Xerostomia among adult New Zealanders: a national survey.

Thesis for Masters of Community Dentistry

Angela Benn BDS, MSc (Dent) (Witwatersrand), PDD (Clin Dent) (Stellenbosch)

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Abstract

Objectives

To date, no nationally-representative epidemiological survey of xerostomia has been undertaken. The aim of this study was to examine the prevalence, associations and impacts of xerostomia in a nationally representative sample of dentate adult community-dwelling New Zealanders aged 18 years and above.

Methods

The data were collected as part of the 2009 New Zealand Oral health Survey (NZOHS). A representative sample of 3475 adults (representing approximately 94% of the population) participated in this snapshot survey of community-dwelling New Zealanders. The sample comprised 1267 Māori, 353 Pacific Islanders, 518 Asian and 2125 European/other people. There were 2209 dentate adults in the sample. Data were collected using face-to-face interviews and dental examinations. The OHIP-14 was used to investigate xerostomia's impact on oral-health-related quality of life. The Stata 12 statistical package was used for all analyses. Data analysis took the complex survey design into account by using appropriate weighting for all procedures. Univariate and bivariate analyses were undertaken to describe the sample and the unadjusted associations. Multivariate modeling (logistic and binomial regression) was used to examine the association between xerostomia, sociodemographic characteristics and oral health impacts.

Results

The overall prevalence estimate for xerostomia was 13.1% (approximately one in eight). There was a gender difference, with more xerostomic females than males. Individuals aged 75+ and those between 25 and 34 years old had the highest odds (OR 6.5 and OR 4.0 respectively) of experiencing xerostomia. Xerostomia was strongly associated with

the mean OHIP-14 score (after controlling for covariates such as sociodemographic characteristics and oral health indicators), but xerostomics were not more likely to experience one or more oral health impacts. Xerostomic individuals had a higher mean OHIP score and a higher prevalence of oral health impacts than non-xerostomic individuals. Xerostomia was also strongly associated with being female, Pacific Islander or Māori, and with having periodontitis. The oral-health-related quality of life domains most strongly associated with xerostomia were functional limitation, handicap and social disability; those with the weakest association with it were physical pain and psychological discomfort.

Conclusion

Xerostomia is a distressing condition which affects New Zealanders of all ages, particularly those older than 45 and those aged between 25 and 34 years. In addition, females, Māori and Pacific Islanders and individuals with periodontitis are most likely to suffer. Moreover, xerostomia affects complainants' day-to-day lives by limiting oral function and impinging on their psychosocial well-being. These findings suggest that xerostomia is a chronic condition of some consequence to the individual sufferer. Xerostomia in dentate New Zealand adults constitutes an important public health issue.

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Thanks be to God, from whom all blessings flow.

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1.Literature review

1.1 Introduction

An inherent and yet profound aspect of our well-being is dependent on a humble, unassuming fluid called saliva. Mandel (1990) eloquently stated: “saliva is not one of the popular bodily fluids. It lacks the drama of blood, the sincerity of sweat and the emotional appeal of tears”. However, this unpretentious secretion is a multifaceted, multipurpose bodily fluid which is indispensable. Living with insufficient quantities of this essential, complex fluid leads to an appreciation of what has been lost. Hence, the incentive to discover more about it.

Dry mouth is used as an all-encompassing term for a condition or a state, which, on further investigation, could prove to be xerostomia with or without salivary gland hypofunction (Navazesh et al, 2003; Guggenheimer and Moore, 2003; Thomson, 2005; Hopcraft and Tan 2010). The term “dry mouth” is used ubiquitously and rather indiscriminately in the dental literature. Not all authors clarify whether their discussions and research on dry mouth include (or exclude) xerostomia or salivary gland hypofunction, nor which particular aspect of the field they are investigating and discussing.

Salivary gland hypofunction is detectable as a scientifically measurable chronically low flow of saliva (Thomson et al, 1999b). This sign of pathology is quantifiable and observable by a clinician. Salivary flow is measured using sialometry, by which saliva is collected over a given time and the volume collected is measured (Navazesh, 1993). Hence, salivary flow is normally described as the number of millilitres per minute. The flow rate for an individual is compared to a predefined “normal” to determine whether a diagnosis of salivary gland hypofunction is appropriate (Ship, 2004; Dawes, 2004; Hopcraft and Tan, 2010).

Xerostomia is a symptom (or symptoms) which is felt by the individual. This subjective perception of dry mouth may or may not be due to hypofunction of the

salivary glands. The symptoms of xerostomia can be grouped into experiential and behavioural ones. Experiential symptoms include dryness of the mouth and throat, associated structures, tasting impairment and eating difficulty, halitosis and burning mouth and soreness (Ship, 2004; Hopcraft and Tan, 2010). Behavioural manifestations include sucking sweets and cough lozenges, and frequent sipping or drinking fluids during waking hours, sleep and when eating certain foods (Guggenheimer and Moore, 2003; Hopcraft and Tan, 2010; Thomson et al, 2011a).

The presence of xerostomia can be established only by direct questioning of the individual (Fox et al, 1987; Hopcraft and Tan, 2010; Thomson et al, 2011a). Three methods have been used to confirm the presence of xerostomia. These are: single-item global indicators such as "How often does your mouth feel dry?" (Thomson et al,1993; Thomson et al, 1999a; Thomson et al, 1999b; Thomson et al, 2006a; Thomson et al, 2011b); a battery of questions, such as that used by Locker (2003); or a multi-item scale such as the Xerostomia Inventory (Thomson et al, 1999a).

1.2 The saliva gland system

The salivary glands producing saliva in the oral cavity are differentiated by size into major and minor glands. The major saliva glands are made up of three paired glands: the parotid, the submandibular and the sublingual glands. The parotid glands are found behind the ramus of the mandible anterior to the ear. Secretions from the parotid gland reach the oral cavity via Stensen's duct. The submandibular glands lie under the body of the mandible. Wharton's duct runs from each gland across the floor of mouth opening under the anterior part of the tongue. The sublingual glands (the smallest major gland), are found underneath the tongue. Some sections of these glands open into Wharton's duct; the remainder secrete saliva via a number of small ducts (Bartholin's ducts) which lie beneath the tongue. The minor salivary glands are distributed throughout the oral cavity in the buccal and labial mucosa, the posterior palate, and the labial border of the tongue (Scott and Symons, 1977; Drake et al, 2010; Thomson et al, 2011a).

Approximately 90% of saliva is produced by the major glands, while the minor glands contribute the remainder (Dawes, 2004; Widmaier et al, 2011; Hopcraft and Tan, 2010; Thomson et al, 2011a). Serous saliva and mucous saliva constitute the two varieties of saliva secreted. Serous saliva is a thin, watery secretion, while mucous saliva is more viscid due to the presence of mucin, a glycoprotein. Mucin mixed with water forms mucus. A second classification of salivary glands is derived from the histochemical nature of the saliva they secrete. The parotids are serous glands; the submandibular and sublingual are mixed glands, and the minor glands are either serous or mucous. The minor glands of the palate and dorsum of the tongue, and the anterior lingual glands are mucous. The minor serous glands of the tongue (for the most part) lie close to the vallate papillae and their ducts open into the sulci of these papillae (Scott and Symons, 1977).

Broadly summarised, the functions of the different secretions are that the serous secretions help to remove epithelial debris and food particles from the gingival surface, buccal mucosa and the dorsum of the tongue, while the mucous secretions both bind masticated food together into a bolus and protect the oral epithelium from the abrasive action of food particles (Whelton, 2004).

1.3 Blood supply

The parotid gland's arterial supply is from the external carotid artery and its terminal branches (superficial temporal and maxillary arteries), into which it divides within the substance of the parotid gland. Branches of the facial and lingual arteries supply the submandibular and sublingual glands. Venous drainage is into the external jugular vein from the parotid gland and into the lingual and facial veins from the submandibular and sublingual glands. Lymphatic vessels from the parotid gland drain into the superficial and deep cervical nodes via the parotid nodes, while the submandibular and sublingual lymphatics drain into the submandibular nodes, and then into the deep cervical nodes (Drake et al, 2010).

1.4 Innervation

The two divisions of the autonomic nervous system both innervate the saliva glands. The sympathetic fibres originate in the superior cervical ganglion and follow the course of the external carotid artery to the glands. The parasympathetic fibres, which arise in the salivary nuclei in the pons and medulla, are carried in the facial and glossopharyngeal nerves (Scott and Symons, 1977; Drake et al, 2010; Thomson et al, 2011a). Table 1.1 outlines the parasympathetic nerve supply to the major and minor salivary glands (adapted from Scott and Symons, 1977).

Table 1.1 Parasympathetic nerve supply to the salivary glands.

Gland	Cranial Nerve	Branches
Parotid	Glossopharyngeal (IX)	Lesser petrosal nerve Otic ganglion
Minor glands in lower lip and lower part of vestibule	Glossopharyngeal (IX)	Inferior alveolar and buccal nerves
Submandibular	Facial (VII)	Chorda tympani
Sublingual		Lingual and submandibular ganglion
Minor anterior lingual glands		
Minor glands in palate, upper lip, upper part of vestibule	Facial (VII)	Greater petrosal nerve, nerve of the pterygoid canal and pterygopalatine (sphenopalatine) ganglion

(Adapted from Scott and Symons, 1977)

The parasympathetic (cholinergic) stimulation results in the production of a high volume of watery saliva with low concentrations of protein and mucin. In contrast, sympathetic (adrenergic) stimulation yields low volumes of viscous saliva. Adrenergic stimulation is of two types, resulting in two different concentrations of mucins: β-adrenergic stimulated saliva has a high mucin

concentration while α-adrenergic stimulation produces a low mucin concentration saliva (Thomson et al, 2011a).

The three specific triggers which stimulate saliva secretion are mechanical (mastication), gustatory and olfactory. The olfactory stimulus is unexpectedly poor. Of the gustatory stimuli, acid is the strongest trigger and sweet the weakest (Humphrey and Williamson, 2001). Other triggers include nausea, vomiting and anxiety (Dawes, 2004).

1.5 Histology of salivary glands

The saliva glands are compound tubulo-alveolar glands. At the termination, the branching duct system comprises clusters of secretory cells or acini (Scott and Symons, 1977). The types of cells found in saliva glands are acini cells, various duct cells and myoepithelial cells. Acinar cells determine whether serous, mucous or mixed saliva is secreted. The contraction of the myoepithelial cells constricting the acini results in the secretion of the accumulated fluid in the acinar cells (Humphrey and Williamson, 2001).

The duct system consists of interlobular, intralobular, intercalated and striated ducts, as well as larger excretory channels. The duct system cells are classified as intercalated, striated or excretory. The saliva formed in the acini is isotonic with respect to saliva, and modification in the duct system results in a hypertonic product (Humphrey and Williamson, 2001; de Almeida et al, 2008; Thomson et al, 2011a). The intercalated duct cells do not modify the acinar secretion. The striated cells resorb sodium and chloride as an electrolyte regulation (Mese and Matsuo, 2007). The last ductal cells (the excretory cells) continue sodium resorption and secrete potassium (Humphrey and Williamson, 2001).

1.6 The composition of saliva

Saliva is composed of 99% water. The normal pH of saliva is 6 to 7, with a range from 5.3 (low flow) to 7.8 (peak flow). The other components of saliva are

sodium, potassium, calcium, magnesium, bicarbonate, phosphates, immunoglobulins, proteins, enzymes, mucins, urea and ammonia (Humphrey and Williamson, 2001). Table 1.2 shows the contributions of the different saliva glands to the components which make up saliva.

The minor salivary glands consistently contribute less than 10% to the volume of unstimulated or stimulated whole saliva. The estimated quantities that the parotid glands, submandibular glands and sublingual glands contribute to unstimulated saliva are 25%, 60% and 7.8% respectively. On stimulation, the contribution from the parotid glands increases to about 50% of whole saliva secreted (Dawes, 2004). This variation in contribution will alter the composition of saliva (Veerman et al, 1996; Humphrey and Williamson, 2001; Thomson et al, 2011a).

Table 1.2 Salivary gland secretions and components.

Gland	Secretion Type	Components
Parotid	Serous	Amylase Proline-rich proteins Agglutinins Cystatins Lysosymes Extraparotid glycoproteins Na, Ca, Cl, PO_4, K IgA
Sublingual	Mucous	Mucins: MG1 MG2 Lysozymes Na, Ca, Cl, PO_4 Amylase IgA
Submandibular	Mixed	Cystatins Na, K, Ca, Cl, PO_4 Amylase Cystatin, IgA, Mucin MG1
Palatine	Mucous	Amylase Na, K, Ca, Cl, PO_4 Cystatins IgA

(Adapted from Veerman et al, 1996; Humphrey and Williamson, 2001)

1.7 The functions of saliva

In short, saliva is a complex fluid which is more than the sum of its parts and (as yet) is not fully understood. It should be noted that the various components have multiple functions, and they also interact to enhance or inhibit other components' actions (Humphrey and Williamson, 2001). Table 1.3 summarises the array of functions that saliva fulfils.

Table 1.3 The functions of saliva.

Function	Description	Components
Lubrication	Coats, protects against mechanical, thermal, chemical irritation. Assists air flow, speech and swallowing	Mucin glycoproteins
Cleansing	Moistening assists mastication, clearing food and swallowing	
Ionic reserve	Modulates demineralisation and remineralisation of teeth	Calcium phosphate Statherins, proline-rich proteins
Buffering	Modulates pH of biofilm and buffering capacity of saliva	Bicarbonates phosphates, urea
Antibacterial action	Immunological agents and non-immunological agents help control oral microflora	IgA, IgG, IgM proteins, mucins, peptides and enzymes (lactoferrin, lysozyme, peroxidise)
Agglutination	Aggregate bacteria in saliva accelerating clearance from the oral cavity	Glycoproteins, Statherins, agglutinins,histadine-rich proteins, proline-rich proteins
Pellicle formation	Proteins form a protective layer on the teeth	Macromolecular proteins, stratherins, histatins, cystatins, proline-rich proteins, MG1
Digestion	Enzymes in saliva begin the breakdown of starch and fat	A-amylase
Gustation	The solvent action and hypotonicity of saliva enhances tasting capacity by allowing interaction between nutrients and taste buds	Protein, gustin, zinc
Hydration	Oral dehydration and dryness of the month; stimulates desire to drink	

(Adapted from Humphrey and Williamson, 2001; Whelton, 2004; Thomson et al, 2011a)

1.8 Salivary output

At rest, the parotid glands contribute 20-25% to whole saliva flow with the submandibular glands and the sublingual glands contributing 60-65% and 7-8% respectively, while the minor saliva glands at rest and during stimulated flow consistently produce less than 10% (Humphrey and Williamson, 2001; Thomson et al, 2011a). When saliva flow is stimulated, the parotid glands increase their contribution to between 50 and 70% of the total flow (Veerman et al, 1996; Humphrey and Williamson, 2001; Thomson et al, 2011a).

The precise definition of what constitutes a "normal" flow rate in both stimulated and unstimulated salivary flow is still a matter of debate (Ship et al, 1991; Navazesh et al, 1992; Ghezzi et al, 2000). Table 4 illustrates the range of values which various researchers have defined as normal. Ghezzi et al (2000) suggested that a 45% variation in flow could be considered normal, with values below 45% defined as hypofunction. Quantifying flow rates is complicated by considerable variation within and between individuals (Ship et al, 1991; Valdez and Fox, 1993). In addition, circadian rhythms affect the flow rate, with variations of as much as 50% (Guggenheim and Moore, 2003; Dawes, 2004).

Stimulated saliva flow rates of 7 mL/min have been reported by Dawes (2004) and Humphrey and Williamson (2001). It is estimated that the daily saliva production is between 0.5 to 1.5 L, with stimulated flow contributing 50 to 90% of this total (Guggenheim and Moore, 2003; Humphrey and Williamson, 2001; de Almeida et al, 2008; Navazesh and Kumar, 2008). However, Mese and Matsuo (2007) commented that, since comparatively little time is spent eating, resting saliva constitutes the major portion of saliva output during the diurnal cycle. Navazesh and Kumar (2008) suggested that the duration, intensity and nature of the stimulus affect the saliva flow rate, with strong acid, high-frequency chewing and high bite force increasing saliva production. The degree of saliva-production compromise which produces xerostomia and oral dysfunction is not known (Ghezzi et al, 2000).

Table 1.4 Normal whole saliva flow rates reported in the literature.

Author	Unstimulated flow rate (ml/min)	Stimulated flow rate (ml/min)
Thomson, 2005 and Thomson et al,2011a	0.3	1.7
de Almeida et al, 2008	0.25 – 0.35	0.7 – 1.0
Fontana and Zero, 2006	0.3	Not specified
Dawes, 2004	0.3 – 0.4	4
Porter et al, 2004	0.1 – 0.3	4.0 – 5.0
Ikebe et al, 2002	Not specified	>0.5
Humphrey and Williamson, 2001	0.1	0.2
Nederfors, 2000	>0.25	>1.0
Bergdahl, 2000	>0.1	Not specified
Thomson, 1999b	>0.1	Not specified
Narhi et al, 1992 and Narhi, 1994	>0.1	>0.8
Billings, 1993	>0.05	>0.5
Valdez and Fox, 1993	Not specified	0.3 – 0.5
Navazesh et al, 1992	0.12 – 0.16	Not specified
Sreebny and Valdini, 1988	0.1	Not specified

The research of Ship et al (1991) and Valdez and Fox (1993) suggested that the amount of saliva flow necessary for oral health is specific to each individual. In addition, the range among individuals shows a wide variation, with some maintaining good oral health, normal function and comfort with very little saliva flow. Some authors have suggested that, when the unstimulated flow rate reduces by 50% or more, the symptom of dry mouth manifests, regardless of the initial

flow rate (Dawes, 1987; Ship et al, 1991; Sreenby and Schwartz, 1997). Given the indeterminate nature of what constitutes “normal”, the diagnosis of salivary gland hypofunction may best be made by assessing an individual over time for any changes in saliva secretion (Ship et al, 1991). Humphrey and Williamson (2001) suggested that a baseline saliva flow measurement be taken at 15 years of age, and follow-up measurements should be repeated at regular intervals during an individual's lifetime (such as at regular dental check-ups), thus creating a longitudinal record of any changes, pathological or otherwise. Because little is known of the natural history of dry mouth (Thomson et al, 2006a), this would contribute to both the care of the individual and knowledge of the condition of dry mouth during the life course. However, given that three in five New Zealand adults are episodic users of dental care, the practicality of collecting follow-up measurements is questionable (Ministry of Health 2010a).

Navazesh (2003) suggested that oral health care providers make use of the four-question battery developed by Fox et al (1987) to identify patients with “dry mouth” and use the visual analogue scale (Pai et al 2001) to assess the severity of the condition in a symptomatic patient. The visual analogue scale could also be used, on subsequent visits, to evaluate the patient’s response to therapy. An alternative to this approach could be the use of a “gold standard” single-item question combined with the Xerostomia Inventory in the clinical setting. To date, there are no reports in the literature of either method being used in dental practice. The use of these tools in daily dental practice may lead to early identification of dry-mouth sufferers which, in turn, may lower the incidence of complications by sound management of the condition. Additionally, valuable information about the natural history of dry mouth may be gathered from well-kept chronological clinical records.

1.9 Risk factors for dry mouth

Because saliva is a complex fluid with an array of functions, the risk factors that might influence the development of “dry mouth” are numerous and varied. Those reported in the literature include smoking and alcohol use, ageing, oral and systemic diseases, head and neck radiotherapy and medications.

1.9 a) Smoking and Alcohol

Although smoking and alcohol use have been implicated as risk factors for both xerostomia and salivary gland hypofunction, the exact relationship has yet to be clarified (Thomson, 2005). Although no epidemiologic association has been reported between alcohol use and xerostomia, alcohol use (including in mouthwashes) can cause some oral dryness and, hence, it can be considered a potential risk factor for xerostomia (Antilla et al 1998; Thomson et al 2000; Scully, 2003). While findings reported on smoking and xerostomia were equivocal, authors such as Thomson et al (2000), Thomson (2005) and Scully (2003) have argued that tobacco smoking should be considered a potential risk factor for xerostomia. Notably, in a 15-year longitudinal study, Johannson et al (2009) reported a strong association between smoking and xerostomia, but suggested further investigation was needed.

1.9 b) Age

Ageing *per se* is not considered to be a risk factor for xerostomia (Nederfors et al, 1997; Smidt et al, 2011). Xerostomia in the elderly is not a natural part of becoming old (Baum et al, 1992). Current opinion is that salivary production by the major salivary glands does not decrease with age (Navazesh et al, 2003; Ghezzi and Ship, 2003). However, Ghezzi and Ship (2003) showed that the reserve capacity of the glands decreases with age, making elders more vulnerable to the effects of systemic diseases/medical conditions and medications. In addition, the effect of xerostomic medications over time was more substantial in the elderly. Xerostomic medications may decrease the saliva volume produced, and/or alter the perception of mouth dryness. As the body ages, individuals are naturally more likely to develop systemic diseases, which may contribute to xerostomia directly or via the use of xerogenic drugs (Sreenby and Schwartz, 1997; Ghezzi and Ship, 2003).

