disothers [ ]
Prescribed medication: (0) No (1) Yes ____ ____	Meds [ ]

Appendix E: Interview form

Part 1: Symptom status

In the past month, how often that (Xerostomia Inventory)

S/N	Items	Never	Hardly ever	Occasionally	Fairly often	Very often	Code
1	You sip liquids to aid in swallowing food	1	2	3	4	5	
2	Your mouth feels dry when eating a meal	1	2	3	4	5	
3	You get up at night to drink	1	2	3	4	5	
4	Your mouth feels dry	1	2	3	4	5	
5	You have difficulty eating dry foods	1	2	3	4	5	
6	You suck sweets or cough lollies to relieve dry mouth	1	2	3	4	5	
7	You have difficulties swallowing certain foods	1	2	3	4	5	
8	The skin of your face feels dry	1	2	3	4	5	
9	Your eyes feel dry	1	2	3	4	5	
10	Your lips feel dry	1	2	3	4	5	
11	The inside of your nose feels dry	1	2	3	4	5	

Part 2: Dry mouth functional status (OHIP-14)

In the past month, how often have you

S/N	Items	Never	Hardly ever	Occasionally	Fairly often	Very often	Code
1	Had trouble pronouncing any words because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
2	Felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
3	Had painful aching in your mouth?	0	1	2	3	4	
4	Found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
5	Been self-conscious because of your teeth, mouth or dentures?	0	1	2	3	4	
6	Felt tense because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
7	Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?	0	1	2	3	4	

S/N	Items	Never	Hardly ever	Occasionally	Fairly often	Very often	Code
8	Had to interrupt meals because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
9	Found it difficult to relax because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
10	Been a bit embarrassed because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
11	Been a bit irritated with other people because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
12	Had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
13	Felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?	0	1	2	3	4	
14	Been totally unable to function because of problems with your teeth, mouth or dentures?	0	1	2	3	4	

Part 3: Diabetic functional status (ADDQoL-19)

This questionnaire asks about your quality of life – in other words how good or bad you feel your life to be.

Please put an “X” in the box that best indicates your response for each item.

What we would like to know is how you feel about your life now.

I) In general, my present quality of life is							Code
extremely good	very good	good	neither good nor bad (0)	bad	very bad	extremely bad	
(3)	(2)	(1)		(-1)	(-2)	(-3)	

Now we would like to know how your quality of life is affected by your diabetes, its management and any complications you may have.

II) If I did not have diabetes, my quality of life would be					Code
very much better	much better	a little better	the same	worse	
(-3)	(-2)	(-1)	(0)	(1)	

Please respond to the more specific statements on the following pages. Foe each aspect of life described you will find two parts:

For part (a): put an "X" in one box to show how diabetes affects this aspect of your life. For part (b): put an "X" in one box to show how important this aspect of your life is to your quality of life.

1 (a)	If I did *not* have diabetes, I would enjoy my leisure activities:					Code
	very much more (-3)	much more (-2)	a little more (-1)	the same (0)	less (1)	
(b)	My leisure activities are:					
	very important (3)	important (2)	somewhat important (1)	not at all important (0)		

2	Are you currently working, looking for work or would like to work?					Code
	Yes	If yes, complete (a) and (b).				
	No	If no, go straight to 3a.				
(a)	If I did *not* have diabetes, my working life would be:					
	very much better (-3)	much better (-2)	a little better (-1)	the same (0)	worse (1)	
(b)	For me, having a working life is:					
	very important (3)	important (2)	somewhat important (1)	not at all important (0)		

3 (a)	If I did *not* have diabetes, local or long-distance journeys would be:					Code
	very much easier (-3)	much easier (-2)	a little easier (-1)	the same (0)	more difficult (1)	
(b)	For me, local or long-distance journeys are:					
	very important (3)	important (2)	somewhat important (1)	not at all important (0)		

4	Do you ever go on holiday or want to go on holiday? Yes If yes, complete (a) and (b). No If no, go straight to 5a.	Code
(a)	If I did *not* have diabetes, my holidays would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	
(b)	For me, holidays are: very important (3) important (2) somewhat important (1) not at all important (0)	

5 (a)	If I did *not* have diabetes, physically I could do: very much more (-3) much more (-2) a little more (-1) the same (0) less (1)	Code
(b)	For me, how much I can do physically is: very important (3) important (2) somewhat important (1) not at all important (0)	

6	Do you have any family/relatives? Yes If yes, complete (a) and (b). No If no, go straight to 7a.	Code
(a)	If I did *not* have diabetes, my family life would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	
(b)	My family life is: very important (3) important (2) somewhat important (1) not at all important (0)	

