Dental caries, tooth wear and dietary sugar intake in a sample of Northland Māori.

Caleb Lawrence

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Supervisors:
Professor Mauro Farella
Dr Joseph Antoun
De Louise Mainvil
Dr Li Mei
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Abstract

Background
In New Zealand, there are well known disparities in oral health between different ethnicities and groups with different socioeconomic status.

It has been recently shown that Māori are 1.8 times more likely to be higher daily consumers of sugar-sweetened beverages and food (SSB and SSF) in comparison to their European counterparts. Excessive intake of dietary sugar as well as carbonated drinks can have consequences on oral health, such as caries and tooth wear, but also broader implication for overall health.

The aims of this study were: 1) to describe self-reported oral hygiene, caries experience, tooth wear and dietary sugar intake in a Northland Māori sample; and 2) to investigate for possible associations between dental health and consumption of SSB/SSF. As whanau ora is an important aspect of Māori health, families were investigated as a unit.

Methods
A pilot study was designed as cross-sectional, family aggregation study. Forty-three Māori families (41 parents and 90 children) residing in Northland, New Zealand were recruited from three primary health care services. The study participants were firstly asked to fill in a questionnaire on self-reported oral hygiene, dental health, jaw habits, dental care service utilisation, and sweet beverages and food frequency consumption. Participants underwent a clinical dental examination, received an intraoral scan, and finally provided a hair sample for an objective measure of dietary sugar consumption ($^{13}$C). Oral hygiene was measured using Greene’s simplified oral hygiene index (OHI-S). Dental caries experience was assessed using the Decayed Missing Filled Teeth Index (DMFT/dmft), while tooth wear was assessed by the Basic Erosive Wear Examination (BEWE). Data were analysed by a mixed model with DMFT/dmft and BEWE as response variables, adjusted for gender, OHI-S, and family member
(parent versus child), and family cluster as random effect. Family pattern were investigated using intraclass correlation coefficients and scattergrams, as appropriate.

Results
Some 95% of study participants lived in an area with high deprivation scores (NZDep=8-10), and about half of the parent sample reported an inability to see a dentist. Self-reported caries experience was high in parents, as the vast majority of them received dental restorations (90.2%) and tooth extractions (65.9%). Children reported brushing their teeth and having greater access to dental care services more often than parents. Tooth clenching/grinding were self-reported by over 30% of the parents and children samples, while almost 90% of them reported snacking between meals (i.e. grazing). Oral hygiene was fair in both parents and children (Mean OHI-S levels ≤ 1.3). The mean DMFT/dmft (± SD) for parents and children were 9.8 (± 5.6) and 2.3 (± 2.1), respectively. Tooth wear levels were mostly confined to enamel in both parents (BEWE=6.3 ± 2.3) and children (4.3 ± 2.7). Oral hygiene, as represented by OHI-S, was significantly associated with both DMFT/dmft (IRR=1.39; P=0.006) and BEWE scores (P=0.028). Sugar intake, as represented by SSB, SSF, and $^{13}$C hair content, was not significantly associated with DMFT/dmft and BEWE scores. Weak family patterns were identified for both caries experience and erosion (ICC ≤ 0.23).

Conclusion
The small investigated sample had high deprivation scores and modest-to-low oral health. Caries experience and tooth wear were significantly associated with oral hygiene, but not with dietary sugar intake. A larger sample is needed to confirm this result. It is evident that oral health disparities still exist in New Zealand, and also affect Māori.
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Preface

This three-year Doctoral Thesis was completed as partial fulfillment of the Degree of Clinical Dentistry. The thesis describes the research conducted in the Department of Oral Sciences, Discipline of Orthodontics, University of Otago, New Zealand. It contains work conducted between January 2016 and August 2018.

An abstract for this study was accepted for presentation at the Sir John Walsh Institute Research Day, August 2018.

C. Lawrence, L. Mainvil, J. Antoun, L. Mei, M. Farella. Dental caries, tooth wear and dietary sugar intake in a sample of Northland Māori.