Thomson et al (2006a) noted that very few studies have been undertaken in samples of young individuals, thus inadvertently contributing to the impression that the elderly are more likely to experience xerostomia. Their study of a cohort of 32-year-olds found that 10% were affected by xerostomia. The prevalence of

xerostomia was significantly higher among participants taking antidepressants, iron supplements or narcotic analgesics (Thomson et al, 2006b). In addition, Thomson et al (2006a) reported that xerostomia was not a trivial condition in 32-year-olds, with sufferers experiencing poorer oral-health-related quality of life.

1.9 c) Oral conditions

The oral conditions which may be associated with xerostomia and salivary gland hypofunction include acute and current chronic parotitis, sailolithiasis, minor salivary gland mucocoeles, partial or complete salivary obstruction, adenomas and carcinomas (Ship, 2004). These conditions may cause hyposalivation which, in turn, can contribute to the subjective feeling of dry mouth.

1.9 d) Systemic diseases

There are a number of systemic diseases which are associated with xerostomia; these include Sjögrens syndrome, diabetes mellitus, HIV/AIDS, sarcoidosis, connective tissue disease, graft-vs-host disease, cystic fibrosis, end-stage renal disease, Alzheimer's disease, and anxiety or depression (Fox, 1991; Porter et al, 2004; Guggenheim and Moore, 2003; Ship, 2004). Prevalence estimates of xerostomia related to systemic diseases vary, with Sjögrens syndrome reported to have nearly 100% prevalence, HIV/AIDS 7-8%, sarcoidosis 9%, graft-vs-host disease 45-60% and depression 11% (Antilla et al, 1998; Guggenheimer and Moore, 2003; Porter et al, 2004; Ship, 2004). It is likely that both the aforementioned systemic diseases and their treatments (such as medications and chemotherapy) contribute to the occurrence of xerostomia (Ship, 2004).

1.9 e) Head and neck radiotherapy

Epidemiologically, radiotherapy (a common treatment for head and neck cancer) has been shown to be a risk factor for xerostomia and salivary gland hypofunction (Thomson, 2005). At dose thresholds of 25Gy and above, permanent destruction of salivary gland tissue occurs. Some later recovery of saliva gland capacity may take place if lower doses are used (Ship, 2004). There is a dose-dependent relationship between the amount of radiation and the damage that occurs, with the serous acini being most radiosensitive, followed by the mucous acini.

1.9 f) Medications

This putative risk factor has been the focus of a great deal of research, but much has yet to be learned about which medications cause dry mouth and the aspects of dry mouth which they influence. Xerogenic drugs may (for instance) reduce the volume of saliva secreted and/or alter the perception of when xerostomia is experienced. The side-effects of medications (in addition to the synergistic or antagonistic actions of medications in the case of polypharmacy) further complicate the clinical manifestations of xerogenic drugs (Thomson, 2005). Polypharmacy has been shown to be associated with xerostomia in older populations (Hopcraft and Tan, 2010); in a younger cohort (aged 32), Thomson et al (2006b) reported a moderate effect of polypharmacy. In general, the more medications taken, the greater the likehood of a dry mouth (Ship, 2004). This is probably because of the overall anticholinergic burden (Chew et al, 2008) or (additionally) the xerostomic effect of polypharmacy in elders could compromise the reduced reserve capacity in the major saliva glands, secondary to the ageing process (Ghezzi and Ship, 2003). The anticholinergic effect inherent in some drugs can reduce saliva flow, particularly with long-term use. In addition, the higher the quantities of anticholinergic drugs (anticholinergic burden) taken, the higher the possibility that the individual is likely to experience severe xerostomia.

Table 1.5 lists the classes of drugs implicated in causing xerostomia; however, not all medications in each class have been reported to contribute to xerostomia (Hopcraft and Tan, 2010; Thomson et al, 2011a). Both prescription and non-prescription medications (and also dietary supplements such as iron supplements) have been associated with xerostomia (Ship, 2004; Thomson et al 2006b). In summary, the investigation of medications as a risk factor for xerostomia is an extremely complex research field, posing numerous major methodological challenges (Thomson, 2005).

Table 1.5 Medications related to the occurrence of xerostomia.

Author and Year	Population	Drugs implicated
Osterberg et al, 1984	70-year-old Swedish; n = 973	Anticholinergics Antihistamines Hypnotics Phenothiazines Sedatives
Narhi et al 1992	Finns, aged 76, 81 and 86; n = 368	Cardiovascular drugs Antidepressants
Thomson et al, 2000a	65- to 100-year old South Australians; n = 913	Anginals Antidepressants Antiasthma drugs Diuretics Thyroxine
Pajukoski et al, 2001	Elderly Finns; n = 427	Allergy Cardiovascular drugs Hormones Psychiatric drugs
Rindal et al, 2005	Americans aged 55+; n = 7720	Antidepressants
Thomson et al, 2006b	32-year-old New Zealanders; n = 950	Antidepressants Iron supplements Narcotic analgesics
Thomson et al, 2006c	South Australians aged 60+; n = 246	Daily aspirin Diuretics
Maupomé et al, 2006	Americans aged 55+; n = 11249	Cardiovascular drugs
Janket et al, 2007	Americans aged 29 to 90; n = 290 males	Cardiovascular drugs Psychotropic drugs Anticholinergics Sympathetic agonists
Smidt et al 2011	Danes aged 65 to 95; n = 668	Thyroid hormones Glucocorticoids Psycholeptics Psychoanaleptics Antispasmodics Antineoplastics Proton pump inhibitors Antidiabetics Loop diuretics Quinine Bisphosphonates

(Adapted from Hopcraft and Tan, 2010)

Drugs are a common cause of dry mouth with a frequent oral adverse drug reaction being a complaint of dry mouth (Scully, 2003). As can be seen in Table 1.5, the range of drugs implicated in xerostomia is large; additionally, there is the issue of the high frequency of polypharmacy. The evidence from majority of epidemiological studies should be viewed with caution as most have been cross-sectional, with drug exposure and xerostomia occurrence being measured simultaneously. In addition, the duration of exposure and the effects of drug combinations were assumed to produce symptoms at the time of the particular study. Thomson et al (2000) and Thomson et al (2006c) have reported on medications and xerostomia in longitudinal studies (taking into account polypharmacy and using multivariate analysis); their findings implicated anginals, antidepressants, antiasthma drugs, diuretics and daily aspirin.

1.10 The clinical significance of xerostomia

The many and varied clinical manifestations of xerostomia presented in Table 1.6 clearly relate to the multi-faceted functions of saliva (Table 1.3). Some of these clinical manifestations interlink with behavioural changes adopted to alleviate the feeling of a dry mouth.

Table 1.6 Clinical manifestations of xerostomia.

Clinical manifestations of xerostomia.	
Altered oral microflora	Mucus accumulation
Dental caries	Nocturnal oral discomfort
Denture problems	Oral dysfunction
Dry mouth	Oropharyngeal burning
Dysgeusia	Oropharyngeal infections
Dysphagia	Plaque accumulation
Food retention in the mouth	Speech difficulties
Mucosal changes	Thirst

(Adapted from Thomson et al, 2011a)

1.11 Caries

The salivary gland hypofunction which results from damage to the glandular tissue caused by radiation therapy for head and neck cancer has been associated with "rampant" caries (Guggenheim and Moore, 2003). This unfortunate consequence of cancer treatment gives support to the view that one of the clinical consequences of dry mouth is greater caries experience due to the loss of the protective functions of saliva. There is a predisposition to rampant, atypical decay, both cervically and on the incisal or cusp tips when saliva flow is reduced (Mese and Matsuo, 2007). The absence of saliva compromises the ability to irrigate the mouth, clear foods, rapidly buffer acids and inhibit cariogenic microorganisms from adhering to tooth enamel. The reduction in the volume of saliva and concomitant defence systems facilitates an increase in caries (Lenander-Lumikari and Loimaranta, 2000; Guggenheim and Moore, 2003; Turner and Ship, 2007). Hence, demineralisation of enamel occurs more readily after eating and drinking, particularly after the consumption of refined carbohydrates (Ship, 2004; Thomson et al, 2011a). Locker (1993) reported that participants in a study of older people in Ontario reporting xerostomia had more decay and fewer teeth than those who had no complaint of xerostomia.

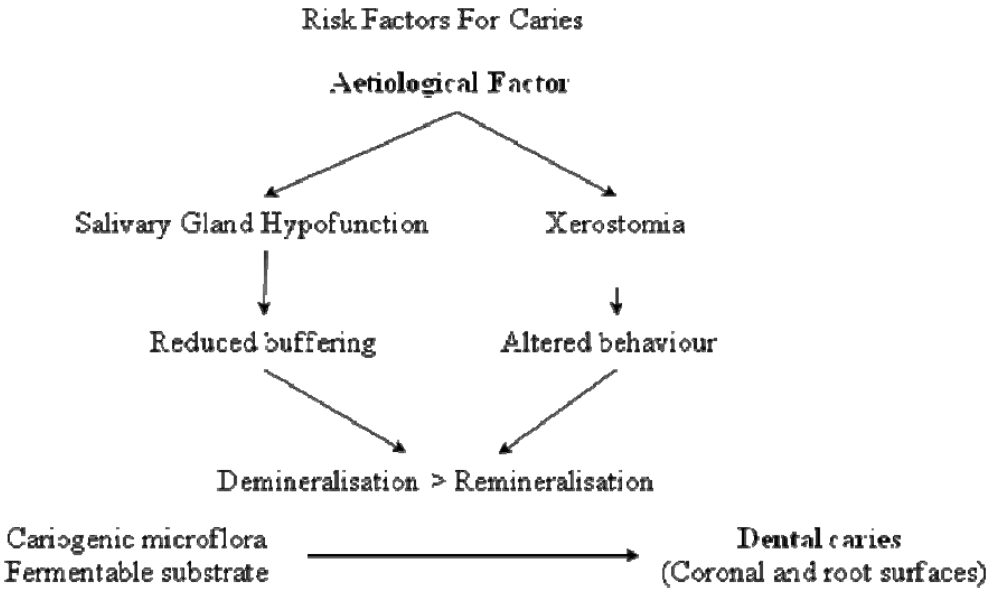


Figure 1.1 Risk factors for caries (adapted from Thomson et al, 2002).

Behaviour change also may contribute to greater caries experience in individuals complaining of xerostomia. It has been proposed that the feeling of dryness of the mouth and its effects on daily oral comfort leads to detrimental behaviours, such as sucking sweets and continual sipping of drinks. These detrimental behaviours result in the teeth being constantly bathed in cariogenic substances, thus contributing to the increase in the occurrence of caries (Guggenheim and Moore, 2003; Hopcraft and Tan, 2010).

1.12 Denture problems

The minor saliva glands (which consistently secrete about 10% of whole saliva) play an important role in mucosal protection from mechanical, chemical, allergic and biological irritants by lubricating and hydrating the mucosa. The majority of minor saliva glands are mucus-secreting. The presence of a thin film of saliva is essential for the adhesion and retention of dentures, as well as providing protection for the tissues from the frictional forces produced during mastication (Ship, 2004; Ikebe et al, 2005). Ship (2004) stated that the quality as well as the quantity of saliva can be linked to denture discomfort. The decreased or inadequate stimulated flow of saliva, resulting in a lack of lubrication during chewing, contributes to the pain and discomfort experienced by denture wearers suffering with dry mouth (Guggenheim and Moore, 2003; Ship, 2004; Ikebe et al, 2005; Ikebe et al, 2007; Hopcraft and Tan, 2010; Thomson et al, 2011a). The desiccated and friable denture bearing tissues are prone to trauma and infections (Ship, 2004; Ikebe et al, 2005). Additionally, Ikebe et al (2005) reported that oral dryness affected speech and taste satisfaction in denture users. Their findings indicated that complete denture wearers may be more vulnerable than those wearing partial dentures.

1.13 Fungal infections

Decreased quantities of saliva increase an individual's susceptibility to painful mucositis and opportunistic oropharyngeal infections, most commonly candidiasis. The latter is caused by the oral commensal organism *Candida albican*s, and can be severe in immunocompromised patients (Guggenheim and Moore, 2003; Ship, 2004; Thomson et al, 2011a). The clinical manifestations of

oral candidiasis include angular cheilitis, erythematous candidiasis (denture stomatitis), and atrophic, hyperplastic or pseudomembranous candidiasis (Ship, 2004).

1.14 Dysgeusia

A decrease in saliva leads to the distortion of taste sensation (Narhi, 1994). As a food solvent, a carrier of taste-eliciting molecules and as a hypertonic solution, saliva facilitates taste by enabling substances to interact with taste cells via receptors (Mandel, 1987; Ship, 2004; Turner and Ship, 2007). Saliva is low in sodium and chloride, glucose, buffering capacity and urea; this aids the ability to experience tasting salt, sweet, acid and bitter substances (Ship, 2004). While specific electrolytes and minerals are required for taste, no particular component of saliva has been related to dysgeusia (Ship, 2004; Mese and Matuso, 2007; Thomson et al, 2011a).

1.15 Dysphagia

The lack of saliva can cause problems in the production of a bolus that contributes to dysphagia (Ikebe et al, 2005). Additionally, salivary lubrication of the oropharyngeal mucosa is essential to ensure safe and efficient swallowing. Dysphagia has been proposed as a significant risk factor for aspiration pneumonia (Ship, 2004). Cleansing of the oral cavity is compromised in dry mouth due to the lack of lavage of the mouth; the resulting retained remnants of food contribute to halitosis (Thomson et al, 2011a). In addition, difficulty in chewing and swallowing leads to the avoidance of dry foods and a preference for softer, possibly more cariogenic foods (Guggenheim and Moore, 2003; Thomson et al, 2011a). Quandt et al (2011) reported that dry mouth was strongly associated with greater consumption of sugary drinks, food modification and avoidance of some foods. Changes in food selection might compromise an individual's nutritional status (Ikebe et al, 2005; Turner and Ship, 2007). Food selection and ability to eat may compromise food intake and influence dietary adequacy, thus contributing to macro- and micro-nutrient deficiencies which, in turn, affect nutritional and general health status (Walls et al, 2000; Moynihan, 2007)

1.16 Impaired quality of life

Quality of life is that which makes life worth living. The contribution of good oral health to one's daily quality of life would thus be a state devoid of pain, discomfort, functional limitation, social or psychological self-consciousness or embarrassment (Locker, 2003; Folke et al, 2009a). This accords with the World Health Organization's 1948 definition of health as being "a state of complete physical and mental and social well-being and not merely the absence of disease or infirmity" (Last, 2001).

The complaint of xerostomia as described by sufferers involves experiences of unpleasant taste, bad breath, painful ulcers, uncomfortable and ill-fitting dentures, speech and eating difficulties, and self-consciousness and embarrassment while eating and speaking (Narhi, 1994; Foerster et al, 1998; Thomson et al, 2006a; Turner and Ship, 2007; Hopcraft and Tan, 2010). In 2003, Locker examined the relative effects of tooth loss and xerostomia on the oral-health-related quality of life (OHRQoL) of group of older Canadians. He used five measures, namely: self-ratings, satisfaction ratings, an index of chewing capacity, the General Oral Health Assessment index (GOHAI) and the short-form of the Oral Health Impact Profile (OHIP-14). Significantly, xerostomia was found to be associated with all five functional and psychosocial measures. Locker concluded that xerostomia had a pervasive influence the participants' OHRQoL. Their concerns included being self-conscious and embarrassed about the health of their teeth and mouth, in addition to problems with eating and their appearance. Thomson et al (2006a) investigated xerostomia and OHRQoL in younger adults using a single-item dry mouth question and the OHIP-14. They found a strong association between xerostomia and OHRQoL in 32-year-olds which persisted after controlling for confounding variables such as poor clinical oral health indicators, smoking status and negative and positive emotionality. The participants reported self-consciousness, embarrassment and experiencing discomfort while eating.

In a qualitative study on the subjective meaning of xerostomia, Folke at al (2009b) found that, for those afflicted by xerostomia, it was a burden and an aggravating constant misery. Xerostomia had a devastating and debilitating impact on their

well-being as a result of continuous oral discomfort, eating difficulties, costly poor dental health, inadequate social support, lack of empathy and commitment from health care professionals and social withdrawal due to enunciation difficulties, restrictions to daily life and feelings of stimatisation. These detrimental effects of xerostomia on the simple joys of living, described by sufferers, indicate that xerostomia has the potential to have a severe negative effect on an individual's quality of life (Locker, 2003; Folke et al, 2009b).

1.17 Measuring dry mouth

Because the phrase “dry mouth” is really all-inclusive, it can mean xerostomia (the subjective feeling of dry mouth) or salivary gland hypofunction (presenting with or without xerostomia). No distinction between xerostomia and saliva gland hypo-function was made early on in research in this field; consequently, xerostomia was often reported to be a reduced salivary output, rather than the subjective feeling of dry mouth. The use of different measurement protocols for xerostomia has resulted in various definitions (Hopcraft and Tan, 2010). Decreased salivary gland function may or may not be a precondition for xerostomia, while the relationship between xerostomia and salivary flow rate remains unclear (Narhi, 1994; Thomson et al, 1999b). Ship et al (1991) and Valdez and Fox (1993) noted that some individuals with very little saliva flow were healthy, with no complaint of dryness.

1.18 Measuring salivary gland hypofunction

Salivary gland function is measured using sialometry to directly record saliva flow at a given point in time (Navazesh, 1993). A range of methods are described in the literature; this is a testament to the fact that, although it is logical to measure saliva flow, it is by no means simple.

The initial difficulty is in the variation in the definition of normal flow (as illustrated in Table 1.4). In addition, normal flow for an individual is affected by factors such as circadian rhythms, posture, lighting conditions and psychic stimuli (Dawes, 2004). Furthermore, during the life course, the secretion of both unstimulated and stimulated saliva is variable (Ship et al, 1991). Thus, the

characteristics by which to compare individuals are difficult to establish, as are those to use at the population level. The researcher needs to establish case definition for salivary gland hypofunction by establishing a designated clinical threshold (Thomson, 2005). Some authors have clearly stated their case definition criteria (Locker, 1995; Thomson et al, 1999b; Navazesh et al, 2000; Smidt et al, 2011). However, not all authors do so. This makes any attempt to replicate the research method in further investigations in differing populations impossible. Additionally, any comparisons with other research findings or the generalisation of findings are practically out of the question and can be done only with extreme caution.

Narhi (1994) postulated that the sensation of dry mouth results from the drying of the oral mucosa. The wide distribution of the minor salivary glands, the majority of which are mucous secreting, plus the constancy of the output of these glands significantly contributes to the protection and lubrication of the mucosa (Scott and Symons, 1977; Thomson, 2005; Drake et al, 2010). The question of whether saliva wets the mucosa uniformly has yet to be answered. It is possible that different glands play different roles in wetting, lubricating and protecting the oral cavity (Humphrey and Williamson, 2001). Hence, questions such as the following need answers: (a) should individual gland function be measured; (b) what is the significance of the overall flow rate; and (c) what effect does the quality of saliva have on dry mouth (Narhi, 1994; Navazesh and Kumar, 2008)?

There is a need to study individual gland secretions but, despite various methods for measuring flow rates, no method has been accepted internationally (Thomson, 2005). There are particular difficulties in measuring saliva, in part because the composition and flow rate of saliva are highly sensitive to changes in the oral cavity, circadian rhythms, hydration levels, physiological and psychological stimuli. In addition, there are technical difficulties in obtaining saliva secreted from individual glands. Numerous techniques and devices have been developed and tested in a century of research, and new ideas continue to be tested (Hanning et al, 2012). The number, size and anatomical distribution of the minor glands make it virtually impossible to measure total output or isolate a particular gland. The fact that, in most individuals, the sublingual gland empties some of its

secretions into Wharton's duct precludes analysing the quality or quantity of the sublingual or submandibular glands separately. The parotid gland is thus the only gland that can be individually cannulated, to allow the quality and quantity of its secretions to be measured accurately.

Thomson (2005) suggested that measuring whole saliva flow (both unstimulated and stimulated) rather than measuring that of individual glands better reflects daily life. The collection of whole saliva is also easier for the participant and researcher, particularly in large-scale epidemiological studies (Thomson et al, 1999b). Whole unstimulated and stimulated saliva can be collected using the drain, split, suction or swab methods. Unstimulated saliva should be collected first to avoid the risk (through latent stimulation) of increasing the rate (Thomson, 2005). Whichever collection method is used, the saliva is collected for a specific period in order to determine the flow rate in millilitres per minute. Only the drain and split methods are suitable for collecting both unstimulated and stimulated secretions, because the use of the suction or swab risks the stimulation of saliva flow (Thomson, 2005). Saliva flow is stimulated by a gustatory stimulus, such as 2% citric acid, or masticatory stimuli such as neutral tasting paraffin wax or pre-softened, polyvinyl acetate gum (Thomson 2005). All of these methods are time-consuming and not particularly comfortable for the participant. These limitations may result in fewer people agreeing to participate in studies, thus affecting the generalisability and utility of study findings.