7 (a)	If I did *not* have diabetes, my friendships and social life would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My friendships and social life are: very important (3) important (2) somewhat important (1) not at all important (0)	

8	Do you have or would you like to have a close personal relationship (e.g. husband/ wife, partner)? Yes If yes, complete (a) and (b). No If no, go straight to 9a.	Code
(a)	If I did *not* have diabetes, my closet personal relationship would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	
(b)	For me, having a closet personal relationship is: very important (3) important (2) somewhat important (1) not at all important (0)	

9	Do you have or would you like to have a sex life? Yes If yes, complete (a) and (b). No If no, go straight to 10a.	Code
(a)	If I did *not* have diabetes, my sex life would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	
(b)	For me, having a sex life is: very important (3) important (2) somewhat important (1) not at all important (0)	

10 (a)	If I did *not* have diabetes, my physical appearance would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My physical appearance is: very important (3) important (2) somewhat important (1) not at all important (0)	

11 (a)	If I did *not* have diabetes, my self-confidence would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My self-confidence is: very important (3) important (2) somewhat important (1) not at all important (0)	

12 (a)	If I did *not* have diabetes, my motivation would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My motivation is: very important (3) important (2) somewhat important (1) not at all important (0)	

13 (a)	If I did *not* have diabetes, the way people in general react to me would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	The way people in general react to me is: very important (3) important (2) somewhat important (1) not at all important (0)	

14 (a)	If I did *not* have diabetes, my feelings about the future (e.g., worries, hopes) would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My feelings about the future are: very important (3) important (2) somewhat important (1) not at all important (0)	

15 (a)	If I did *not* have diabetes, my financial situation would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My financial situation is: very important (3) important (2) somewhat important (1) not at all important (0)	

16 (a)	If I did *not* have diabetes, my living conditions would be: very much better (-3) much better (-2) a little better (-1) the same (0) worse (1)	Code
(b)	My living conditions are: very important (3) important (2) somewhat important (1) not at all important (0)	

17 (a)	If I did *not* have diabetes, I would have to depend on others when I do not want to: very much less (-3) much less (-2) a little less (-1) the same (0) more (1)	Code
(b)	For me, not having to depend on others is: very important (3) important (2) somewhat important (1) not at all important (0)	

18 (a)	If I did *not* have diabetes, my freedom to eat as I wish would be: very much greater (-3) much greater (-2) a little greater (-1) the same (0) less (1)	Code
(b)	My freedom to eat as I wish is: very important (3) important (2) somewhat important (1) not at all important (0)	

19 (a)	If I did *not* have diabetes, my freedom to drink as I wish (e.g. fruit juice, alcohol, sweetened hot and cold drinks) would be: very much greater (-3) much greater (-2) a little greater (-1) the same (0) less (1)	Code
(b)	My freedom to drink as I wish is: very important (3) important (2) somewhat important (1) not at all important (0)	

If there are any other ways in which diabetes, its management and any complications effect your quality of life, please say what they are below:

Part 4: General health and oral health perceptions

In general, how would you rate your health today? 1. Very good 2. Good 3. Moderate 4. Bad 5. Very bad	Code
Would you say that the health of your teeth, lips, jaws, or mouth is ….? 1. Poor 2. Fair 3. Good 4. Very good 5. Excellent	

Part 5: Psychological distress (HADS)

In the past week, how you have been feeling

D	A	
		1. I feel tense or 'wound up'
	3	Most of the time
	2	A lot of the time
	1	From time to time, occasionally
	0	Not at all
		2. I still enjoy the things I used to enjoy
0		Definitely as much
1		Not quite so much
2		Only a little
3		Hardly at all
		3. I get a sort of frightened feeling as if something awful is about to happen
	3	Very definitely and quite badly
	2	Yes, but not too badly
	1	A little, but it doesn't worry me
	0	Not at all
		4. I can laugh and see the funny side of things
0		As much as I always could
1		Not quite so much now
2		Definitely not quite so much now
3		Not at all
		5. Worrying thoughts go through my mind
	3	A great deal of the time
	2	A lot of the time
	1	From time to time, but not too often
	0	Only occasionally
		6. I feel cheerful
3		Not at all
2		Not often
1		Sometimes
0		Most of the time

D	A	
		7. I can sit at ease and feel relaxed
	0	Definitely
	1	Usually
	2	Not often
	3	Not at all
		8. I feel as if I am slowed down
3		Nearly all the time
2		Very often
1		Sometimes
0		Not at all
		9. I get a sort of frightened feeling like ‘butterflies’ in the stomach
	0	Not at all
	1	Occasionally
	2	Quite often
	3	Very often
		10. I have lost interest in my appearance
3		Definitely
2		I don’t take as much care as I should
1		I may not take quite as much care
0		I take just as much care as ever
		11. I feel restless as I have to be on the move
	3	Very much indeed
	2	Quite a lot
	1	Not very much
	0	Not at all
		12. I look forward with enjoyment to things
0		As much as I ever did
1		Rather less than I used to
2		Definitely less than I use to
3		Hardly at all
		13. I get sudden feelings of panic
	3	Very often indeed
	2	Quite often
	1	Not very often
	0	Not at all

D	A	
		14. I can enjoy a good book or radio or TV program
0		Often
1		Sometimes
2		Not often
3		Very seldom

Part 6: Sense of coherence (SOC-13)

Please tell us how do you feel?