Dawes (2004) stated that unstimulated saliva flow rate is probably more indicative of dry mouth since, for the majority of any day, a person lives with unstimulated saliva secretion protecting and lubricating the oral cavity. He asserted that most researchers diagnose salivary gland hypofunction if the unstimulated flow rate is less than 0.1 mL/min. However, the variation in measurement methods creates difficulties in reading the literature and comparing studies.

1.19 Measuring xerostomia

Because xerostomia is the subjective feeling of oral dryness, the only way in which xerostomia can be measured is by asking the individual directly (Fox et al, 1987; Hopcraft and Tan, 2010; Thomson et al, 2011a). Three different methods have been used to elicit information from research participants and thus measure xerostomia, namely: single-item global indicators; a battery of questions; and a multi-item scale (Table 1.7).

The primary purpose of a summary measure such as the dry mouth question is to gain a patient-centred understanding of the issue through a single summary judgement. global question. As such, the single-item global question should be useful in its own right. The single-item global question is particularly useful in large studies, minimising the response burden. Secondarily, single-item global questions are an important tool used to validate multi-item scales such as the Xerostomia Inventory. Single-item global questions lack universal applicability because no single-item question has been accepted for use internationally. Examples of global questions used by various researchers since 1984 are presented in Table 1.7. Most questions have been used only once by a particular researcher in a particular study (Thomson, 2005). However, some researchers, such as Thomson and Bergdahl, have used their particular questions in more than one study (Thomson et al, 1993; Thomson et al, 1999a; Thomson et al, 1999b; Thomson et al, 2006a; Thomson et al, 2011b; Bergdahl, 2000; Bergdahl and Bergdahl, 2000). Additionally, other researchers such as Nayak et al (2004) chose to use Thomson's dry mouth question in order to make comparisons between findings.

Table 1.7 Methods of measuring dry mouth symptoms (xerostomia) reported in the literature.

Method of measuring dry mouth symptoms	Author(s)
Single-item (and/or battery) approaches:	
Does your mouth feel distinctly dry?	Osterberg et al, 1984
Do you sip liquids to aid in swallowing dry foods?	Fox et al, 1987
Does your mouth feel dry when eating a meal?	Fox et al, 1987
Do you have difficulties swallowing any foods?	Fox et al, 1987
Does the amount of saliva in your mouth seem to be too little, too much, or you don't notice it?	Fox et al, 1987
Do you feel dryness in the mouth at any time?	Fure and Zickert, 1990
Do you have mouth dryness?	Osterberg et al, 1992
Is your mouth sometimes dry?	Gilbert et al, 1993
How often does your mouth feel dry?	Thomson et al, 1993 Thomson et al, 1999b
During the last 4 weeks, have you had any of the following… dryness of mouth?	Locker, 1993 Locker, 1995
Does your mouth feel dry?	Narhi, 1994
Difficulty in eating dry foods	Narhi, 1994
Difficulty in speaking	Narhi, 1994
Difficulty in swallowing	Narhi, 1994
Taste impairment	Narhi, 1994
Dry lips	Narhi, 1994
Does your mouth usually feel dry?	Nederfors et al, 1997 Bergdahl, 2000 Bergdahl and Bergdahl, 2000
Visual Analogue Scale questionnaire	Pai et al, 2001
Does the amount of saliva in your mouth seem to be too little or too much, or don't you notice it?	Ikebe et al, 2002 Navazesh et al, 2003
Does your mouth feel dry when eating a meal?	Ikebe et at, 2005 Ikebe et al, 2007
Does your mouth usually feel dry in the daytime?	Johansson et al, 2009
Does your mouth usually feel dry at night?	Johansson et al, 2009
Have you had a daily sensation of dry mouth for more than 3 months?	Smidt et al, 2011
Scale approach:	
Xerostomia Inventory	Thomson et al, 1999a Thomson and Williams, 2000

(Adapted from Thomson, 2005)

The use of a battery of questions to measure xerostomia has resulted in a number of variations, such as four questions used by Fox et al (1987), seven questions by Locker (2003) and as part of the visual analogue scale developed by Pai et al (2001). Fox et al (1987) found four questions useful for identifying xerostomics, after examining the association of nine questions with salivary flow rate. The visual analogue scale was developed using a battery of questions asked of patients who had taken an antisialogogue. In 2003, Locker tested a battery of seven

questions, which elicited a simple yes or no response. The scores are computed by summing the responses to give a xerostomia index score between 0 and 7.

In 1999, Thomson et al reported on the development and use of an 11-item summative rating scale, the Xerostomia Inventory (XI). The 11 items encompass the experiential and behavioural facets of xerostomia. This scale combines 11 responses into a single continuous score representing the severity of the condition. A change in the score over time, would indicate a lessening or worsening of the level of severity of chronic xerostomia (Thomson et al, 1999a; Thomson, 2005). Thomson et al used the single-item global indicator "How often does your mouth feel dry?" as a concurrent validity check during the development of the XI multi-scale and found the XI to be valid (Thomson et al, 1999a) The Xerostomia Inventory has been further validated in a number of different studies (Thomson and Williams, 2000; Thomson et al, 2000, Thomson et al, 2002; Thomson, 2007; Thomson et al 2011b). A shortened Xerostomia Inventory (the "Summated Xerostomia Inventory-Dutch Version") has been developed and subsequently validated in a variety of samples as a measure of xerostomia in clinical and epidemiological research (Thomson 2011b). The "Summated Xerostomia Inventory-Dutch Version" has 5 items with the choice of three response options.

Thomson suggested in 2005 that all of these measures need to be validated further, and should preferably be used in conjunction with a single-item measure. Some questions, groups of questions, the visual analogue scale and the Xerostomia Inventory have been used in different studies, contributing to an increasing body of knowledge on their validity (Thomson et al, 1993; Thomson et al, 1999a; Thomson et al, 2006a; Thomson et al, 2006b; Nederfors et al, 1997; Hochberg et al, 1998; Bergdahl and Bergdahl, 2000; Jannson et al, 2003; Nayak et al, 2004; Johansson et al, 2009).

In addition, Thomson et al (1999a) noted that there are inherent problems related to the content, orientation and response options of dry mouth questions, whether they are single-item or used as part of a battery of questions. The framing of these questions, how they are understood and the answering options given, may create very different classifications of which individuals would describe themselves as

xerostomic. For example, questions, such as “Does your mouth feel distinctly dry?”, “Is your mouth sometimes dry?” “How often does your mouth feel dry?”, “Does your mouth usually feel dry?”, are all different and will thus be answered differently, making the resulting estimates difficult to compare (Hopcraft and Tan, 2010).

All questions with a single-item, and also those forming part of a group, present problems relating to how the participant interprets the questions and the range of possible answers. These problems are inherent in the phrasing of the actual question and the answer choices presented to the participant. The content and orientation of the questions play a key role in the validity of the participant's response (Thomson et al, 1999a). Thomson (2005) commented that the prevalence estimates of xerostomia in non-institutionalised older populations range from 12 to 39%, but pointed out that these estimates are not strictly comparable, because different questions were the used.

1.20 Epidemiology of dry mouth

Epidemiological investigation of dry mouth has been ongoing for several decades. In the earlier literature, the term “dry mouth” was used to describe all aspects of the complaint, and no differentiation was made between the subjective feeling of dry mouth (xerostomia) and salivary gland hypofunction (Hopcraft and Tan, 2010). In the more recent literature, authors have distinguished between these two aspects of dry mouth and acknowledged that one can exist without the other, or that both can occur together (Navazesh et al, 2003; Guggenheim and Moore, 2003; Hopcraft and Tan, 2010; Thomson et al, 2011a).

This lack of consistency and clarity makes comparisons between studies, the generalisation of study findings and the building of a consistent, reliable, accurate portrait of dry mouth and its distinct aspects difficult. Hence, much research into dry mouth is still needed (Thomson, 2005). The types of epidemiological studies undertaken thus far include surveys, prospective cohort studies and longitudinal studies (Locker, 1995; Thomson et al, 1999b; Thomson et al, 2006a; Thomson et al, 2006b; Johansson et al, 2009).

According to Last (2001), a case is defined by a set of diagnostic criteria derived from clinical and/or laboratory criteria. In epidemiology, it may be a person or a study group who fit these criteria (Thomson, 2005). Establishing a case definition for dry mouth is complex and problematic, not least because the phenomenon that is xerostomia is subjective and can be assessed only through direct questioning ((Fox et al, 1987; Hopcraft and Tan, 2010; Thomson, 2005; Thomson et al, 2011a). Salivary gland hypofunction may be said to be present when the saliva flow rate of an individual is determined by sialometry to be 40-50% below the "normal" (Dawes, 1987; Ship et al, 1991; Screenby and Schwartz, 1997). There is no internationally accepted normal flow rate because of a wide range of individual variation and the difficulty of comparing and generalising findings from studies which have used different research methods (Ghezzi et al, 2000).

As can be seen in Table 1.7, there have been a range of questions and configurations of questions used in xerostomia research. The content and the context of these questions differ and will have influenced individuals' responses. Moreover, the researchers' analytical choices would affect how the findings are presented and how these were interpreted (Thomson, 2005). The consequence of a particular method having been used only once is a lack of established validity and reliability (Thomson, 2005). However, some questions, groups of questions, the visual analogue scale and the Xerostomia Inventory have been used in different studies, increasingly contributing to establishing their validity and reliability (Thomson et al, 1993; Thomson et al, 1999a; Thomson et al, 1999b; Thomson et al, 2006a; Thomson et al, 2006b; Nederfors et al, 1997; Hochberg et al, 1998; Bergdahl and Bergdahl, 2000; Jannson et al, 2003; Johansson et al, 2009).

The natural history of dry mouth

The term "natural history" of dry mouth refers to the course of the condition, from the onset of signs and symptoms to its possible resolution either by remission or treatment; conversely the condition may persist (Last, 2001). Little is known about the natural history of dry mouth, xerostomia or salivary gland hypofunction.

The first indication that the condition could start quite early in life was highlighted by Thomson et al (2006a; 2006b) in reports from a cohort study of 32-year-olds. The study findings included the surprisingly high prevalence rate of 10% (Thomson et al, 2006b) and a strong association between xerostomia and a poorer oral-health-related quality of life (Thomson et al, 2006a). Assumptions have been made about the condition and its consequences from research into the effects of xerostomia and/or salivary gland hypofunction related to known systemic causes such as Sjogren's syndrome and radiotherapy for cancer (Fox et al, 1987; Guggenheim and Moore, 2003; Porter et al, 2004).

Knowledge of the natural history of the condition would shed light on the understanding of dry mouth in all its aspects and presentations. Moreover, efficacious, effective and efficient prevention and management can only be developed when it is known whether intervention is needed, or whether cases resolve over time of their own accord (Thomson, 2005).

Longitudinal studies (which are designed to yield information about the natural course of the disease) are the gold standard. Such studies systematically document the natural history of the course of dry mouth over time. Few such studies exist. Locker (1995) reported on three-year changes in xerostomia in a cohort of 50+-year-olds. He reported a baseline prevalence of 15.5%, which increased to 29.5% at three-year follow-up, and an incident rate of 22.5%. In a xerostomia and medication exposure study (over a 6-year period) in South Australians (aged 60+), Thomson et al (2006c) reported a baseline prevalence estimate of 21.4% which increased to 24.8%; the incidence rate was 14.7% , the remission rate 11.4%, and 10.1% were cases at both baseline and follow-up. Johannson et al published findings from a 15-year longitudinal study of xerostomia in a Swedish population of 50+-year-olds in 2009. In this study, the incidence rate was 13% and the resolution rate 42%; the prevalence of xerostomia at 50 years of age was 6%, and it increased to 15% by 65 years of age. Should the intention of the researchers involved in the Dunedin Multidisciplinary Health and Development Study (DMHDS) be to continue to measure xerostomia prevalence and incidence (as well as putative risk factors), the findings will contribute valuable information to understanding the natural history of dry mouth.

The prevalence of dry mouth

As previously described, determining the prevalence of dry mouth, xerostomia or salivary gland hypofunction is complicated by the inability to accurately define what constitutes a case, as does the different and often concurrent (sometimes indiscriminate) use of all three terms in the literature. In addition, not all authors have actually defined what they consider to be a case for their research or have clarified their understanding of the terms dry mouth, xerostomia or salivary gland hypofunction. The latter is particularly true of the earlier papers (Hopcraft and Tan, 2010).

However, despite the differences in questions used to measure xerostomia, the estimates in Table 1.8 lie mostly within the range of 10 to 25%, with two studies reporting estimates below 10% and four studies more than 25%. The generally accepted prevalence is that 20% of adults (or one in five) have xerostomia (Thomson, 2005; Thomson et al, 2011a; Hopcraft and Tan, 2010). Note should be taken most studies have been undertaken in older adults, with 50 years being the lowest age found (Locker, 1993; Johansson et al, 2009). Two studies in young adults reported the prevalence estimates of 10% in 32-year-olds (Thomson et al, 2006b) and 19% in 20-year-olds and 18% in 30-year-olds (Nederfors et al, 1997). These findings suggest that the clinical course of dry mouth, (whether xerostomia, salivary gland hypofunction or both) may start at quite a young age and not be a condition associated with old age.

Table 1.8 Prevalence estimates for xerostomia from population-based studies.

Author and year	*Population*	*Prevalence(%)*	*Assessment*
Johnson et al, 1984	Institutionalised older Swedish; *n = 154*	42.0	Unspecified
Osterberg et al, 1984	70-year-old Swedish; *n* = 973	20.0	Does your mouth feel distinctly dry?
Gilbert et al, 1993	Florida residents aged 65+; *n* = 600	39.0	Is your mouth sometimes dry?
Locker, 1993	Ontario residents aged 50+; *n* =907	17.7	During the last four weeks have you had any of the following – dryness of mouth?
Thomson et al, 1993	Institutionalised New Zealanders aged 65+; *n* = 359	20.0	How often does your mouth feel dry?
Narhi et al, 1994	76-, 81- and 86-year-old Finns; *n* =368	12.0	Does your mouth feel dry? If "yes" when: morning, periodically, evening or at night?
Nederfors et al, 1997	Swedish aged 60+; *n* = 1424.	28.5	Does your mouth usually feel dry? Plus nine additional questions
Antilla et al, 1998	Finnish aged 55; *n* = 780	30.0	One question (unspecified)
Hochberg et al, 1998	Americans aged 65 to 84 years; *n* = 2520	17.2	Does your mouth usually feel dry? Do you wake at night feeling so dry in your mouth that you need to drink fluids?
Thomson et al, 1999	South Australians aged 60+; *n* =700	21.0	How often does your mouth feel dry?
Bergdahl et al, 2000	Swedish aged 20 to 69; *n* = 1427	22.0	Does your mouth usually feel dry?
Pajukoski et al, 2001	Finns aged 70+; Institutionalised *n* = 175 Community dwelling *n* = 252	63.0 57.0	Unspecified questions
Jannson et al, 2003	Swedish females aged 53 to 54 years; *n* =1180	16.0	Does your mouth usually feel dry?
Nayak et al, 2004	British aged 60 to 85 years; n = 770	15.5	How often does your mouth feel dry?
Thomson et al, 2006	New Zealanders aged 32; *n* =923	10.0	How often does your mouth feel dry?
Ikebe et al, 2007	Japanese aged 60+; *n* =287	8.3	Does your mouth feel dry when eating a meal?
Johansson et al, 2009	Swedish 50, 55, 60, 65 years of age; *n* =4714	6.0 (aged 50) 15.0 (aged 65)	Does your mouth usually feel dry in the daytime? Does your mouth usually feel dry at night?
Smidt et al 2011	Danish aged 65 to 95 years; n=668	12.0	Have you had a daily sensation of dry mouth for more than 3 months?

(Adapted from Thomson, 2005 and Hopcraft and Tan, 2010)

The incidence of xerostomia

To date, three studies have reported incidence rates for xerostomia. Locker (1993) from a cohort study of 50+ year olds found that the crude three-year estimate of incidence was 22.5%. As part of a longitudinal study on medication exposure and xerostomia in a cohort of 60+-year-olds Thomson et al (2006c) reported a six-year incidence rate of 14.7%; xerostomia incidence was estimated from data collected in the fifth and eleventh years of the study. Johansson et al (2009) reported an incidence rate of 13% in a cohort of 50-year-olds who were followed up at 60 and 65 years of age. These three studies reported quite different incidence rates over three very different periods. Further research into the incidence of xerostomia is needed before any valid conclusions can be drawn about it through the life-course. The DMHDS will be able to add valuable knowledge to the understanding of incidence over the life-time, should the researchers continue to include dry mouth questions in their study.

In summary, dry mouth whether it be xerostomia or salivary gland hypofunction, has been investigated internationally with vigour over the past few decades. However, much remains to be discovered. Importantly, universally accepted definitions of dry mouth, xerostomia and salivary gland hypofunction should be established. Along with these, methods of measuring dry mouth, xerostomia and salivary gland hypofunction should be agreed upon. The benefit of agreed definitions and methods would be to increase the usefulness of those laudable international research efforts. In addition, further longitudinal studies are needed to add to the meagre bank of incidence data. This literature review has revealed no published research based on a population national sample. All current prevalence estimates come from sub-population samples.

Furthermore, no studies to date have examined the impact of xerostomia on quality of life in a nationally representative sample. Given that the internationally accepted prevalence rate for xerostomia is about 20%, the impact of this complaint on the oral-health-related quality of life (OHRQoL) of such a large minority of the population may be substantial.

1.21 Oral-health-related quality of life (OHRQoL)

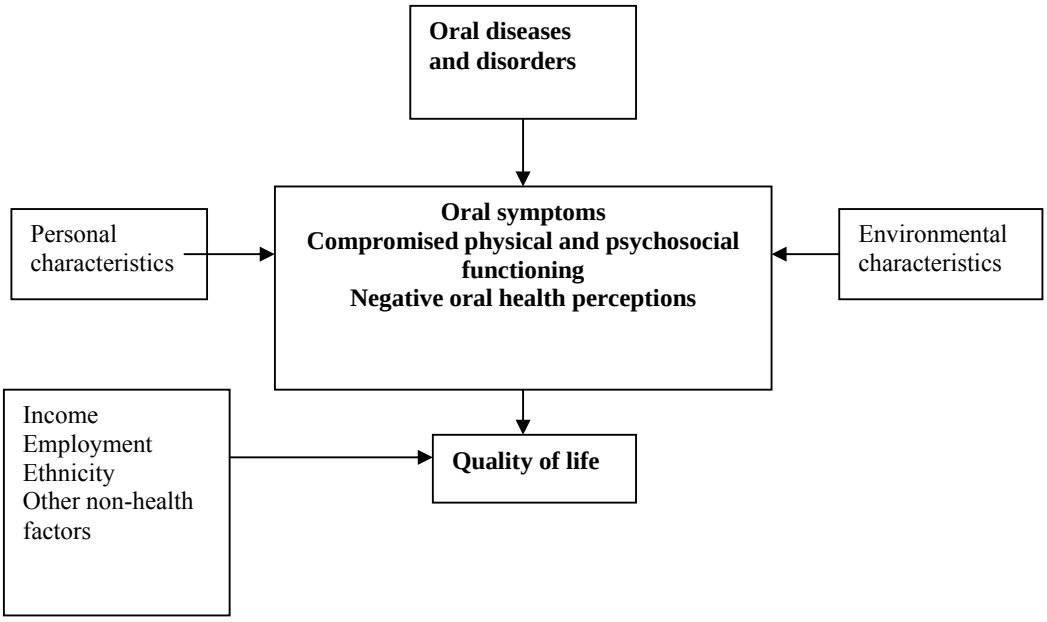
The 1948 Constitution of the World Health Organization defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Last, 2001). More specifically, Locker (2001) defined oral health as "a standard of oral tissues which contribute to the overall physical, physiological and social well-being by enabling individuals to eat, communicate and socialise without discomfort, embarrassment or distress and which enables them to fully participate in their chosen roles". Because quality of life is the degree to which persons see themselves able to function physically and emotionally and socially, health, oral health and quality of life are (in essence) inseparable (Last, 2001).

The core concept of oral health-related quality of life research embraces a holistic approach which takes into account all the aspects of an individual's (or community's) life. The health status measures developed to ascertain or estimate an individual's or population's oral health status range from clinical indices (such as DMFT or CPITN) to self-reported indicators of health, including oral health-related quality of life (OHRQoL) measures. In dental epidemiological research, this has meant a movement away from almost total reliance on traditional objective clinical disease measures (such as DMFT or CPITN) to the use of subjective oral health-related quality of life measures. Objective clinical disease measures reflect only the accumulated disease at a moment in time; they give no information about a person's perceived oral health and how this may affect their daily life. OHRQoL measures relate to self-perceived oral health status. These range from single item global indicators of health perceptions to complex multi-item scales and indices.

Oral health-related quality of life research derives from three related and equally valuable approaches: (1) the oral cavity as the outcome; (2) the effect of the condition of the oral cavity or the oral cavity on the rest of the body; and (3) the effects of systematic health and health-related quality of life on the oral cavity and oral-health-related quality of life. Generally, quality of life is that which makes life worth living, so the quality of life may be a good indicator of disadvantage and deprivation (Gift and Atchison, 1995).

The conceptual framework on which the research into the relationship between health, quality of life and oral diseases and disorders is based is best represented in the 2004 Locker adaption of Wilson and Cleary's model of oral diseases and their consequences. This is illustrated in Figure 1.2.

Figure 1.2: Wilson and Cleary's model of oral diseases and their consequences (adapted by Locker, 2004).



Quality of life research attempts to assess an individual's perspective of how their health affects their day-to-day life. Figure 1.2 illustrates how this can be divided into domains. Although one domain seems to lead directly to the next, life is not static and health or quality of life in any situation is dynamic. Moreover, when viewed from a population perspective the perception of health and/or quality of life may differ from an individual's assessment. Similarly, the dental profession's perception of a patient's the OHRQoL could be diametrically opposed to that of the patient and/or the general public.

The subjective measures developed initially were referred to as socio-dental indicators or subjective oral health indicators. They are now more usually referred to as measures of oral-health-related quality of life (Locker and Allen, 2007). A measure can be defined as an indicator when it assesses the impact of oral disorders, clinical status and perceived and effective need, as well as the ability to benefit from treatment. This line of research is based on the assumption that the functional and psychosocial impacts which are documented affect people's quality of life (Gift and Redford, 1992).

Two main types of OHRQoL measures have been developed; these are global oral health measures and multi-item scales. The various OHRQoL measures so developed differ according to their application. The development and use of these indices and global measures makes use of both qualitative and quantitative research methodology (Slade and Spencer, 1994; Thomson et al, 1999a). Single-item measures are often used in the development of summative scales and in their validation (Atchison and Gift, 1997; Thomson and Williams, 2000; Thomson et al, 1999a; Thomson et al, 2011b). The scores from single-item global indicators and the scores from multi-item scales are strongly correlated (Locker and Gibson, 2005). Although global and multi-item measures are often used together, they are also used singly and with clinical data collection or in a variety of combinations. Global and multi-item approaches are usually used together because the global item acts as an important concurrent validity check.

1.22 Multi-item scales

Multi-item and multidimensional scales and indices ask a number of specific and conceptually related questions which reflect different domains of oral health-related quality of life, such as functional limitation or physical, psychological or social disability (Shearer et al, 2007). The multi-item measures take the form of either a summated scale or a simple list of questions (also referred to as battery of items). The analysis of a simple list necessitates treating each item as a separate entity, resulting in limitations to the subsequent statistical manipulation and data interpretation. A scale allows for the combining of the item data in one or more summated scales which have been psychometrically validated and can be treated with more statistical rigour

(Thomson et al, 1999a). A summary of OHRQoL measures developed since the mid-1980s is presented in Table 1.9.

Examples of commonly used multi-item scales are the General Oral Health Assessment index (GOHAI), the Oral Health Impact Profile (OHIP) and the Oral Impacts on Daily Performance (OIDP) scales (Atchison and Dolan, 1990; Slade and Spencer, 1994; Adulyanon and Sheiham, 1997). The scale selected depends on its proposed application. For instance, the GOHAI seeks to measure a range of adverse effects from functional disorders to the social consequences, while the OHIP and ODIP seek to measure the frequency and severity of oral problems in relation to function and psychosocial well-being (Shearer et al, 2007).

Table 1.9 Summary of OHRQoL measures developed since the mid-1980s.

Measure	Authors	Number of items
Social Impacts of Dental Disease (SIDD)	Cushing et al, 1986	14
General Oral Health Assessment Index (GOHAI)	Atchison and Dolan, 1990	12
Subjective Oral Health Status Indicators	Locker and Miller, 1994	42
Dental Impact Profile (DIP)	Strauss and Hunt, 1993	25
Oral Health Impact Profile (OHIP)	Slade and Spencer, 1994	49
Dental Impact of Daily Living (DIDL)	Leao and Sheiham, 1996	36
Oral Impacts on Daily Performances (ODIP)	Adulyanon and Sheiham,1997	9
Oral Health Impact Profile-14 (OHIP-14)	Slade, 1997	14
Oral Health Impact Profile-20 (OHIP-20)	Allen and Locker, 2002	20
UK Oral Health Related Quality of Life measure (OHQoL-UK)	McGrath and Bedi, 2001	16
Oral Health Related Quality of Life	Kressin et al, 1996	3
Oral Health Quality of Life Inventory	Cornell at al, 1997	56
Rand Dental Health Index	Gooch and Dolan, 1989	3
Sickness Impact Profile (SIP)	Reisine and Weber, 1989	73

(from Thomson, 2011c)

1.23 The Oral Health Impact Profile (OHIP)

The OHIP (an individual-level subjective measure) was developed using statements from a representative patient group rather than being framed by researchers. This measure is a comprehensive attempt to assess how oral health impacts on an individual's life. It is a multi-item scale of 49 items which are conceptually related to Locker's seven dimensions of OHRQoL (Locker, 1988). These dimensions are functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap (Slade and Spencer, 1994).

The OHIP-14 is a short form of health impact profile derived from the OHIP and validated by Slade in 1997. The other shorter form of OHIP is the OHIP-20, developed for use with edentulous individuals (Shearer et al, 2007). The OHIP-14 was originally developed for older adults. It has since been validated in a number of different age groups and cultures (Slade, 1997; Locker and Allen, 2002, Thomson et al, 2006a; Ikebe et al, 2007). The OHIP-14 represents multiple health concepts and a range of health states pertaining to general function and well-being. It has good psychometric properties such as reliability, precision and validity. Additionally, the scale allows the ability to discriminate between subgroups by combining item data in one or more summative scales. This is done by summing the response scores for corresponding items which, in turn, relate a dimension of OHRQoL. The brevity of the measure makes it practical, simple and easy to use in health status surveys. However, it should be noted that there are no specific items relating to denture use (Slade, 1997). A further limitation of the OHIP-14 is that different response profiles can result in the same severity score. This results in individuals with different response profiles being treated as the same during statistical analysis and interpretation (Tsakos et al, 2011). For example, OHIP-14 items are scored 0 to 4 (Never = 0, Hardly ever = 1, Occasionally = 2, Fairly often = 3, Very often = 4), a participant who responded "Hardly ever" to the 14 items would be given a score of 14 and someone who responded "Very often" to three items, "Occasionally" to one item and "Never" to ten items would also score 14. The summated OHIP-14 scores are the same, but

the response profiles (in terms of day-to-day oral-health-related quality of life) are very different.

1.24 Global health status measures

These patient-centred measures require research participants to respond to a single question or statement, endeavouring in this way to encapsulate their overall (global) oral-health-related quality of life. The response is deemed to describe the person's perceived oral health status at the time. The response options are usually in the form of an ordinal response format scale such as "excellent", "good", "fair", and "poor". An array of synonyms for global oral health status measures are used in the literature and this can result in some confusion. These synonyms include "global ratings", "single-item global oral health measures", "single questions" and "global oral health perceptions".

The lack of standardisation and consistency in how single-item questions are framed, and what response options are used, creates difficulties in comparing studies and findings. The considerable differences in question content and orientation may well affect the response of the participants. By way of illustration, Thomson et al (1999b), commenting on a study that reported data rather differently from others reviewed, suggested that different wording to the question "Is your mouth sometimes dry?", possibly substituting "often" for "sometimes", would have produced findings more consistent with other studies (Gilbert et al, 1993; Thomson et al, 1999b). However, problems remain as to how the respondent understands the question, as well as the meanings of the responses to these apparently simple questions. The meanings of the responses are complex and contradictory. In addition, the problem with asking questions is that they beg an answer; survey respondents will often provide answers if even if they do not understand the question, or the response option or the question is of little relevance to them (Locker and Gibson, 2006).

Single-item questions have the advantage of minimising the burden on the respondent. Moreover, the scores from single-item global indicators and the scores from multi-item scales are strongly correlated (Locker and Gibson, 2005).

The simplicity of these measures allows for great flexibility in their use and application. The ordinal response format scale is used to assist both the respondent (in answering the question) and the researcher (in assessing and analysing the data captured). Often, the researcher dichotomises the Likert scale to allow comparative statistical analysis with a summative multi-item scale (Thomson et al, 2006a).

This study has made use of the single-item global indicator of oral health quality of life developed by Locker (2001) in conjunction with the OHIP-14 multi-item scale. These quality-of-life measures were used together with the sociodemographic and clinical data collected from the national representative sample of community-dwelling New Zealand dentate adults to examine the OHRQoL impacts of xerostomia. Although the quality-of-life impacts of xerostomia have been reported to have consistent and noticeable effects on individuals' day-to day lives (Locker, 2003; Gerdin et al 2005; Thomson et al 2006a), no investigation (to the best of the researcher's knowledge) has yet been undertaken of xerostomia and OHRQoL in a representative national population sample.

1.25 Aims and objectives

The aim of this study was to examine the prevalence, associations and oral-health-related quality of life impacts of xerostomia in a nationally representative sample of dentate adult community-dwelling New Zealanders aged 18 years and above.
The findings will contribute to knowledge and understanding of xerostomia at a population level. Moreover, because the NZOHS 2009 survey and Australian National Survey of Adult Oral Health 2004-06 were similar, and the intention of the New Zealand Ministry of Health is to undertake regular surveys of the population, this research will form a baseline for additional research into xerostomia among New Zealanders.

2. Methods

The aims of this research include determining the prevalence of xerostomia and describing the associations and impacts of xerostomia in a national sample of adult New Zealanders. This national sample was of adults usually resident in private dwellings. The research used the data collected from this community-dwelling sample during the 2009 New Zealand Oral Health Survey (NZOHS).

The 2009 NZOHS was a sample snapshot survey which surveyed a national sample of the usually community-resident population. Approximately 94% of the New Zealand population is considered to live in private dwellings in the community.

2.1 The survey

The 2009 NZOHS was commissioned by the New Zealand Ministry of Health to gather up-to-date information about the oral health status of New Zealand adults and children and their use of oral health services.

In 2006/2007, a New Zealand Health Survey (NZHS) was undertaken, and 84% of households surveyed in the NZHS agreed to be re-contacted for future health surveys. The 2009 NZOHS followed up on the 2006/07 NZHS, with the sample selected from the re-contact database.

The 2009 NZOHS was conducted from February to December 2009. The survey had two components: a computer-assisted face to face interview, and a dental examination. Information was collected from 4906 New Zealanders (adults and children), with 3196 dental examinations conducted by survey dentists. The interview gathered information on self-reported oral health status, risk and protective factors for oral health outcomes and use of oral health care services. Clinical examinations by survey dentists collected information on oral disease with a focus on caries and periodontal disease. A specialised survey company

undertook the interviewing, data collection and preparation of the data-sets. The dental examinations were conducted by specially-trained and currently registered dentists.

By investigating the prevalence, associations and impacts of xerostomia in the adult New Zealanders, this research aimed to expand on particular objectives of the 2009 NZOHS. These included examining the prevalence of risk and protective factors associated with oral conditions, the relationship between general health and oral health and inequalities between population subgroups (as defined by age, sex, ethnicity, rurality and socioeconomic position).

The New Zealand Health and Disability Multi-Region Ethics Committee granted approval for the 2009 NZOHS and approved the wording of all public materials for the survey (MEC/07/11/149).

2. 2 Selection of survey participants

The 2009 NZOHS made use of the 2006/07 NZHS re-contact database. A total of 12 874 New Zealand households participated in the NZHS; of these, 84% agreed to be re-contacted for future health surveys, creating a re-contact database.

The 2006/07 NZHS used a multi-stage, stratified, probability-proportional-to-size (PPS) sample design, with greater sampling of some ethnic groups, primarily through a "screened" sample. Meshblocks were randomly chosen, with larger areas and areas with greater proportions of Māori, Pacific or Asian people having a greater chance of selection.

Interviewers in each area selected every *k*th house as the "core" sample household, randomly selecting one adult and one child from each household. Then each *j*th house in each area was selected as the "screened" sample household; occupants were eligible only if they identified themselves as ethnically Maori, Pacific or Asian (determined using the Census ethnicity question and Statistics New Zealand ethnicity classification). There was no substitution of households or

participants if the selected household or participant refused, was not contactable, or was unavailable.

All of the Pacific, Asian and Maori respondents in the 2006/07 re-contact database were selected from the 2009 NZOHS. This ensured that sample sizes for these key population subgroups were maximised. Four out of ten European/Other respondents were selected. A total of 6318 households were selected, comprising 8938 people. The Ministry of Health used best-practice survey techniques throughout the 2009 NZOHS.

2.3 Sample Size

A total of 4906 New Zealanders completed the face-to-face interview, 3475 of whom were adults aged 18 years and over. This adult sample included 1267 Maori, 353 Pacific, 518 Asian and 2125 European/other people. Some 2209 adults were dentally examined, with 2048 undergoing a periodontal examination. Precluded from the periodontal examination were those adults who (at interview) indicated that they were edentulous, and those whose medical history indicated they needed to take antibiotics before a dental visit.

Table 2.1 presents the sample size numbers for adult New Zealanders who participated in the face-to-face interviews, dental examinations and periodontal examinations, by age group, for the 2009 NZOHS.

Table 2.1: Sample size numbers for the 2009 New Zealand Oral Health Survey, by age group[a].

Age Group	Number interviewed	Number dentally examined	Number periodontally examined
18-24 years	268	168	163
25-35 years	549	364	352
35-44 years	783	578	560
45-54 years	687	464	433
55-64 years	510	303	269
65-74 years	375	202	176
75 years and older	303	130	95
Total	4906	3196	2048

[a]Adapted from Ministry of Health (2009)

2.4 Sampling error

The delete-a-group jack-knife method was used to determine standard errors as a means of measuring sampling error. Sampling error may result in estimates from a survey differing from results that would have been produced if all of the information had been obtained for all people in the population.

2.5 Non-sampling error

Possible non-sampling errors include coverage errors, response bias and measurement errors. Substantial effort was made to reduce non-sampling error by careful designing and testing of the survey, questionnaire and processes, and to ensure quality control of procedures and data.

Efforts to reduce response bias included the use of weighting and the interview introduction; the latter was an attempt to ensure that people would participate in the survey.

Measurement errors include recall error, under- and over-reporting, and item non-response (which can occur when using a questionnaire). Self-reported information may be inaccurate because it is reliant on accurate recall, exact reporting and response to all questions by the respondent. Measurement bias in the clinical data was reduced by measuring the inter-examiner reliability of each dental examiner relative to the gold standard examiner, and reporting on this using the intra-class correlation coefficient (ICC).

2.6 The face-to-face interviews

Thirty-nine interviewers conducted face-to-face computer-assisted personal interviews. Responses were typed directly into a laptop computer, with predetermined response categories on show cards used to assist the participants. Participation was voluntary and informed consent was obtained. The duration of the adult interviews averaged thirty-one minutes.

The interview questionnaires were field-tested in a pilot survey in March 2008 and adapted where necessary. Information was collected on the topics of self-reported oral health and perceptions, risk and protective factors, use of oral health services, history of orofacial trauma, and attitudes and opinions about oral health. The questionnaire contained 129 items. The items of particular relevance to this research are the self-rated oral health question, the dry mouth question and the OHIP-14 items. Neither the full Xerostomia Inventory nor its shortened form were included in the questionnaire, because xerostomia was not the primary focus of the main study. The inclusion of either of these would have added to the response burden placed on the participants and been an additional drain on the available resources.

The self-rated oral health question (Q.12) asked was: " How would you describe the health of your teeth or mouth?" with seven possible responses of "excellent", "very good", "good", "fair", "poor", "don't know" or "refused". The dry mouth question (Q.23) asked was: "How often does your mouth feel dry?" with the six

possible responses of “never”, “occasionally”, “frequently”, “always”, “don’t know” or “refused”. The OHIP-14 was used to measure how oral health affects a person’s day-to-day life. OHIP-14 scores were computed in two ways: first, an overall OHIP-14 score was calculated by summing responses over all 14 items; second, OHIP-14 subscale scores were calculated for each of the dimensions by summing the response scores for the two corresponding items. The total OHIP-14 score and subscale scores constitute measures of the “severity” of adverse impacts caused by oral conditions, as such; these measures used all response categories. The prevalence of impacts was computed (at item, subscale and whole-scale level) by identifying individuals who experienced impacts “Very often” or “Fairly often”.

2.7 Dental examinations

Adult respondents with at least one tooth were invited at the end of their interview to participate in the dental examination. An information sheet was given to those who accepted the invitation. Those still willing to take part after reading the information sheet were offered a selection of appointment times at a convenient facility. An in-house examination was offered when a participant was physically unable to travel. Dental examinations did not occur on the same day as the interview.

The survey dental examiner obtained informed consent from adult respondents. The participants were advised they could stop the examination at any time. They were asked to complete a medical history form which included questions on general medical conditions, including any conditions which would preclude a periodontal examination.

Dental examiners followed a standardised protocol to record clinical information about tooth loss, decay, fluorosis, dental trauma, mucosal lesions, oral debris and periodontal disease. No sharp explorers were used and no radiographs were taken. For adults aged 45 years or younger, the distinction was made between missing teeth extracted due to caries or periodontal disease and those missing due to

trauma, impaction or congenital absence (determined at the time of the examination by asking the participant). No such distinction was made for adults aged over 45 years. Decay was recorded when cavitation of the enamel or dentine (or both) was observed.

Periodontal measurements, of three sites (mesio-buccal, mid-buccal and distolingual), were made of all teeth present, except third molars. Gingival recession (GR, the distance in millimeters from the cemento-enamel junction to the gingival margin) and probing depth (PD, the distance from the probe tip to the gingival margin) were recorded, using a periodontal probe with 2 mm markings. Where the cemento-enamel junction was subgingival, a negative GR value was recorded. The combined attachment loss (CAL) was computed by summing GR and PD. Periodontal measurements were undertaken only on those particiants who did not have any medical conditions which would preclude a periodontal examination.

The survey participants were given a written report after the examination describing the finding and providing oral health advice. They also received a thank-you letter and financial assistance towards travel costs.

2.8 Dental examiners

A lead examiner, a gold standard examiner and twenty-one dental examiners were used for this research; all dental examiners were fully qualified and registered. The interviewers were trained as dental recorders to record the dental examination clinical data.

To ensure consistency among dental examiners, all examiners were given a manual describing examination protocols and they attended a two-and-a-half-day training and calibration course run by the head examiner. In addition, the gold standard examiner worked with, and recalibrated, the dentist when there had been a delay between training and the start of the dental examinations. Consistency of the dental examiners was measured by the gold standard examiner conducting

replicate examinations for about six survey participants per examiner. The intra-class correlation coefficient (ICC) was measured at 0.78 or greater.

2.9 Data analysis

The Stata statistical package (version 12; StataCorp LP, Texas, USA) was used for all statistical analyses. The survey set ("svyset") approach was employed due to the complex sampling design. Univariate analyses were undertaken to describe the sample by sociodemographic characteristics, clinical variables, the single-item dry mouth question, xerostomia, global oral health status and the OHIP-14.

Mulivariate modeling used logistic and binomial regression (where appropriate). Logistic regression analysis was used to model xerostomia prevalence, and to determine whether xerostomia was associated with poor OHRQoL. In addition, logistic regression modeling was used to examine the prevalence of OHIP subscale impacts.

Binomial regression modeling was used to examine the association between the mean OHIP scores and the sociodemographic characteristics and the mean OHIP scores and xerostomia, while controlling for confounders.

3. Results

The 2009 NZOHS snapshot survey collected data from a representative sample of adult community-resident New Zealanders. This national sample was representative of the approximately 94% of New Zealanders living in private dwellings in the community. All data reported here refer to the dentate adult (18+ years of age) population of New Zealand. In all tables, the brackets contain the 95% confidence interval unless otherwise stated.

3.1 Sociodemographic characteristics

The sociodemographic characteristics of community dwelling adults are shown in Table 3.1.

Table 3.1 Sociodemographic characteristics of adult community resident New Zealanders (data are percentages).