1. Do you have the feeling that you do not really care about what goes on around you? 1 2 3 4 5 6 7 Very seldom or never ... Very often	Code
2. Has it happened in the past that you were surprised by the behaviour of people whom you thought you knew well? 1 2 3 4 5 6 7 Never happened ... Always happened	
3. Has it happened that people whom you counted on disappointed you? 1 2 3 4 5 6 7 Never happened ... Always happened	
4. Until now your life has had 1 2 3 4 5 6 7 No clear goals or purpose at all ... Very clear goals or purpose	
5. Do you have the feeling that you are being treated unfairly? 1 2 3 4 5 6 7 Very often ... Very seldom or never	
6. Do you have the feeling that you are in an unfamiliar situation and do not know what to do? 1 2 3 4 5 6 7 Very often ... Very seldom or never	

7. Doing the things you do every day is 1 2 3 4 5 6 7 A source of deep pleasure and satisfaction ... A source of pain and boredom	Code
8. Do you have very mixed-up feelings and ideas? 1 2 3 4 5 6 7 Very often ... Very seldom or never	
9. Does it happen that you have feelings inside you would rather not feel? 1 2 3 4 5 6 7 Very often ... Very seldom or never	
10. Many people – even those with strong character – sometimes feel like sad losers in a certain situation. How often have you felt this way in the past? 1 2 3 4 5 6 7 Never ... Very often	
11. When something has happened have you generally found that 1 2 3 4 5 6 7 You overestimated or underestimated its importance ... You saw things in the right proportion	
12. How often do you have the feeling that there is little meaning in the things you do in your daily life? 1 2 3 4 5 6 7 Very often ... Very seldom or never	
13. How often do you have the feeling that you are not sure you can keep under control? 1 2 3 4 5 6 7 Very often ... Very seldom or never	Code

Part 7: Self-esteem (RSES)

How much are you agree or disagree with the following statements?

S/N	Items	Strongly agree	Agree	Disagree	Strongly disagree	Code
1	On the whole, I am satisfied with myself	1	2	3	4	
2	At times I think I am no good at all.	1	2	3	4	
3	I feel that I have a number of good qualities.	1	2	3	4	
4	I am able to do things as well as most other people.	1	2	3	4	
5	I feel I do not have much to be proud of.	1	2	3	4	
6	I certainly feel useless at times.	1	2	3	4	
7	I feel that I'm a person of worth.	1	2	3	4	
8	I wish I could have more respect for myself.	1	2	3	4	
9	All in all, I am inclined to think that I am a failure.	1	2	3	4	
10	I take a positive attitude toward myself.	1	2	3	4	

Part 8: Health locus of control (HLOC)

How much are you agree or disagree with the following statements? (MHLC-C)

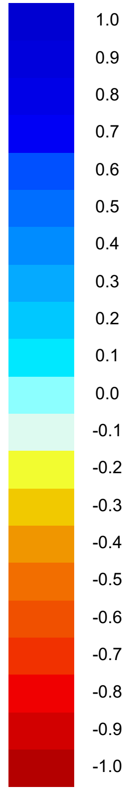
S/N	Items	Strongly disagree					Strongly agree	Code
1	If my condition worsens, it is my own behaviour which determines how soon I feel better again.	1	2	3	4	5	6	
2	I am directly responsible for my condition getting better or worse.	1	2	3	4	5	6	
3	Whatever goes wrong with my condition is my own fault.	1	2	3	4	5	6	
4	The main thing which affects my condition is what I myself do.	1	2	3	4	5	6	
5	If my condition takes a turn for the worse, it is because I have not taking proper care of myself.	1	2	3	4	5	6	
6	I deserve the credit when my condition improves and the blame when it gets worse.	1	2	3	4	5	6	
7	Most things that affect my condition happen to me by chance.	1	2	3	4	5	6	
8	Luck plays a big part in determining how my condition improves.	1	2	3	4	5	6	
9	Whatever improvement occurs with my condition is largely a matter of good fortune.	1	2	3	4	5	6	
10	If my condition worsens, it's a matter of fate.	1	2	3	4	5	6	
11	If I am lucky, my condition will get better.	1	2	3	4	5	6	
12	As to my condition, what will be will be.	1	2	3	4	5	6	
13	If I see my doctor regularly, I am less likely to have problems with my condition.	1	2	3	4	5	6	