	Female	Male	All
Age group			
18-24	53.6 (46.0, 60.9)	46.4 (39.0, 53.9)	13.1 (11.5, 14.8)
25-34	54.2 (47.6, 60.7)	45.7 (39.3, 52.3)	16.9 (15.0, 19.1)
35-44	55.1 (55.1, 59.7)	44.9 (40.2, 49.6)	22.6 (20.9, 24.6)
45-54	53.7 (47.8, 59.4)	46.3 (40.5, 52.1)	20.0 (18.4, 21.8)
55-64	44.3 (38.4, 50.4)	55.7 (49.5, 61.6)	13.8 (12.5, 15.2)
65-74	53.1 (46.3, 59.7)	46.9 (40.2, 53.6)	7.9 (6.9, 9.1)
75+	52.2 (44.0, 60.2)	47.8 (39.7, 55.9)	5.6 (4.9, 6.4)
Ethnic group			
Māori	54.2 (50.9, 57.3)	45.8 (42.6, 49.0)	10.6 (9.8, 11.4)
Pacific	53.4 (48.1, 58.4)	46.6 (41.5, 51.8)	5.0 (4.4, 5.6)
Asian	44.1 (35.3, 53.1)	55.9 (46.8, 64.6)	9.6 (8.0, 11.6)
European/Other	53.3 (51.0, 55.5)	46.7 (44.5, 48.9)	82.9 (80.9, 84.8)
Deprivation quintile			
1 (least deprived)	49.8 (43.4, 56.1)	50.2 (43.8, 56.5)	21.8 (19.9, 23.6)
2	52.1 (45.6, 58.4)	47.9 (41.5, 54.3)	22.0 (20.2, 24.0)
3	56.2 (49.5, 62.6)	43.8 (37.3, 50.4)	19.1 (17.3, 21.0)
4	51.7 (44.9, 58.5)	48.3 (41.4, 55.1)	19.8 (18.1, 21.5)
5 (most deprived)	53.8 (46.3, 61.1)	46.2 (38.8, 53.6)	17.3 (15.7, 18.8)
All combined	52.6	47.4	100.0

There were more female adult community-dwelling New Zealanders than male. The largest ethnic group is described as European or other; the smallest group is formed by the Pacific Island peoples. The WHO pathfinder age-groups of 35-44 and 65-74 years represented 22.6% and 7.9% of the sample.

3.2 Dental Status

The dentate population in the 2009 NZOHS was defined as persons who had at least one natural tooth. One in eleven adults (9.4%) were edentulous. Data in Tables 3.2, 3.3 and Table 3.4 refer to the adult dentate population.

Table 3.2 presents data on the occurrence of missing teeth (due to pathology) by sociodemographic characteristics.

Table 3.2 The prevalence of tooth loss, mean number of missing teeth and prevalence of a functional dentition, by sociodemographic characteristics (brackets contain 95% CI).

	Missing 1+ teeth (%)	Mean number of missing teeth	Functional dentition (%)
Sex			
Female	61.6 (57.6, 65.5)	4.5 (4.1, 4.9)	89.8 (87.9, 91.3)
Male	62.6 (58.7, 66.4)	4.7 (4.2, 5.1)	87.2 (84.2, 89.7)
Age group			
18-24	7.9 (4.1, 14.7)[a]	0.3 (0.1, 0.5)	99.7 (97.8, 1.0)[a]
25-34	35.2 (27.5, 43.8)	0.9 (0.7, 1.2)	99.9 (99.3, 1.0)
35-44	41.3 (35.1, 47.8)	1.7 (1.3, 2.0)	98.0 (96.7, 98.8)
45-54	91.8 (87.8, 94.6)	6.0 (5.3, 6.7)	87.6 (82.0, 91.6)
55-64	98.1 (95.2, 99.2)	7.7 (6.9, 8.5)	84.1 (78.6, 83.4)
65-74	98.1 (94.6, 98.1)	12.1 (10.6, 13.5)	55.1 (45.7, 64.1)
75+	100.0	13.3 (11.7, 15.0)	55.8 (45.3, 65.9)
Ethnic group			
Māori	56.3 (51.8, 60.7)[a]	4.5 (3.9, 5.1)	87.0 (83.5, 89.9)
Pacific	65.4 (56.3, 73.4)	4.3 (3.4, 5.2)	87.7 (81.6, 92.0)
Asian	42.7 (34.9, 50.8)[a]	2.2 (1.7, 2.7)	94.8 (92.5, 96.4)[a]
European/Other	63.6 (60.2, 66.9)[a]	4.8 (4.4, 5.2)	84.4 (86.1, 93.3)
Deprivation quintile			
1 (least deprived)	64.4 (56.4, 71.6)	4.3 (3.5, 5.2)	90.3 (85.1, 93.8)
2	63.3 (55.2, 70.7)	4.8 (4.0, 5.6)	89.3 (85.2, 92.4)
3	59.5 (52.5, 66.3)	5.0 (4.0, 6.0)	85.0 (86.1, 93.4)
4	59.7 (52.7, 66.3)	4.1 (3.5, 4.8)	90.3 (86.1, 93.4)
5 (most deprived)	63.2 (55.0, 70.8)	4.8 (4.0, 5.5)	87.3 (83.4, 90.3)
All combined	62.1 (59.1, 65.0)	4.6 (4.3, 4.9)	88.6 (86.7, 90.2)

[a]P< 0.05

There were clear age gradients in tooth loss, with one in eight of the youngest age group having lost 1+ teeth, but almost all of those in the older age groups having done so. Concerning the functional dentition (defined as 21 or more teeth present), just over half of the 75+ age group had one, whereas almost all of the 18-24-year-olds had one. The Asian population had a mean of 2.2 missing teeth, the lowest of the ethnic groups. There was no marked difference in tooth-loss or retention of a functional dentition by deprivation quintile.

Table 3.3 presents summary data on caries experience. The data on the mean number of missing teeth is presented in both Table 3.2 and Table 3.3 because it is relevant to both tooth loss and caries experience.

Table 3.3 Mean decayed, missing and filled teeth, by sociodemographic characteristics (brackets contain 95% CI).

	DMFT	Decayed teeth	Missing teeth	Filled teeth
Sex				
Female	14.4 (13.7, 15.0)	0.9 (0.7, 1.0)[a]	4.5 (4.1, 4.9)	9.0 (8.5, 9.4)[a]
Male	14.2 (13.6, 14.9)	1.4 (1.1, 1.6)	4.7 (4.2, 5.1)	8.2 (7.7, 8.7)
Age group				
18-24	3.7 (2.7, 4.8)[a]	0.8 (0.5, 1.2)	0.3 (0.1, 0.5)	2.6 (1.9, 3.4)[a]
25-34	7.1 (6.2, 8.0)	1.5 (1.0, 2.0)	0.9 (0.7, 1.2)	4.7 (3.9, 5.4)
35-44	10.1 (9.3, 10.9)	1.0 (0.8, 1.2)	1.7 (1.3, 2.0)	7.4 (6.9, 8.1)
45-54	18.8 (17.9, 19.6)	1.1 (0.7, 1.5)	6.0 (5.3, 6.7)	11.6 (10.7, 12.5)
55-64	22.3 (21.4, 25.5)	1.1 (0.7, 1.5)	7.7 (6.9, 8.5)	13.5 (12.4, 14.5)
65-74	24.8 (24.1, 25.5)	1.0 (0.6, 1.3)	12.1 (10.6, 13.5)	11.8 (10.5, 13.1)
75+	25.3 (24.2, 26.4)	1.1 (0.6, 1.5)	13.3 (11.7, 15.0)	10.9 (9.4, 12.4)
Ethnic group				
Māori	12.9 (12.1, 13.7)[a]	1.8 (1.5, 2.1)[a]	4.5 (3.9, 5.1)	6.6 (6.0, 7.1)[a]
Pacific	9.9 (8.6, 11.1)[a]	2.0 (1.5, 2.4)[a]	4.3 (3.4, 5.2)	3.6 (3.0, 4.3)[a]
Asian	7.2 (6.2, 8.3)[a]	0.9 (0.7, 1.1)[a]	2.2 (1.7, 2.7)[a]	4.2 (3.4, 4.9)[a]
European/Other	15.3 (14.7, 15.9)[a]	1.0 (0.9, 1.2)[a]	4.8 (4.4, 5.2)[a]	9.5 (9.0, 1.0)[a]
Deprivation quintile				
1 (least deprived)	16.0 (14.5, 17.6)[a]	0.7 (0.4, 1.0)[a]	4.3 (3.5, 5.2)	11.0 (9.9, 12.0)[a]
2	15.1 (13.7, 16.5)	1.0 (0.7, 1.3)	4.8 (4.0, 5.6)	9.3 (8.4, 10.3)
3	14.1 (12.6, 15.7)	0.9 (0.7, 1.1)	5.0 (4.0, 6.0)	8.2 (7.2, 9.1)
4	13.0 (11.6, 14.4)	1.2 (1.0, 1.5)	4.1 (3.5, 4.8)	7.6 (6.6, 8.6)
5 (most deprived)	12.8 (11.5, 14.0)	1.8 (1.3, 2.3)	4.8 (4.0, 5.5)	6.2 (5.4, 7.1)
All combined	14.3 (13.8, 14.8)[a]	1.1 (1.0, 1.2)[a]	4.6 (4.3, 4.9)[a]	8.5 (8.2, 9.0)[a]

[a]P< 0.05

Filled teeth scores were the largest contributor to the DMFT scores. There were clear age gradients in the mean DMFT. Pacific Islanders had more missing teeth than filled teeth, on average. The most deprived quintile had the lowest mean DMFT.

Summary data on the prevalence of untreated decay are presented in Table 3.4. The data are presented by one or more untreated decayed teeth and three or more untreated decayed teeth.

Table 3.4 Prevalence of untreated decayed teeth, by sociodemographic characteristics (data are percentages, brackets contain 95% CI).

	1+ untreated decayed teeth	3+ untreated decayed teeth
Sex		
Female	32.2 (28.8, 36.0)[a]	7.6 (5.9, 9.6)[a]
Male	46.6 (41.9, 51.4)	11.9 (9.1, 15.4)
Age group		
18-24	32.3 (22.4, 44.2)[a]	8.6 (3.9, 18.0)[a]
25-34	46.6 (38.4, 54.9)	11.8 (7.9, 17.2)
35-44	38.7 (33.4, 44.1)	9.1 (6.2, 13.0)
45-54	37.7 (32.2, 43.7)	9.2 (6.1, 13.7)
55-64	37.8 (31.1, 45.0)	10.1 (6.0, 16.4)
65-74	36.1 (27.6, 45.6)	8.1 (4.3, 14.6)
75+	95.3 (93.7, 96.5)	92.2 (90.4, 93.6)
Ethnic group		
Māori	52.8 (47.0, 58.5)[a]	16.7 (13.0, 21.3)[a]
Pacific	66.1 (58.2, 73.2)[a]	21.0 (14.4, 29.5)[a]
Asian	37.0 (29.6, 45.0)	6.2 (4.1, 9.2)[a]
European/Other	36.7 (33.3, 40.2)[a]	8.6 (6.8, 10.8)[a]
Deprivation quintile		
1 (least deprived)	28.2 (22.0, 35.3)[a]	5.0 (2.6, 9.5)[a]
2	36.7 (30.9, 43.0)	8.6 (5.5, 13.1)
3	37.1 (29.8, 45.0)	8.7 (5.3, 13.8)
4	48.4 (41.8, 55.1)	8.4 (5.4, 13.0)
5 (most deprived)	47.1 (40.2, 54.1)	19.0 (14.0, 25.2)
All combined	61.7 (59.2, 64.1)	43.2 (40.7, 45.7)

[a]$P < 0.05$

A higher proportion of males than females had untreated decay. Over 90% of those aged 75+ years had three or more untreated decayed teeth, while only one in 12 of the 65-74 year age-group had untreated decay. A higher proportion of Pacific Islanders and Māori had untreated caries than Asian and European peoples. There were clear deprivation gradients in untreated caries.

3.3 Periodontal Status

Some 2048 dentate adults examined were assessed for periodontal disease. There were 161 dentate adults (7.3%) excluded from the periodontal examinations, due to pre-existing medical conditions which precluded measurements being made.

Table 3.5 presents summary data on combined attachment loss (CAL) and the extent of CAL sites by sociodemographic characteristics.

Table 3.5 Prevalence and extent of periodontal attachment loss, by sociodemographic characteristics (brackets contain 95% CI).

	Percent with 1 or more sites with:			Mean percent of sites with:		
	CAL 4+mm	CAL 5+mm	CAL 6+mm	CAL 4+mm	CAL 5+mm	CAL 6+mm
Sex						
Female	45.1 (41.1, 49.1)[a]	22.9 (20.0, 26.1)[a]	10.8 (8.7, 13.3)[a]	4.4 (3.7, 5.1)[a]	1.7 (1.3, 2.1)[a]	0.8 (0.5, 1.0)
Male	55.2 (50.2, 60.1)	32.6 (28.6, 36.9)	16.2 (13.5, 19.4)	6.9 (5.8, 8.0)	2.9 (2.1, 3.7)	1.3 (0.8, 1.7)
Age group						
18-24	17.9 (11.3, 27.1)[a]	8.0 (3.7, 16.5)[a]	4.5 (1.5, 12.5)[a]	1.2 (0.9, 2.3)[a]	0.6 (-0.2, 1.5)[a]	0.5 (-0.4, 1.3)[a]
25-34	35.3 (26.9, 44.7)	13.2 (8.1, 20.5)	6.8 (3.7, 12.1)	1.8 (1.1, 2.5)	0.4 (0.2, 0.6)	0.1 (0.0, 0.2)
35-44	44.0 (38.2, 49.9)	19.5 (15.8, 23.7)	8.4 (6.1, 11.6)	3.4 (2.8, 4.0)	0.9 (0.7, 1.2)	0.4 (0.2, 0.5)
45-54	62.6 (55.7, 69.0)	36.1 (30.2, 42.4)	18.4 (14.4, 23.3)	7.2 (5.4, 8.9)	2.7 (1.7, 3.8)	1.2 (0.6, 1.8)
55-64	68.9 (60.3, 76.4)	42.6 (34.8, 50.8)	18.4 (13.3, 24.8)	9.1 (6.7, 11.4)	4.0 (2.2, 5.7)	2.0 (0.7, 3.2)
65-74	73.2 (64.1, 80.7)	50.4 (41.5, 59.3)	22.6 (15.7, 31.4)	10.7 (8.3, 13.1)	4.2 (2.9, 5.6)	1.8 (1.0, 2.5)
75+	86.7 (77.6, 92.4)	67.7 (55.0, 78.3)	41.3 (28.6, 55.4)	21.0 (14.4, 27.7)	11.3 (6.0, 16.6)	4.6 (2.2, 6.9)
Ethnic group						
Māori	54.0 (48.9, 59.0)	28.9 (25.4, 32.8)	18.3 (14.6, 22.8)[a]	8.5 (7.0, 10.1)[a]	3.7 (2.8, 4.7)[a]	1.8 (1.2, 2.4)[a]
Pacific	51.9 (43.0, 60.8)	33.2 (24.5, 43.3)	19.8 (13.8, 27.7)[a]	8.5 (5.7, 11.4)[a]	3.8 (2.2, 5.5)	1.9 (0.9, 2.8)
Asian	46.6 (35.7, 57.7)	30.2 (22.8, 38.8)	18.4 (13.1, 25.2)	5.3 (3.8, 6.9)	2.1 (1.4, 2.7)	0.9 (0.5, 1.3)
European/Other	49.1 (45.6, 52.7)	26.1 (23.3, 29.1)[a]	11.7 (9.7, 14.1)[a]	5.1 (4.3, 5.9)[a]	2.0 (1.5, 2.6)[a]	0.8 (0.5, 1.2)[a]
Deprivation quintile						
1 (least deprived)	49.4 (40.9, 57.8)	25.1 (19.1, 32.3)	9.6 (6.3, 14.3)	3.9 (2.9, 5.0)[a]	1.6 (0.9, 2.2)[a]	0.5 (0.1, 0.8)[a]
2	50.5 (43.9, 57.1)	26.3 (20.4, 33.3)	13.3 (9.7, 18.1)	4.9 (3.8, 6.0)	1.7 (1.1, 2.3)	0.6 (0.4, 0.9)
3	44.5 (37.1, 52.2)	25.2 (19.9, 31.4)	11.8 (8.2, 16.6)	5.6 (3.7, 7.4)	2.2 (1.0, 3.4)	1.0 (0.3, 1.7)
4	50.7 (43.8, 57.5)	31.0 (25.5, 37.2)	17.9 (13.3, 23.7)	6.9 (4.8, 9.0)	2.8 (1.5, 4.2)	1.1 (0.6, 1.7)
5 (most deprived)	55.0 (47.1, 62.7)	30.7 (24.9, 37.2)	14.8 (11.0, 19.7)	7.3 (5.3, 9.2)	3.2 (1.8, 4.7)	1.8 (0.6, 2.9)
All combined	49.9 (47.1, 52.7)	27.5 (25.2, 30.0)	13.4 (11.6, 15.4)	5.6 (5.0, 6.3)[a]	2.3 (1.8, 2.7)[a]	1.0 (0.7, 1.3)[a]

[a]P< 0.05

In every measurement category, a higher proportion of males than females were cases, and males had a greater extent of CAL than females. There were clear age and deprivation gradients in both prevalence and extent of periodontal attachment loss. The prevalence was lowest among the European/Other group (with the exception of CAL 4+mm) and the extent of CAL was also lowest among that group. The gradients by deprivation quintile were more consistent for CAL extent than prevalence.

3.4 Xerostomia

In response to the question: "How often does your mouth feel dry?", 36.7% reported "Never", 48.5% "Occasionally", 11.6% "Frequently", 1.5% "Always" and 1.7% "Don't know" (or refused to answer"). The "frequent" and "always" response categories were combined to indicate those individuals with xerostomia.

Data on the dry mouth question item responses and the prevalence of xerostomia are presented by sociodemographic characteristics in Table 3.6.

Table 3.6 Dry mouth question item responses and prevalence of xerostomia by sociodemographic characteristics (brackets contain 95% CI)

	How often does your mouth feel dry?					Xerostomic %
	Never	Occasionally	Frequently	Always	Don't know	
Sex						
Female	38.3 (34.3, 42.5)	45.2 (41.1, 49.3)	13.7 (11.2, 16.6)	1.9 (1.0, 3.5)	0.9 (0.4, 2.3)[a]	15.6 (12.9, 8.7)[a]
Male	35.2 (30.8, 39.8)	51.3 (46.5, 56.1)	9.3 (0.7, 12.0)	1.1 (0.4, 3.0)	3.1 (1.7, 5.5)	10.4 (8.1, 13.3)
Age group						
18-24	38.1 (28.1, 49.2)	52.8 (42.5,62.8)	3.6 (1.3, 9.3)	1.6 (0.2, 11.0)	3.9 (1.2, 12.0)	5.0 (2.1, 11.4)[a]
25-34	30.9 (24.4, 38.3)	50.4 (42.8, 57.9)	15.7 (11.1, 21.6)	1.3 (0.2, 9.3)	1.7 (0.4, 7.8)	17.1 (11.9, 24.0)
35-44	39.5 (32.5, 46.9)	49.4 (42.7, 56.2)	8.1 (5.6, 11.6)	1.4 (0.5, 4.2)	1.7 (0.6, 0.4)	9.5 (6.7, 13.3)
45-54	37.7 (30.7, 45.1)	45.8 (39.7, 52.0)	13.2 (9.3, 18.6)	1.2 (0.4, 3.7)	2.1 (1.0, 4.6)	14.2 (10.4, 19.2)
55-64	41.3 (33.5, 49.5)	43.7 (35.7, 52.0)	11.0 (6.9, 17.3)	2.1 (0.7, 5.9)	2.0 (0.4, 9.7)	12.8 (8.4, 19.2)
65-74	31.9 (23.5, 41.7)	51.5 (43.1, 59.8)	15.6 (10.3, 22.9)	0.3 (5.3e-04, 1.3)	0.8 (0.1, 5.6)	16.0 (10.6, 23.2)
75+	36.2 (32.7, 39.8)	48.4 (44.5, 52.3)	12.6 (10.4, 15.1)	1.7 (1.0, 2.9)	1.2 (0.6, 2.3)	26.0 (17.2, 37.3)
Ethnic group						
Māori	34.9 (30.0, 40.1)	49.8 (44.6, 54.9)	10.7 (8.3, 13.7)	1.9 (0.7, 4.8)	2.8 (1.7, 4.7)	12.6 (9.7, 16.1)
Pacific	36.5 (28.8, 44.9)	46.1 (38.4, 53.9)	12.2 (7.6, 19.2)	2.3 (0.9, 5.8)	3.0 (1.4, 6.5)	14.5 (9.6, 21.3)
Asian	47.1 (37.9, 56.7)	41.3 (32.2, 51.0)	7.6 (4.8, 12.0)	0.5 (0.1, 0.2)	3.5 (1.0, 11.7)	8.1 (5.1, 12.6)[a]
European/Other	35.9 (32.5, 39.4)	49.1 (45.8, 52.4)	12.0 (10.1, 14.1)	1.5 (0.8, 2.7)	1.6 (0.9, 3.1)	13.4 (11.4, 15.7)
Deprivation quintile						
1 (least deprived)	34.2 (28.0, 41.0)	51.4 (45.1, 57.6)	11.0 (7.3, 16.2)	1.4 (0.5, 4.2)	2.1 (0.6, 7.2)	12.4 (8.6, 17.5)
2	40.2 (33.5, 47.3)	46.7 (40.3, 53.1)	10.5 (7.0, 15.5)	0.8 (0.3, 2.1)	1.9 (0.6, 5.8)	11.2 (7.5, 16.5)
3	41.1 (33.9, 48.7)	50.0 (42.1, 60.0)	8.4 (5.2, 13.4)	0.5 (0.2, 1.4)	1.0 (0.4, 2.5)	8.9 (5.7, 13.8)
4	37.0 (30.8, 43.6)	44.6 (37.5, 51.8)	14.9 (11.0, 20.0)	2.4 (0.8, 7.0)	1.2 (0.6, 2.5)	17.3 (12.4, 23.5)
5 (most deprived)	31.0 (24.7, 38.1)	48.9 (42.0, 55.8)	13.6 (1.0, 18.3)	2.7 (1.0, 7.3)	3.8 (1.6, 8.9)	16.3 (12.1, 21.6)
All combined	36.7 (34.5, 38.9)	48.5 (46.2, 50.8)	11.6 (10.4, 13.0)	1.5 (1.0, 2.2)	1.7 (1.2, 2.5)	13.1 (11.7, 14.7)

[a]P<0.05

The proportion of adult New Zealanders who had experienced xerostomia was 13.1%; this was higher among females than males. The age groups with the highest proportion of sufferers were those aged 25-34 and 75+ years, while the second most deprived group had the highest percentage of people with xerostomia.

Data on dentition status and caries experience are shown by xerostomia status in Table 3.7.

Table 3.7 Dentition status and caries experience, by xerostomia status (brackets contain 95% CI)

	Xerostomic?	
	No	Yes
Dentition status		
Missing 1+ teeth (%)	60.9 (57.6, 64.2)	69.8 (60.7, 77.5)
Mean number of missing teeth	4.4 (4.0, 4.7)	6.3 (5.2, 7.4)[a]
Functional dentition (%)	90.0 (87.9, 91.3)	80.6 (74.5, 85.3)[a]
Caries status		
Mean DMFT	14.0 (13.5, 14.5)	16.3 (14.5, 18.1)[a]
Mean number of decayed teeth	1.0 (0.9, 1.2)	1.5 (0.9, 2.2)
Mean number of missing teeth	4.4 (4.0, 4.7)	6.3 (5.2, 7.4)[a]
Mean number of filled teeth	8.6 (8.2, 9.0)	8.5 (7.1, 9.8)
All combined	86.9 (85.3, 88.3)	13.1 (11.7, 14.7)

[a]$P < 0.05$

Individuals who were xerostomic had a higher mean DMFT score, with the difference in scores being mainly due to the missing teeth component of the DMFT. Those with more than one missing tooth were more likely to suffer from xerostomia, while a lower proportion of those with a functional dentition were xerostomic.

Summary data on xerostomia status are presented by periodontal status in Table 3.8.

Table 3.8 Periodontitis experience by xerostomia status (brackets contain 95% CI).

	Xerostomic?	
	No	Yes
Percent with 1 or more sites with:		
CAL 4+mm	49.4 (46.1, 52.7)	53.2 (44.2, 61.8)
CAL 5+mm	27.0 (24.5, 29.6)	31.6 (24.3, 40.0)
CAL 6+mm	12.3 (10.5, 14.5)	20.8 (14.8, 28.4)[a]
Mean percent of sites with:		
CAL 4+mm	5.3 (4.7, 6.0)	7.7 (4.9, 10.4)
CAL 5+mm	2.1 (1.6, 2.5)	3.5 (1.5, 5.5)
CAL 6+mm	0.9 (0.6, 1.2)	1.3 (0.7, 2.0)
All combined	86.9 (85.3, 88.3)	13.1 (11.7, 14.7)

[a]P< 0.05

A lower proportion of non-xerostomic individuals experienced periodontitis.

3.5 Self-reported oral health

Self-reported oral health data are reported by the "Locker" question and OHIP-14.

The Locker item responses data are presented by sociodemographic characteristic in Table 3.9.

Table 3.9 Locker item responses by sociodemographic characteristics (brackets contain 95% CI).

	How would you describe the health of your teeth and mouth?				
	Excellent	Very good	Good	Fair	Poor
Sex					
Female	10.2 (7.7, 13.3)	29.5 (25.3, 34.0)	36.5 (31.9, 41.3)	16.7 (14.2, 20.0)	7.0 (4.6, 8.7)[a]
Male	5.4 (3.6, 8.1)	26.3 (22.2, 30.9)	35.7 (31.2, 40.4)	23.9 (20.0, 28.2)	8.7 (6.2, 12.5)
Age group					
18-24	8.2 (3.7, 17.0)	25.4 (16.6, 36.8)	43.0 (32.4, 54.3)	14.2 (7.9, 24.2)	9.3 (4.3, 18.7)
25-34	7.1 (3.9, 12.4)	28.0 (21.3, 35.9)	36.5 (28.2, 45.7)	17.8 (12.9, 24.1)	10.7 (6.8, 16.5)
35-44	9.6 (6.3, 14.3)	30.3 (25.0, 36.2)	33.0 (27.7, 38.8)	21.5 (17.0, 26.8)	5.7 (3.9, 8.3)
45-54	7.3 (4.5, 11.8)	23.8 (18.7, 29.6)	31.1 (24.9, 38.1)	26.0 (20.8, 32.1)	11.8 (7.9, 17.2)
55-64	5.8 (2.9, 11.4)	30.5 (23.3, 38.7)	36.6 (28.7, 45.3)	21.9 (16.5, 28.6)	5.2 (2.8, 9.3)
65-74	8.6 (5.0, 14.3)	32.6 (25.1, 41.3)	38.7 (31.2, 46.8)	17.0 (11.8, 23.9)	3.0 (1.2, 7.3)
75+	10.6 (8.5, 13.2)	28.5 (24.9, 32.7)	37.7 (34.1, 41.3)	16.7 (13.8, 20.1)	6.6 (5.0, 8.5)
Ethnic group					
Māori	5.1 (3.5, 7.2)	20.3 (16.6, 24.6)	29.8 (25.1, 35.0)	30.9 (26.5, 35.7)	13.9 (10.9, 17.6)[a]
Pacific	4.8 (2.5, 8.9)	22.7 (17.2, 29.4)	35.3 (27.5, 43.9)	25.9 (19.0, 33.4)	11.8 (7.2, 18.7)
Asian	7.7 (3.9, 14.9)	24.4 (18.1, 32.1)	35.5 (27.1, 45.0)	26.8 (19.8, 35.2)	5.5 (2.5, 11.9)
European/Other	8.2 (6.5, 10.4)	29.2 (25.8, 32.9)	37.0 (33.3, 41.0)	18.3 (15.8, 21.1)	7.3 (5.6, 9.4)[a]
Deprivation quintile					
1 (least deprived)	11.2 (7.5, 16.5)	32.4 (25.5, 40.2)	36.1 (28.8, 44.0)	17.0 (12.3, 23.0)	3.3 (1.5, 7.3)[a]
2	9.1 (5.9, 14.0)	28.2 (22.2, 35.2)	34.8 (28.9, 41.2)	21.2 (16.7, 26.6)	6.6 (3.8, 11.4)
3	5.7 (3.4, 9.4)	30.7 (24.3, 37.8)	39.6 (33.0, 46.7)	17.5 (13.0, 23.2)	6.5 (3.8, 10.9)
4	6.9 (4.3, 10.7)	27.2 (21.3, 34.2)	37.6 (31.0, 44.7)	20.0 (15.2, 25.8)	8.3 (5.3, 12.6)
5 (most deprived)	5.9 (3.1, 10.9)	19.9 (15.0, 25.9)	32.1 (25.4, 39.7)	26.1 (20.5, 32.5)	16.1 (12.0, 21.1)
All combined	8.3 (6.7, 10.2)	27.8 (25.0, 30.9)	36.0 (33.1, 39.1)	19.8 (17.3, 22.5)	8.1 (6.6, 9.9)

[a]P< 0.05

More females than males described their oral health as excellent. Of the ethnic groups, a higher proportion of Māori than their European/Other counterparts reported their oral health as “fair” or “poor”.

Data on Locker item responses, dentition status and caries experience are shown in Table 3.10.

Table 3.10 Dentition status and caries experience by Locker item responses (brackets contain 95% CI).

	How would you describe the health of your teeth and mouth?				
	Excellent	Very good	Good	Fair	Poor
Dentition status					
Missing 1+ teeth (%)	51.3 (40.0, 62.7)	56.1 (50.4, 61.6)	62.3 (55.9, 67.8)	68.1 (61.6, 74.0)	79.4 (65.5, 88.7)[a]
Mean number of missing teeth	3.3 (2.3, 4.3)	3.8 (3.2,4.3)	4.5 (4.0, 5.0)	5.6 (4.7, 6.4)	7.0 (5.2, 8.7)[a]
Functional dentition (%)	94.9 (89.8, 97.5)	92.3 (88.8, 94.7)	89.5 (86.6, 91.9)	83.1 (78.3,87.0)	78.4 (68.0, 86.1)[a]
Caries status					
Mean DMFT	11.9 (9.9, 13.8)	13.1 (12.0, 14.2)	14.1 (13.1, 15.2)	15.7 (14.8, 17.0)	17.8 (15.8, 19.8)[a]
Mean number of decayed teeth	0.5 (0.14, 0.87)	0.4 (0.3, 0.5)	0.9 (0.8, 1.1)	1.6 (1.3, 2.0)	3.5 (2.4, 4.6)[a]
Mean number of missing teeth	3.3 (2.3, 4.3)	3.8 (3.2,4.3)	4.5 (4.0, 5.0)	5.6 (4.7, 6.4)	7.0 (5.2, 8.7)[a]
Mean number of filled teeth	8.0 (6.5, 9.6)	8.9 (8.1, 9.8)	8.7 (7.9, 9.5)	8.6 (7.9, 9.5)	7.3 (5.7, 8.9)

[a]$P < 0.05$

Individuals reporting “fair” or “poor” oral health had a higher mean number of missing teeth, contributing to a higher mean DMFT score. There were clear gradients in having a functional dentition, with almost all of those who described their oral health as “excellent” having a one, while 78.4% of respondents with “poor” self-reported oral health had 21 or more teeth.

Table 3.11 presents summary data on Locker item responses by combined attachment loss (CAL) and the extent of CAL.

Table 3.11 Periodontitis prevalence and extent by Locker item responses (brackets contain 95% CI).

	How would you describe the health of your teeth and mouth?				
	Excellent	Very good	Good	Fair	Poor
Percent with 1 or more sites with:					
CAL 4+mm	37.5 (27.9, 48.3)	47.1 (40.6, 53.7)	46.9 (41.4, 52.4)	60.0 (52.3, 65.3)	63.5 (51.5, 74.1)[a]
CAL 5+mm	18.2 (11.7, 27.2)	19.3 (15.2, 24.2)	27.2 (23.0, 31.9)	37.6 (31.7, 43.8)	42.3 (32.5, 52.8)[a]
CAL 6+mm	11.1 (5.9, 19.9)	7.8 (5.6, 10.8)	11.1 (8.5, 14.5)	20.3 (15.5, 25.9)	28.0 (19.4, 38.6)[a]
Mean percent of sites with:					
CAL 4+mm	3.6 (1.8, 5.4)	3.0 (2.4, 3.6)	5.2 (4.3, 6.2)	7.4 (5.9, 9.1)	13.6 (8.3, 18.9)[a]
CAL 5+mm	1.6 (0.1, 3.1)	0.8 (0.6, 1.1)	2.1 (1.5, 2.7)	2.9 (1.8, 4.0)	7.0 (3.4, 10.6)[a]
CAL 6+mm	1.1 (-0.3, 2.4)	0.3 (0.2, 0.4)	0.8 (0.5, 1.1)	1.3 (0.5, 2.2)	3.2 (1.6, 4.9)[a]

[a]$P < 0.05$

There were clear gradients across the Locker item response categories in both the prevalence and extent of attachment loss.

Table 3.12 presents data on the mean OHIP-14 score and prevalence of one or more OHIP-14 impacts by sociodemographic characteristics.

Table 3.12 Mean OHIP-14 score and prevalence of OHIP impacts, by sociodemographic characteristics (brackets contain 95% CI)

	Mean OHIP	1+ OHIP impacts
Sex		
Female	4.0 (3.7, 4.4)	19.0 (15.7, 22.7)[a]
Male	3.5 (3.0, 4.0)	12.7 (10.0, 16.0)
Age group		
18-24	3.8 (2.6, 4.9)[a]	16.3 (9.4, 26.7)
25-34	4.8 (3.8, 5.8)	16.0 (11.1, 22.6)
35-44	3.8 (3.1, 4.6)	13.9 (10.5, 18.3)
45-54	5.1 (4.2, 6.1)	21.7 (16.9, 27.4)
55-64	3.3 (2.6, 4.0)	13.0 (8.4, 19.6)
65-74	3.1 (2.2, 4.0)	13.2 (8.1, 20.6)
75+	3.4 (3.0, 3.8)	14.5 (12.1, 17.2)
Ethnic group		
Māori	6.3 (5.4, 7.2)[a]	22.7 (19.0, 22.7)[a]
Pacific	7.3 (5.6, 9.0)[a]	24.2 (17.7, 32.1)[a]
Asian	3.5 (2.7, 4.3)	15.8 (10.4, 23.3)
European/Other	3.8 (3.4, 4.2)[a]	15.0 (12.6, 17.8)[a]
Deprivation quintile		
1 (least deprived)	3.6 (2.8, 4.4)[a]	10.1 (6.6, 15.1)[a]
2	3.2 (2.5, 3.9)	13.9 (9.7, 19.5)
3	3.5 (2.7,4.3)	14.5 (10.4, 19.9)
4	3.8 (3.2, 4.5)	16.8 (12.9, 21.7)
5 (most deprived)	6.4 (5.2, 7.6)	26.9 (20.9, 33.9)
All combined	3.8 (3.6, 4.1)[a]	15.4 (13.7, 17.3)

[a]$P<0.05$

Females had both a higher mean OHIP score and prevalence of impacts than males. The age group with the highest mean OHIP score was the 45-54-year-olds, and one in five of them had experienced one or more oral health impacts. There are clear deprivation gradients in both mean OHIP score and impact prevalence, with the most deprived having the highest score and prevalence of impacts.

Summary data on dentition status and caries experience by prevalence of one or more OHIP impacts are presented in Table 3.13.

Table 3.13 Dentition status and caries experience by prevalence of no OHIP-14 impacts and one or more impacts (Brackets contain 95% CI).

	No OHIP impacts	1+ OHIP impacts
Dentition status		
Missing 1+ teeth (%)	59.4 (56.2, 62.6)[a]	76.0 (68.4, 82.2)[a]
Mean number of missing teeth	4.2 (3.8, 4.6)[a]	6.7 (5.8, 7.5)[a]
Functional dentition (%)	90.3 (88.1, 92.1)[a]	79.6 (74.1, 84.2)[a]
Caries status		
Mean DMFT	13.8 (13.2, 14.4)[a]	16.7 (15.4, 18.0)[a]
Mean number of decayed teeth	0.9 (0.8, 1.0)[a]	2.1 (1.6, 2.8)[a]
Mean number of missing teeth	4.2 (3.8, 4.6)[a]	6.7 (5.8, 7.5)[a]
Mean number of filled teeth	8.7 (8.3, 9.2)	7.9 (6.9, 8.8)

[a]P<0.05

Individuals who reported experiencing no oral health impacts were more likely to have a functional dentition and less likely to have missing teeth. The mean number of decayed teeth was a small contributor to the mean DMFT score of those who experienced one or more oral health impacts. The mean number of filled teeth was the highest contributor to the mean DMFT score of those experiencing no OHIP impacts.

The mean OHIP score for those missing one or more teeth was 4.7 (95% CI 4.2, 5.1); for those not missing any teeth, it was 3.0 (95% CI 2.5, 3.5; P <0.0001). The mean OHIP score for those with a functional dentition of 21 teeth was 3.8 (95% CI 3.4, 4.1); for those with fewer teeth, it was 6.2 (95% CI 4.9, 7.5; P <0.001)

Data on oral health impacts by periodontal status are shown in Table 3.14 and Table 3.15.

Table 3.14 Case definition for periodontitis by mean OHIP-14 score and prevalence of 1+ OHIP impacts.

	CAL 4+ mm		CAL 5+ mm		CAL 6+ mm	
	No	Yes	No	Yes	No	Yes
Mean OHIP	3.4 (2.8, 3.9)	4.6 (4.1, 5.2)[a]	3.6 (3.2, 4.1)	4.9 (4.2, 5.5)[a]	3.7 (3.3, 4.1)	6.0 (5.0, 6.9)[a]
Prevalence of 1+ OHIP impacts	12.8 (9.1, 16.4)	17.8 (15.0, 20.8)[a]	13.1 (10.3, 26.0)[a]	21.0 (16.3, 26.0)[a]	13.4 (10.7, 16.1)	27.6 (20.1, 35.7)[a]

[a]P< 0.05

There were clear gradients in both mean OHIP score and the prevalence of 1+ OHIP impacts across the three case definitions for attachment loss prevalence.

Table 3.15 The extent of periodontitis experience by the prevalence of no OHIP impacts and one or more impacts (brackets contain 95% CI).

	No OHIP impacts	1+ OHIP impacts
Mean percent of sites with:		
CAL 4+mm	4.8 (4.1, 5.5)[a]	10.0 (7.4, 12.5)[a]
CAL 5+mm	1.8 (1.4, 2.3)[a]	4.7 (3.1, 6.3)[a]
CAL 6+mm	0.7 (1.3, 3.5)[a]	2.4 (1.3, 3.5)[a]

[a]$P<0.05$

Individuals with the lowest extent of attachment loss experienced the highest prevalence of oral health impacts.

Summary data on Locker item responses by mean OHIP score and the prevalence of one or more oral health impacts are presented in Table 3.16.

Table 3.16 Locker item responses by mean OHIP and prevalence of 1+ OHIP impacts (brackets contain 95% CI).

	Mean OHIP	1+ OHIP impacts
How would you describe the health of your teeth?		
Excellent	1.4 (0.7, 2.1)[a]	3.3 (1.8, 6.4)[a]
Very Good	2.0 (1.7, 2.4)	12.3 (8.0, 18.5)
Good	3.0 (2.6, 3.4)	27.5 (22.3, 33.4)
Fair	5.7 (5.0, 6.5)	29.8 (25.1, 34.9)
Poor	12.9 (11.2, 14.7)	27.0 (22.1, 32.5)

[a]$P<0.05$

The highest mean OHIP score was reported by those respondents who described the health of their teeth as “poor”. The lowest prevalence of one or more oral health impacts was among those who answered “excellent” to the Locker question.

3.6 Self-reported oral health and xerostomia

Data on the xerostomia status of respondents by Locker item responses are shown in Table 3.17.

Table 3.17 Xerostomia status by Locker item responses (data are percentages, brackets contain 95% CI).

	Xerostomic
How would you describe the health of your teeth?	
Excellent	11.0 (6.7, 17.4)[a]
Very good	12.3 (9.3, 16.2)
Good	10.7 (8.4, 13.4)
Fair	16.4 (13.1, 30.8)
Poor	23.0 (16.7, 30.8)
All combined	13.1 (11.7, 14.7)

[a]P< 0.05

There was no clear gradient in xerostomia prevalence across the Locker item responses. The highest proportion of respondents who were xerostomic reported "fair" or "poor" oral health. Those who reported their oral health as "good" were the lowest proportion with xerostomia.

Summary data on xerostomia status by OHIP score and one or more OHIP impacts are presented in Table 3.18.

Table 3.18 Xerostomia status by mean OHIP score and 1+OHIP impacts (brackets contain 95% CI).

	Xerostomic?	
	No	Yes
1+ OHIP impacts (%)	13.9 (12.1, 15.8)	25.5 (20.4, 31.5)[a]
Mean OHIP	3.5 (3.2, 3.7)	6.3 (5.3, 7.5)[a]
All combined	86.9 (85.3, 88.3)	13.1 (11.7, 14.7)

[a]P< 0.05

Individuals who were xerostomic had a higher mean OHIP score and had a higher prevalence of one or more OHIP impacts.