S/N	Items	Strongly disagree					Strongly agree	Code
14	Following doctor's orders to the letter is the best way to keep my condition from getting worse.	1	2	3	4	5	6	
15	Whenever my condition worsens, I should consult a medically trained professional.	1	2	3	4	5	6	
16	Other people play a big role in whether my condition improves.	1	2	3	4	5	6	
17	The type of help I receive from other people determines how soon my condition improves.	1	2	3	4	5	6	
18	In order for my condition to improve, it is up to other people to see that the right things happen.	1	2	3	4	5	6	

Appendix F: Correlation matrix among variables in T1DM

Table 32: Correlation matrix among variables in T1 diabetic patients at baseline (N = 23)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1) Age	1																									
(2) Sex [1 = male, 2 = female]	.00	1																								
(3) Education level	.01	.05	1																							
(4) Income	.11	.23	.41	1																						
(5) Smoking status	.18	.57**	.14	.06	1																					
(6) Diagnosis Duration	.49*	.19	.14	.29	.06	1																				
(7) Treatment regime	.26	.31	.26	.20	.18	.27	1																			
(8) FBS	.17	.13	.04	.18	.21	.04	.16	1																		
(9) HbA1c	.05	.17	.30	.00	.10	.18	.08	.10	1																	
(10) XI	.08	.22	.40	.02	.04	.35	.20	.15	.21	1																
(11) OHIP-14	.05	.11	.15	.02	.00	.11	.00	.16	.19	.24	1															
(12) ADDQoL	.12	.03	.19	.28	.11	.27	.20	.19	.23	.04	.16	1														
(13) General Health Perception	.21	.02	.25	.17	.43*	.24	.13	.15	.07	.26	.31	.08	1													
(14) General Oral health Perception	.07	.17	.11	.25	.11	.30	.11	.53*	.07	.22	.24	.26	.36	1												
(15) QoL in general	.27	.35	.07	.14	.32	.06	.16	.30	.30	.08	.43*	.12	.53**	.26	1											
(16) Diabetic-related QoL	.29	.07	.10	.07	.05	.59**	.10	.03	.11	.15	.20	.55**	.17	.04	.03	1										
(17) Anxiety	.05	.26	.09	.39	.15	.05	.14	.15	.15	.18	.39	.18	.10	.35	.12	.00	1									
(18) Depression	.31	.12	.15	.18	.33	.05	.14	.01	.07	.16	.43*	.01	.65**	.40	.34	.09	.34	1								
(19) SOC-13	.12	.21	.51*	.03	.05	.00	.48*	.23	.05	.18	.32	.28	.01	.06	.12	.14	.32	.28	1							
(20) RSES	.21	.06	.08	.44*	.29	.06	.02	.11	.16	.02	.12	.13	.63**	.22	.36	.05	.35	.51*	.30	1						
(21) Internality beliefs	.39	.36	.23	.07	.04	.26	.43*	.10	.32	.11	.27	.02	.29	.08	.02	.05	.18	.16	.20	.10	1					
(22) Chance beliefs	.08	.44*	.32	.53**	.34	.31	.01	.00	.19	.23	.08	.52*	.15	.19	.33	.24	.20	.26	.03	.19	.08	1				
(23) Doctor beliefs	.01	.23	.23	.12	.38	.14	.27	.00	.25	.22	.02	.13	.16	.24	.38	.04	.28	.22	.29	.36	.07	.33	1			
(24) Other people beliefs	.02	.32	.26	.24	.19	.22	.07	.24	.36	.01	.08	.30	.10	.33	.50*	.10	.06	.04	.07	.20	.06	.62**	.16	1		
(25) Multimorbidity	.52*	.16	.16	.10	.18	.08	.18	.29	.19	.02	.01	.26	.32	.30	.33	.01	.06	.21	.25	.53**	.09	.30	.22	.34	1	
(26) Polypharmacy	.59**	.27	.46*	.35	.27	.24	.06	.01	.36	.32	.01	.19	.35	.18	.11	.13	.37	.33	.11	.47*	.24	.29	.08	.10	.32	1



*: Correlation statistically significant p < 0.05, **: Correlation statistically significant p < 0.01, (5) Smoking status: [0 = never smoked, 1 = former smoker, 2 = current smoker], (7) Treatment regime: [1 = diet only, 2 = tablets and insulin], (8) FBS: [0 = not in the normal range, 1 = range between 70 to 130 mg/dL], (9) HbA1c : [0 = not in the normal range, 1 = below 7%]