3.7 Multivariate analysis

The logistic regression model for xerostomia by sociodemographic characteristics is presented in Table 3.19.

Table 3.19 Logistic regression model for xerostomia.

	OR[a]	95% CI for OR	P value
Female	1.6	1.1, 2.4	0.016
Age group[b]			
25-34	4.0	1.4, 11.5	0.011
35-44	2.0	0.6, 5.8	0.225
45-54	3.1	1.1, 9.0	0.036
55-64	2.8	0.9, 9.0	0.081
65-74	3.5	1.1, 11.0	0.034
75+	6.5	2.0, 20.9	0.002
Asian ethnicity	0.7	0.3, 1.3	0.221

[a]Odds Ratio
[b]Reference category 18-24

Females were more likely than males to be xerostomic. Individuals aged 75 years and over had over six times the odds of having xerostomia, while those between 25 and 34 years of age had four times the odds; age groups 45-54 and 65-74 years over three times the odds of being xerostomic. Asian ethnicity was not associated with xerostomia, despite having been so in the bivariate analysis.

The logistic regression model for oral health impacts by sociodemographic characteristics is presented in Table 3.20.

Table 3.20 Logistic regression model for the prevalence of OHIP impacts.

	OR[a]	95% CI for OR	P value
Female	1.9	1.3, 2.7	0.001
Age group[b]			
25-34	0.7	0.3, 1.6	0.434
35-44	0.7	0.3, 1.4	0.339
45-54	0.8	0.4, 1.6	0.464
55-64	0.3	0.1, 0.9	0.027
65-74	0.2	0.1, 0.5	0.001
75+	0.2	0.1, 0.7	0.009
Ethnic group[c]			
Māori	1.0	0.7, 1.4	0.944
Pacific	1.0	0.6, 1.7	0.944
Deprivation quintile[d]			
2	1.3	0.7, 2.5	0.462
3	1.2	0.6, 2.3	0.573
4	1.5	0.9, 2.8	0.144
5 (most deprived)	2.3	1.3, 4.1	0.003
Clinical variables			
Number of missing teeth	1.1	1.1, 1.1	<0.001
Number of decayed teeth	1.2	1.1, 1.2	<0.001
1+ sites with CAL 6+mm	1.8	1.1, 3.1	0.021
Xerostomia	1.1	0.6, 1.9	0.782

[a]Odds Ratio
[b]Reference category 18-24
[c]Reference category for each of these is everyone else
[d]Reference category deprivation quintile 1 (least deprived)

Individuals in the most deprived quintile were more likely to experience impacts, along with females and those with periodontal disease. Missing teeth and untreated decay were associated with impact prevalence. Those with xerostomia were not more likely to experience oral health impacts.

The outcomes of the logistic regression models for the prevalence of oral health subscale impacts are summarised in Table 3.21. Each model used the same covariates as in Table 3.20, but, for clarity, those data are not presented.

Table 3.21 Logistic regression model for prevalence of OHIP subscale impacts.

	OR for xerostomia cases[a] (95% CI)	P value
Functional limitation	2.2 (0.8, 6.0)	0.117
Physical pain	1.3 (0.7, 2.6)	0.370
Psychological discomfort	1.0 (0.5, 2.0)	0.911
Physical disability	1.1 (0.4, 3.2)	0.813
Psychological disability	1.9 (0.9, 4.1)	0.095
Social disability	1.9 (0.6, 5.9)	0.273
Handicap	1.9 (0.7, 5.0)	0.190

[a]Odds Ratio

Xerostomic individuals had over twice the odds of reporting experiencing functional limitations, which they were least likely to report psychological discomfort.

The binomial regression model for the mean OHIP score by sociodemographic characteristics is presented in Table 3.22.

Table 3.22 Negative binomial regression model for mean OHIP-14 score.

	IRR[a]	95% CI for IRR	P value
Female	1.4	1.1, 1.7	0.002
Age group[b]			
25-34	0.9	0.6, 1.5	0.819
35-44	0.8	0.5, 1.4	0.502
45-54	0.8	0.5, 1.3	0.455
55-64	0.6	0.3, 0.9	0.021
65-74	0.4	0.3, 0.7	0.002
75+	0.3	0.1, 0.6	0.001
Ethnic group[c]			
Māori	1.3	1.1, 1.6	0.003
Pacific	1.4	1.0, 1.8	0.033
Deprivation quintile[d]			
2	0.8	0.6, 1.1	0.196
3	0.9	0.7, 1.2	0.511
4	0.9	0.7, 1.2	0.518
5 (most deprived)	1.2	0.9, 1.7	0.209
Clinical variables			
Number of missing teeth	1.1	1.0, 1.1	<0.001
Number of decayed teeth	1.1	1.1, 1.2	<0.001
Percent with 1+ sites CAL 6+mm	1.3	1.1, 1.6	0.012
Xerostomia	1.5	1.1, 2.0	0.016

[a]Ratio of geometric means
[b]Reference category 18-24
[c]Reference category for each of these is everyone else
[d]Reference category deprivation quintile 1 (least deprived)

Xerostomia had the strongest association with the mean OHIP-14 score, followed by being female, Pacific Islander or Māori, and have periodontitis. The mean OHIP-14 score in xerostomics was 50% higher then in non-xerostomics after controlling for cofounders.

The negative binomial regression models for the mean OHIP subscale scores is summarised in Table 3.23. Only the estimates for xerostomia are presented.

Table 3.23 Summary of outcomes of negative binomial regression models for mean OHIP-14 subscale scores.

	IRR for xerostomia cases[a] (95% CI)	P value
Functional limitation	2.5 (1.5, 4.3)	0.001
Physical pain	1.2 (0.9, 1.6)	0.197
Psychological discomfort	1.3 (0.9, 1.8)	0.105
Physical disability	1.5 (0.9, 2.4)	0.097
Psychological disability	1.5 (1.1, 2.1)	0.025
Social disability	1.8 (0.9, 3.3)	0.075
Handicap	1.9 (1.1, 3.3)	0.027

[a]Ratio of geometric means; reference category = non-xerostomic individuals

The mean OHIP-14 subscale scores for xerostomic individuals were highest for functional limitation, handicap and social disability. The lowest mean score was for physical pain.

4. Discussion

The phenomenon of dry mouth in all its aspects (including epidemiological surveys) has been studied for many decades, particularly in Western Europe and the USA. However, surprisingly, as yet no epidemiological studies of xerostomia (the subjective perception of dry mouth) have been undertaken in nationally representative samples. The lack of such investigations and the emphasis of studies on older population subgroups (mostly convenience samples) means the current knowledge base can at best only provide prevalence estimates, suggest possible associations and postulate on the oral-health-related quality of life impacts of xerostomia at the population level.

This study is the first national study of the occurrence and associations of xerostomia in a representative dentate, community-dwelling adult population aged 18 years and above. The discussion of these findings will explore the implications of the prevalence, associations and oral-health-related quality of life impacts of xerostomia, commenting on whether xerostomia should be considered as a condition of consequence and whether it constitutes a public health problem. The possibility that xerostomia is an issue of public health importance will be considered, based on the findings in this study of a substantial occurrence of xerostomia, its association with clinical disease and xerostomia's strong association with poorer oral-health-related quality of life. In addition, based on the study findings and the current knowledge of xerostomia, some recommendations will be made to enhance the knowledge base and improve preventive and therapeutic approaches for the condition.

The data used in this study were collected as part of the 2009 National Oral Health Survey, which was conducted to take a snapshot of the oral health of New Zealanders. The particular data used included the sociodemographic characteristics, information from the clinical examinations, responses to Locker's single-item self-reported oral health question and a question on dry mouth, and the responses to the OHIP-14. The prevalence of xerostomia was 13%, or just over one in eight. The odds of experiencing xerostomia were highest in

individuals aged 75 years and over, and in those aged 25 to 34 years. Females were more likely than males to be xerostomic. Xerostomia had strong associations with the mean OHIP-14 score, being female, being Pacific Islander or Māori, and having periodontitis. Individuals with xerostomia were not more likely than the rest of the population to experience oral health impacts. Sociodemographic characteristics associated with impact prevalence were being in the most deprived quintile, female sex, or having periodontitis, missing teeth or untreated decay. However, xerostomia sufferers had a higher mean OHIP score than non-sufferers together with a higher prevalence of one or more oral health impacts. Xerostomic individuals were more likely to experience functional limitations, psychological disability and social disability.

4.1 Weaknesses and strengths of the study

On reflection, this study would have benefited from obtaining additional data. Information on medications and medical conditions would have broadened the findings, adding the ability to contribute to current knowledge of these known risk factors. The use of an individual-based socio-economic status measure, used to complement the NZDep 2006 measure, would have painted a more complete picture of socio-economic status in relation to xerostomia and quality of life. Including a measure of negative emotionality to collect data on the personality effect in self-reporting would perhaps have mitigated the known effects of personality on the estimates of poor oral health. The collection of whole saliva flow rates in a national representative sample would have added a great deal of value to this study and to the international knowledge base on dry mouth. The use of the XI or its shortened form would perhaps have given a more complete picture of xerostomia. Given that the source population was dentate New Zealanders, data on the use of partial dentures would have allowed for further investigation and comment on the effects of xerostomia in relation to this commonly-worn oral appliance. The ability to include these various aforementioned data in this research would have added value to the findings, contributing to the current body of knowledge on this condition and its natural history, risk factors and effects on the sufferers' quality of life. This constitutes a missed opportunity, given that, to

the best of the author's knowledge, this is the first such study on a representative national population sample.

The lack of inclusion of questions to determine the use of both prescribed and over-the-counter medications means that this study can add no information to the knowledge of this putative risk factor. A number of studies on medications associated with xerostomia have been conducted (Table 1.5). In addition, comparisons could have been made to the findings of other New Zealand studies, such as the DMHDS, which has reported on xerostomia and medications among 32-year-olds, most of whom still reside in New Zealand (Thomson et al 2006b). Because this study has no data on medications, there is no way to assess whether the use of medications had any influence on xerostomia occurrence and its associations. Additionally, an understanding of which medications (and combinations of those in conjunction with the sociodemographic characteristics) contribute to xerostomia would have been a valuable contribution to current understanding of this condition. This would also have added to knowledge of prevention and management of the condition, enhancing health professionals' ability to assist in preventing and/or improving a sufferer's day-to-day life.

Certain systemic medical conditions (such as Sj□gren's syndrome, diabetes mellitus or hepatitis C virus infection) have been found to cause xerostomia (Porter et al, 2004). The opportunity existed to collect these data when medical histories were recorded for the clinical examinations, but it was not taken. Information about participants who have these conditions would have created a clearer picture of the prevalence of subjectively felt dry mouth, as opposed to those whose dry mouth may have been due to the hyposalivation caused by their medical condition.

Measuring characteristics such as employment status, education level and household income as part of an individual-based household socio-economic measure would have been a valuable adjunct to the New Zealand 2006 deprivation index (NZDep 2006) which was used. The use of both approaches should have been considered because they complement each other, with individual-based measures linking to behaviours and opportunities and area-based ones relating to

circumstantial and environmental issues (Thomson and Mackay, 2004). An additional ability to analyse the data by household socio-economic status could have yielded important and informative findings given that the data available showed strong associations between being in the most deprived quintile and xerostomia, poor clinical oral health, poor self-rated oral health and poor oral-heath-related quality of life.

Finally, Thomson et al (2011d) suggested that, where practicable, research using self-reported oral health measures (such as the OHIP-14) should include a measure of negative emotionality, because self-reported measures may be somewhat compromised by particular personality traits. Because this research did not include any such measure, the prevalence and severity of poor oral health may be somewhat overestimated. However, it is not possible to determine the extent to which that may have occurred, and it is worth pointing out here that no other population-based study has done so to date.

Ideally, the use of sialometry (to measure unstimulated and stimulated whole saliva flow rates) and analysis of saliva composition as part of the clinical examination should have been considered. The contribution of informative data would have out-weighed the additional time and participant discomfort involved. The data could have assisted in answering such questions as: (a) how much saliva is enough; (b) does the composition of saliva influence the experience of xerstomia; (c) how do xerostomia and hyposalivation inter-relate; and (d) does xerostomia occur at any flow rate or is there a range of flow rates which is indicative of xerostomia? In addition, analysis of the relationships between salivary flow rates (and composition) and sociodemographic characteristics, oral health variables, medications, medical conditions, the global OHRQoL measure and the OHIP-14 would have painted a more comprehensive picture of xerostomia and its impacts in a national population sample.

However, it is worth noting that the study of xerostomia was not the principal focus of the NZOHS, and that the inclusion of sialometry and saliva composition analysis would have created additional complexities to what was already a considerable undertaking. In addition, flow rate is very difficult to measure

consistently, which brings into question whether the resulting data would have justified the time, expense and resources needed to obtain these data. Of necessity, a degree of pragmatism is exercised in research and compromises are made; this is no less true in large population studies such as the NZOHS, with researchers needing to stay true to the primary aims of the investigation and not be diverted by the many secondary areas of interest (such as xerostomia).

This study has been limited to dentate adults; however, consideration should have been given to the inclusion of data on the use of partial dentures. An individual was defined as dentate if he or she had at least one tooth and as having a functional dentition when 21 or more teeth were present. The mean number of missing teeth at 45 years of age was 6, and it was more than 13 at 75 years and older. The probability of these individuals wearing partial dentures would be quite high. Dry mouth (xerostomia or salivary gland hypofunction) does cause difficulty and discomfort when wearing a denture, and this may impact on OHRQoL (Guggenheim and Moore, 2003; Ship, 2004; Ikebe et al, 2005; Ikebe et al, 2007; Hopcraft and Tan, 2010; Thomson et al, 2011a).

The noteworthy strength of this study is that, to date, it is the first study of the prevalence, associations and impacts of xerostomia undertaken in a nationally representative sample of dentate adults. Although numerous population studies have been conducted over the last 30 years, all have used population subgroups; these have usually consisted of individuals aged 50+ and were mostly convenience samples (Table 4.1). Hence, the findings from this study of a representative population sample will make an invaluable contribution to xerostomia epidemiology. The inclusion of a dry-mouth question in this national survey and the reports on the resultant findings may encourage the use of a dry-mouth question in future national oral health surveys, both in New Zealand and internationally.

Another key strength of this study is the quality of the data used. The 2009 NZOHS produced quality data because of the care taken in the sample design, the choice of data instruments, and the use of a comprehensive, standardised data collection approach. The latter made use of professionally trained interviewers

and specially trained and calibrated dental examiners who were ably led, trained and guided by a lead examiner and a gold standard examiner. Similar care was exercised with processing the data and preparing the data-set for use by researchers. The end-result was a very "clean" and complete data-set for analysis.

The comprehensiveness of the data set has enabled the inclusion of accurate clinical data in the analysis of xerostomia's occurrence and associations. The ability to combine prevalence data with the associations and oral-health-related quality of life information in this national representative sample of dentate adult New Zealanders, has allowed a picture to emerge of xerostomia as a health condition of some consequence in the population.

Participants in the 2009 NZOHS were recruited from the re-contact database of the 2006/7 NZHS. Consequently, because the participants had been involved in one health survey, they should have been aware of the importance of accurate responses. In addition, the use of trained interviewers to gather self-reported data (rather than the use of self-completed questionnaires) increased the likelihood of collecting dependable data (Shearer et al 2011). All of these factors will have contributed to the validity of the self-reported information collected.

The use of the two types of OHRQoL measure (Locker's global measure of oral-health-related quality of life and the multi-item OHIP-14) in conjunction with the dry mouth question augmented the validity of the data collected. The global measure summarises people's perceptions of oral diseases and disorders and their impact on functioning and well-being, whereas the OHIP-14 measures the impacts of a person's general oral condition. The OHIP-14 has been validated in a number of different cultures and age groups (Thomson et al, 2006a), while the use of Locker's global measure and the dry mouth question have been reported on in a number of different studies, thereby adding to their validity and allowing for comparison of the findings.

Additionally, the similarities between the 2009 NZOHS and the Australian National Survey of Adult Oral Health 2004-06 should allow for further research

and comparisons to be made between these two populations, adding to the value and validity of this study.

In summary, the inclusion of a dry mouth question as part of a well-designed and conducted national oral health survey has yielded a complete and trustworthy data-set for analysis. The findings of this study (not withstanding its limitations and weaknesses) will add to the understanding of the occurrence and sequelae of xerostomia at a population level.

4.2 The findings of this study

4.2 a) Xerostomia prevalence and associations

The prevalence of xerostomia in this study was 13%. The generally reported prevalence rate quoted in the literature is 20% (Thomson, 2005; Hopcraft and Tan, 2010; Thomson et al 2011a). The range of prevalence rates reported is 10 to 25%. In view of this, the 13% rate in the adult community-dwelling dentate population lies at the lower end of this range and over 6% below that of the internationally reported rate. This might suggest that the generally reported rate is too high. However, to date, this is the first rate reported for a national population sample. Hence, caution needs to be exercised when comparing these findings to those of other studies. All the other reported studies were undertaken on population subgroups (Table 1.8), mainly groups of older persons, due to the prevailing assumption that xerostomia predominately affects elders. In addition, reports from these studies did not include information as to whether participants were dentate or not, with the exception of the DMHDS report on 32-year-olds (Thomson et al, 2006b). The majority of studies have focused on older population groups aged from 50 years, while a Swedish study assessed 1427 people between the ages of 20 and 69 (Bergdahl and Bergdahl, 2000). The prevalence of xerostomia in younger age groups (20-year-olds; 30-year-olds and 32-year-olds) has been investigated by two research groups (Nederfors et al, 1997; Thomson et al, 2006b).

Although prudence has to be exercised when comparing findings, some questions arise as to why the prevalence rates are so different. These include: (a) is the difference due to the use of a nationally representative sample of adults aged 18+ years; (b) does the formulation, content, orientation and participant understanding of the dry mouth question influence the reporting of xerostomia; and (c) does the age of the participant influence how the question may be understood and answered?

Because xerostomia is a subjective sensation, its experience is personal and likely to vary according to the individual's age, gender, ethnicity, personality and socioeconomic circumstances, as well as the manner in which questions and response options are worded and understood. Certainly, other researchers have commented on these factors influencing the findings of research into self-reported health (Locker and Gibson, 2006; Orellana et al, 2006; Nederfors, 2000; Thomson et al, 2011d, Slade and Sanders, 2011).

Consideration also needs given to the wording of the "dry mouth" question (Table 1.8), its response options and the case definition for xerostomia. How the respondent understands and interprets the content and orientation of the question and response options undoubtedly influences the response given; this, in turn, affects the validity of the response (Thomson et al 1999a). The problem with asking a question is that it begs an answer, and survey respondents will often provide answers even if they do not understand the question or the response option, or the question has little relevance to them (Locker and Gibson, 2006).

The meaning of responses to apparently simple questions is often complex and contradictory; answers sometimes need elaboration for respondents to better appreciate their meaning (Locker and Gibson, 2006). The response options for the dry mouth question are a case in point, particularly because the case definition for xerostomia is dependent on dichotomising the options. The response options to the question (How often does your mouth feel dry?) used in this study were "Never", "Occasionally", "Frequently", "Always", "Don't know" and "Refused". The case definition used for xerostomia was "Frequently" and "Always", and was therefore dependent on the distinction between "Occasionally" and "Frequently".

However, the unknown factor is whether every participant understood that the words “Occasionally” and “Frequently” were used and intended to be understood as “seldom” and “repeatedly”. Clearly, if a lack of distinction for some respondents meant that some people’s “Occasionally” was other people’s “Frequently”, this would have affected the prevalence estimate. Sreebny and Valdini (1988) suggested that prevalence estimates for xerostomia were influenced by the wording of questions. However, Nayak et al (2004) in a cross-sectional postal questionnaire xerostomia survey of 1000 randomly selected adults aged 60+, used focus groups to develop their questionnaire. It included the aforementioned dry mouth question (referred to by the authors as a “gold standard” dry mouth question). Although Nayak et al commented that, because xerostomia is a subjective complaint, the interpretation of it may vary from participant to participant (with different social backgrounds), their prevalence estimate (15.5%) was similar to this study’s finding of 13.1% and they made no mention of possible misinterpretation of the response options to the dry mouth question. The similarity between this study’s prevalence estimate and that reported by Nayak et al (2004) illustrates the usefulness of using the same dry mouth question and of assessing dry mouth in a randomly selected sample. In addition, the similarity between the two estimates raises the possibility that they represent a more accurate reflection of xerostomia prevalence.

Table 4.1 compares the prevalence rates from this study and those from other population based studies. The rates shown are total population rates, as well as a breakdown by age and sex. The table illustrates the various subgroups studied since 1984 (including the current study). It is worth noting that the majority of the studies used different methodologies, diagnostic criteria and convenience samples, therefore caution needs to be exercised when comparing these studies. The overall prevalence estimates range from 8% to 39%. All the studies reported a sex difference in prevalence rates, with females more likely to experience xersotomia. The breakdown of prevalence estimate by age demonstrates that xerostomia research has been undertaken predominately in groups aged 50+, how the age groups used show no uniformity for ease of comparison and how few studies have investigated the condition across all adult age groups. The prevalence estimates

by age group are quite varied; however, there is an indication that xerostomia is a condition which affects younger adults as well as those over 50 years of age.

Table 4.1. Comparison of prevalence estimates for xerostomia

Author and year	Population	Overall prevalence (%)	By gender (%)		By age group (%)	
			Male	Female	Age group	Prevalence
Benn, 2012 (present study)	New Zealanders aged 18 to 75+; n = 2209	13.1	10.4	15.6	18-24	5.0
					25-34	17.1
					35-44	9.5
					45-54	14.2
					55-64	12.8
					65-74	16.0
					75+	26.0
Smidt et al, 2011	Danish aged 65 to 95 years; n=668	12.3	7.2	15.9	65-95	12.3
Johansson et al, 2009	Swedish 50, 55, 60, 65 years of age; *n* =4714				50	6.0
					60	15.0
Ikebe et al, 2007	Japanese aged 60+; *n* =287	8.3			60-81	8.3
Thomson et al, 2006b	New Zealanders aged 32; *n* =923	10.0	9.7	10.3	32	10.0
Nayak et al, 2004	British aged 60+; n = 770	15.5	10.6	18.1	60-85	15.5
Jannson et al, 2003	Swedish females aged 53 to 54 years; *n* =1180	16.0		16.0	53-54	16.0
Bergdahl et al, 2000	Swedish aged 20 to 69;*n* = 1427	22.0	14.9	28.2	20-69	22.0
Thomson et al, 1999b	South Australians aged 60+; *n* =700	21.0	17.3	24.1	65-69	20.1
					70-79	20.1
					80+	21.5
Hochberg et al, 1998	Americans aged 65 to 84 years; *n* = 2520	17.2	13.2	20.1	65-69	14.1
					70-74	17.6
					75-79	18.3
					80-84	21.5
Antilla et al, 1998	Finnish aged 55; *n* = 780	30.0	25.8	33.3	55	30.0
Pujol et al, 1998	Spanish aged 18 to 65+; n = 268	9.7	6.2	13.0	18-34	5.3
					35-64	7.3
					65+	18.2
Nederfors et al, 1997	Swedish aged 60+; *n* = 1424	28.5	23.1	28.3	20	19.3
					30	17.7
					40	20.4
					50	22.1
					60	32.2
					70	33.3
					80	35.7
Narhi et al, 1994	76-, 81- and 86-year-old Finns; *n*=368	12.0	6.0	14.0	76, 81, 86	12.0
Locker, 1993	Ontario residents aged 50+; *n*=907	17.7	13.8	20.7	50-64	17.7
Gilbert et al, 1993	Florida residents aged 65+; *n* = 600	39.0			65+	39.0
Osterberg et al, 1984	70-year-old Swedish; n = 973	20.0	16.0	25.0	70	20.0

In the current study, logistic regression analysis showed that, after controlling for the effects of confounding variables, being female or aged between 25-34, 45-54, 65-74 and 75+ were independently associated with xerostomia. The binomial regression analysis showed that the strongest associations with xerostomia were OHRQoL (represented by the mean OHIP-14 score), being female, Pacific Islander or Māori, or having periodontitis.

Females had higher odds of experiencing xerostomia than males. These findings are consistent with other reports (Orellana et al, 2006; Thomson et al, 2006b; Smidt et al, 2011). The reasons for the sex difference remain unclear. Possible explanations suggested in the literature include a decrease in salivary flow rates after menopause and that xerostomia may develop at different rates in males and females (Narhi, 1994; Johansson et al, 2009). The scarcity of longitudinal research on xerostomia is an impediment to elucidating this aspect of the condition. Further quantitative and qualitative research into gender differences is needed to clarify this issue.

The 75+ age group had the highest prevalence (of 26%), which accords with other researchers' findings, as does the age gradient of greater prevalence from age 55 onwards. Additionally, the current study found that individuals from 45 years old had over three times the odds of reporting xerostomia. Furthermore, it was noteworthy that the 25-34 age group had the second highest rate (17.1%) with four times the odds of being xerostomic, while the next highest rate was nearly half that (9.5%) for the 35-44 group with twice the odds. The only other research conducted with people in their thirties studied 32-year-olds and found a prevalence rate of 10%, which is more in accordance with this study's 35-44 year group than the 25-34 age group (Thomson et al 2006b). The difference in the prevalence rates may be due to the fact that the participants in the DMHDS have been part of that prospective longitudinal study all their lives. This long-term relationship with the researchers would have built trust and respect and imbued in the participants an awareness of the need for accurate responses. The one study (Nederfors et al, 1997) reporting on a similar age range to this one found consistently higher prevalence rates across the age groups, but also for the entire sample (Table 4.1). The latter study used different methodology and a different

dry mouth question to both the current study and DMHDS possibly accounting for the variation in prevalence rates reported. The findings of the current study add further evidence to the assertion that xerostomia is not a disorder which only affects older people. Because few studies have included people aged 18 to 50 years, little is known about the occurrence of xerostomia (and its associations and sequelae) in younger adults. There is therefore a need to investigate all aspects of this condition in people under the age of 50. The DMHDS research (if the researchers continue to monitor xerostomia) could add valuable information to knowledge base of xerostomia through the life course and its natural history.

The WHO pathfinder age groups (of 35-44 and 65-74 years) had prevalence rates of 9.5% and 16% respectively. The 35-44 prevalence rate was slightly over half of the internationally reported rate of 20%, and less than the prevalence rate of 13% for the entire sample. The 65-74-year-olds' rate was 4% below the 20% and was marginally higher than the combined rate. The current research is the first to report on xerostomia specifically using age groups which correlate to the WHO pathfinder age groups, indicating a need for global consensus to use these age groups in future research to construct a internationally comparable knowledge base.

This is the first study, to date, to report on ethnic differences in xerostomia experience. The majority of studies have investigated sub-population groups in Europe and the USA and have not reported ethnic differences. People of Pacific Island or Māori heritage were significantly more likely than others to experience xerostomia. The ethnic group least likely to experience xerostomia was Asian people whose prevalence rate was 8.1%. Ikebe et al (2007) reported a rate of 8% in a Japanese sample; this is the only other report of xerostomia experience among Asian people. Notably, Ikebe at al used a large convenience sample raising doubts about the generalisability of their prevalence estimates. Moreover, the connection between the sub-population of Japanese and the Asian sub-population in the current study is rather tenuous, because the current study subgroup comprises a number of different Asian peoples.

The findings of this study suggest that xerostomia prevalence is higher in the most deprived sectors of the New Zealand population; however, while there was a difference by deprivation status, the gradient was not consistent. Locker (1993) reported that xerostomia was more common in low-income individuals (measured by dollars earned per annum). The current study did not collect data on individual incomes or household socioeconomic status; socioeconomic data were collected using an area-based measure of socioeconomic status. The NZDep type of measure has the limitation of possibly misclassifying individual socioeconomic status (because many deprived people do not live in deprived areas). Hence, "most deprived" and "low-income" cannot be assumed to be synonymous; therefore, any direct comparison between the two studies' findings is not possible.

Xerostomia was measured in this study using self-reporting. Because no sialometry was done, objective evidence of low salivary flow was not available. Hence, it was not possible to separate the sample into those whose xerostomia was associated with salivary gland dysfunction and those who had normal glandular function. Consequently, any association between xerostomia and clinical indicators of poor oral health (such as tooth loss and periodontitis) needs to be considered with caution. Nevertheless, some authors have suggested that oral discomfort due to xerostomia leads to altered eating and drinking behaviours which are detrimental to oral health (Guggenheim and Moore, 2003; Thomson et al, 2002; Hopcraft and Tan, 2010; Thomson et al 2011a).

4.2 b) Xerostomia and clinical oral disease

Analysis of the clinical variables showed periodontitis to be strongly associated with xerostomia. In addition, an association was found with missing teeth and untreated decay. No association was found between xerostomia and filled teeth. In comparison, Locker (1993) reported that xerostomics had more decay and fewer teeth but no higher rate of periodontitis. Xerostomia may lead to altered behaviours which, in turn, may be risk factors for poor oral health (Fig 1.1), and this may account for the association of xerostomia with missing teeth and untreated decay. These altered behaviours may also have had an impact on

periodontal health; on the other hand, the strong association of periodontitis with xerostomia may have been due to the loss of some of the protective functions of saliva. Because no salivary flow rates were measured nor any analysis made of saliva composition, no comment can be made on whether xerostomia's association with clinical disease may have been due to lower saliva volumes or differences in saliva composition. Further investigation into the relationship between clinical indicators of oral health, xerostomia and the quality and quantity of saliva would be of great value in understanding the condition and its sequelae.

4.2 c) Xerostomia and OHRQoL

Xerostomic individuals reported nearly twice the prevalence of oral health impacts and nearly double the severity of oral health impacts (reflected in the mean OHIP-14 score) than non-xerostomic individuals. Xerostomia had a strong association with the mean OHIP-14 score (after controlling for confounders such as sociodemographic characteristics and indicators of poor oral health), but xerostomics were not more likely to experience one or more oral health impacts. The higher severity of oral health impacts is consistent with the view, expressed in the literature, that xerostomia has the potential to negatively affect sufferers' quality-of-life (Locker, 2003; Thomson et al, 2006a; Folke at al, 2009).

Xerostomia sufferers' quality of life was most affected by speech problems, being unable to taste their food, finding they were unable to function and were generally dissatisfied with their lives. Additionally, complainants were embarrassed and had difficulty relaxing, and found usual chores problematic and were irritable with others. In contrast, suffers were unlikely to report being affected by aching or pain in the oral cavity. Locker (1993), Nayak et al (2004), Thomson at al (2006a) and Folke et al (2009) all reported similar findings. These findings paint a picture of aggregated misery, illustrating that xerostomia is not a trivial condition for those afflicted by it. The picture is of a chronic and distressing disorder which impacts on oral and general health affecting daily life and wellbeing.

Poorer oral-health-related quality of life was also found to be associated with being female, Pacific Islander or Maori and clinical indicators of poor oral health (missing and decayed teeth, and periodontitis). Although it is understood that innate cultural perceptions, values and expectations of oral health and life quality influence the understanding and responses to questionnaires, how these associated covariates and the aspect of personality characteristics may have affected the study findings is not known (Steele et al, 2004; Tsakos et al, 2011; Sischo and Broder, 2011). OHRQoL is considered to be a multidimensional construct which encompasses biological, social, psychological and cultural dimensions, and represents a person's subjective perspective of their various symptoms and experiences. Hence, this subjective evaluation would naturally include the effects of environmental or contextual factors (such as sociocultural factors, education and family structure), and expectations and satisfaction with respect to oral health. This complex area is in much need of further qualitative and quantitative investigation to clarify the issues.

It is noteworthy that self-reported oral health (measured in this study by Locker's single-item global measure) was found to be associated with xerostomia, with the majority of xerostomics reporting "fair" or "poor" oral health (Table 3.17). There was, however, no clear gradient across the item responses, and those reporting "good" oral health had the lowest proportion with xerostomia (rather than those with excellent oral health). In addition, a clear gradient was observed in mean OHIP-14 score across the response categories of the self-reported oral health global measure, with the highest severity score reported by those with "poor" oral health. Those who described the health of their teeth as 'good", "fair" or "poor" had the highest prevalence of one or more OHIP-14 impacts. These findings validate the use of the OHIP-14 as a measure to determine whether and how xerostomia affects the daily lives of sufferers. This is consistent with the findings of Baker et al (2006) in their paper on the utility of the OHIP-14 as a measure of OHRQoL in xerostomia. Baker et al assessed the performance of the OHIP-14 and OIDP (Oral Impacts on Daily Performance), in a sample of xerostomia sufferers, in relationship to clinical indicators (salivary flow, dry mouth signs and salivary gland condition), the Xerostomia Inventory, speech function, Locker's global oral health rating and psychological well-being. They reported that the

OHIP-14 had good psychometric properties, with significant criterion validity against the global oral health measure and was a useful measure of ORHQoL in xerostomia.

In addition, the findings underscore the importance of including both a single-item global measure and a multi-item scale in any survey (as suggested by Tsakos et al, 2011), particularly because the OHIP-14 scores are derived from individuals who may have very different response profiles. Because people are individual, their responses are particular to their perception of their lives, and therefore they will construct distinctive response profiles. Consequently, when individuals give responses to the OHIP-14 questions, different responses can result in the same summated OHIP-14 score. For example, OHIP-14 items are scored 0 to 4 (Never = 0, Hardly ever = 1, Occasionally = 2, Fairly often = 3, Very often = 4), a participant who responded "Hardly ever" to the 14 items would be given a score of 14 and someone who responded "Fairly often" to two items, "Very often" to two items and "Never" to ten items would also score 14. Hence, a specific score can not be taken to mean the same for each of these individuals, as the profile of these participants in terms of performing daily activities was very different. However, they are treated the same for analytic purposes despite having different response profiles.

4.3 Does xerostomia matter?

This research has shown that xerostomia is a condition which is relatively common in dentate adult New Zealanders aged 18 through to 75+. Those mostly likely to be affected are females, older people aged from 45 years and, strikingly, those aged from 25-34. In addition, xerostomia was strongly and independently associated with poor oral-health-related quality of life. The aspects of oral-health-related quality of life which xerostomia sufferers felt most acutely were functional, psychological and social. Functionally, complainants experienced problems communicating as a result of difficulties with pronunciation and poorer sense of taste. The condition was debilitating enough to create difficulties in day-

to-day living and resulted in irritability, embarrassment, tension and a general dissatisfaction with life (in the average xerostomia sufferer).

Even though health is a subjectively perceived state and xerostomia is a subjective condition, it is evident from these findings that xerostomia is not an inconsequential complaint. This study supports the assertion that xerostomia does matter, because it does indeed compromise well-being and life satisfaction through its functional and psychosocial effects.

4.4 Is xerostomia a clinical and/or public health problem?

In order to assess whether the xerostomia condition constitutes a clinical and/or public health problem, there is a need to consider what might represent health for a society and health for an individual. The accepted definitions of general health and oral health are those of the World Health Organization (1948) and Locker (2001) respectively. The WHO definition states: "health is the state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (Last, 2001), while Locker's definition of oral health states: "a standard of the oral tissues which contributes to overall physical, psychological and social well-being by enabling individuals to eat, communicate and socialise without discomfort, embarrassment or distress and which enables them to fully participate in their chosen social roles". Additionally, the criteria suggested by Burt and Stephen (2005) that would define xerostomia as a public health problem are; firstly that xerostomia is a widespread actual or potential cause of morbidity (diseased state or symptom) and secondly that there is a perception by the public, the state or public health professionals that xerostomia is a public health problem. Therefore, for xerostomia to be considered a public health problem, it would need to be at least moderately prevalent in the general population. Indeed, given that the survey estimates from this study represent 2 965 292 New Zealand adults, the 13% prevalence estimate implies a total of 385 488 affected adults (slightly more than population of Christchurch, New Zealand[a]). This implies that a substantial

[a] www.stats.govt.nz

number of people would be affected by the complaint and its sequelae. Also, the condition might disproportionately affect certain groups within that population. The complaint would also need to affect society in general via its cumulative economic and social costs to citizens (and hence to the nation).

The findings of this study, in line with the published literature, show that xerostomia is a debilitating condition which impacts on the everyday functioning, health and well-being of the sufferer. Hence, when applying the principles embodied in the two definitions of health and the definition of a public health problem, it is possible to assert that xerostomia is an important widespread ailment which results in the sufferer experiencing less than optimum health. The prevalence estimate from this representative national sample of dentate adult New Zealanders indicates that a substantial number are living with the chronic condition of xerostomia. This impacts on their quality of life and their psychosocial functioning. Additionally, these same people tend to describe their general oral health as “poor” or “fair”. Xerostomia disproportionately affects particular groups within the New Zealand population. These include Māori and Pacific Islanders, individuals aged 45 years and above as well as those between 25-34 years and those who are most economically deprived. Consequently, xerostomia can be considered to be a serious and important public health issue in dentate New Zealand adults, with concerning medical, dental and social implications. The findings of the current research will make a valuable contribution to assisting to raise the awareness of the public, government and public health administrations to the chronic debilitating misery that is xerostomia and its widespread occurrence in adult New Zealanders.

In summary, it is remarkable that, after decades of scientific research into the phenomenon of xerostomia, this is the first epidemiological survey of xerostomia in a representative national sample of community-dwelling, dentate adults. This study has investigated the prevalence, associations and impacts of xerostomia, finding a sizable occurrence and strong sociodemographic and clinical associations, in addition to a strong, independent association with poorer oral-health-related quality of life. These findings indicate that xerostomia is a matter for concern and can be considered to constitute an important public health issue.

4.5 Conclusion

This research has found that xerostomia is a considerable problem for New Zealanders of all ages, particularly those older than 45 (and, strikingly, those aged between 25 and 34 years). The condition predominantly affects females, Māori and Pacific Islanders and those with periodontitis. The findings indicate that there can be little doubt that xerostomia affects sufferers' oral-health-related quality of life by limiting oral function and affecting their psychosocial well-being.

4.6 Recommendations

A number of recommendations arise from these findings. These are listed below.

1. Future national oral health surveys in New Zealand should continue to include a dry mouth question, a global oral health measure and OHIP-14 and consideration given to the inclusion of the Xerostomia Inventory or its shortened form. In addition, data should be collected on medications, medical conditions, household socio-economic status, personality characteristics and the use of partial dentures.
2. A concerted effort should be made to develop internationally accepted definitions for xerostomia, hyposalivation and dry mouth. This should also include standardising protocols for collecting and reporting data. Global consensus would enable diagnosis of these conditions, improve the generalisability of research findings, and facilitate communication between researchers.
3. Further research should be undertaken to explore the following areas:
   a) Population-based studies in different ethnic and cultural groups;
   b) Studies of the condition in younger age groups;
   c) Medical, dental and social interdisciplinary causes and effects of xerostomia;
   d) Qualitative research to explore sufferers' perceptions and attitudes with respect to oral health, oral health care, quality of life and xerostomia (with particular emphasis on validating appropriate response options for a standard question);

e) The natural history and the experience of xerostomia during the life course; and

f) Research into appropriate preventive and therapeutic strategies for xerostomia.

4. Raise awareness within the medical and dental professions of the seriousness and consequences of xerostomia to improve their knowledge of all aspects of the condition, thereby ensuring that they have the confidence to provide appropriate and effective clinical management.

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Appendix 1

Questions extracted from the Adult Questionnaire 2009 New Zealand Oral Health Survey for analysis.

Module 4: Assessment of general oral health status [all adults]

OHSA_Q12. How would you describe the health of your teeth or mouth?

Showcard Q12: Module 4

1 Excellent
2 Very good
3 Good
4 Fair
5 Poor
98 Don't know
99 Refused

Module 5: Orofacial pain/symptoms [all adults]

OHSA_Q23. How often does your mouth feel dry?
(Interviewer note: Dry mouth – lack of saliva)

Showcard Q23: Module 5

1 Never
2 Occasionally
3 Frequently
4 Always
98 Don't know
99 Refused

Module 6: OHIP-14 [all adults]

"The next set of questions is designed to look at how oral health affects a person's day to day life. These questions ask about your teeth and mouth over the last 12 months."

Q.24-Q.37 In the last 12 months…

INTERVIEWER NOTE: Please reiterate throughout that these questions pertain to the **"over the last 12 months"**.

OHSA_Q.24: Have you had any trouble PRONOUNCING ANY WORDS because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.25: Have you felt that your SENSE OF TASTE has worsened because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.26: Have you had PAINFUL ACHING in your mouth?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.27: Have you found it UNCOMFORTABLE TO EAT ANY FOODS because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.28: Have you been SELF-CONSCIOUS because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.29: Have you FELT TENSE because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.30: Has your DIET BEEN UNSATISFACTORY because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.31: Have you had to INTERRUPT MEALS because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.32: Have you found it DIFFICULT TO RELAX because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.33: Have you been a bit EMBARRASSED because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.34: Have you been a bit IRRITABLE WITH OTHER PEOPLE because of problems your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.35: Have you had DIFFICULTY DOING YOUR USUAL JOBS because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.36: Have you felt that life in general was LESS SATISFYING because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused

OHSA_Q.37: Have you been TOTALLY UNABLE TO FUNCTION because of problems with your teeth, mouth or dentures?

Showcard question numbers 24-37: Module 6

1 Never
2 Hardly ever
3 Occasionally
4 Fairly often
5 Very often
98 Don't know
99 Refused