The candidate was responsible for:

- Development of the study concept and design in conjunction with his supervisors
- Consulting with the University of Otago Human Ethics Committee regarding ethics protocol
- Completing the ethics and Māori consultation process
- Applications for funding
- Application for an intraoral scanner
- Liaising with the health providers
- Liaising with the University of Otago Human nutrition department
- Supervision of University of Otago, Dietetic student
- Recruitment of participants for the study
- Actively recruited within the community
- Assisted in questionnaire distribution and collection
- Conducted clinical measures oral hygiene and DMFT/dmft
- Conducted the intraoral scans of the dentition
- Measurement of DMFT and BEWE index off 3D rendered models
- Analysing data with the assistance of Prof M. Farella and Dr C. Cameron
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<th>Full Form</th>
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<tr>
<td>$\delta^{15}\text{N}$</td>
<td>Delta 15 Nitrogen</td>
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<tr>
<td>$\delta^{13}\text{C}$</td>
<td>Delta 13 Carbon</td>
</tr>
<tr>
<td>3D</td>
<td>3-Dimensional</td>
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<tr>
<td>BEWE</td>
<td>Basic erosive wear examination</td>
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<tr>
<td>C</td>
<td>Carbon</td>
</tr>
<tr>
<td>CB</td>
<td>Courtney Brierly</td>
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<td>CL</td>
<td>Caleb Lawrence</td>
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<tr>
<td>DMF</td>
<td>Decayed Missing Filled</td>
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<td>DMFS/dmfs</td>
<td>Decayed Missing Filled surfaces (adult/child)</td>
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<td>DMFT/dmft</td>
<td>Decayed Missing Filled teeth (adult/child)</td>
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<td>DNA</td>
<td>Deoxyribonucleic acid</td>
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<td>FFQ</td>
<td>Food frequency questionnaire</td>
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<td>g</td>
<td>Grams</td>
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<td>HDEC</td>
<td>Health and disability ethics committees</td>
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<tr>
<td>ICC</td>
<td>Intraclass correlation coefficient</td>
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<td>ID</td>
<td>Identification</td>
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<tr>
<td>IRR</td>
<td>Incidence Rate Ratio</td>
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<td>MOH</td>
<td>Ministry of Health</td>
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<tr>
<td>N</td>
<td>Nitrogen</td>
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<tr>
<td>NZ</td>
<td>New Zealand</td>
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<tr>
<td>NZ Dep</td>
<td>New Zealand deprivations</td>
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<tr>
<td>OHI-S</td>
<td>Simplified oral hygiene index</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<tr>
<td>SES</td>
<td>Socioeconomic status</td>
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<td>SSB</td>
<td>Sugar sweetened beverages</td>
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<td>SSF</td>
<td>Sugar sweetened food</td>
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<td>TWI</td>
<td>Tooth wear index</td>
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Chapter 1

Literature review
1.1 Introduction

Both tooth wear and dental caries can lead to significant and irreversible tooth surface loss, pain and infection. Though some may find it a relatively new phenomenon, it has in fact been present for many millennia.

In dry skull studies of the first Australian Aboriginal inhabitants, and of those from ancient Egyptians, some, over 6000 years old demonstrated significant tooth wear. This wear was attributed to their hunter gatherer lifestyle and coarse unrefined diets, with their foods containing abrasive particles such as sand, stone and silicate. In addition to this, individuals used their teeth as instruments to hold materials, for hunting and in the preparation of provisions (such as twine and rope (Begg 1954; Forshaw 2014; Pain 2005). Passing through the Egyptian dynasties and with the arrival of the Greek migrants, there was a change to a more sedentary lifestyle; the food became more processed and much sweeter as their technology developed. Other grains were replaced with wheat, which involved breaking down complex carbohydrates to fermentable mono- and di-saccharides. There was an increase in the different varieties of bread, and honey consumption, resulting in a 30% increase in the development of dental caries and abscess in the Egyptian population (Bibby 1990; Forshaw 2014; Pain 2005).

Dental caries is a “disease of civilisation, and its activity is inversely related to the adequacy of food supply” (Bibby 1990). This was evident, as the settlement of Romans in Europe, and the farming and kitchen culture they provided resulted in an increase in dental caries in the population. Conversely, the arrival of the raiding Vikings resulted in a decline in dental caries. Another example is the Tahitians in the South Pacific. French explorer Bougainville and Captain James cook stated that Tahitians had “the most beautifully even and white teeth” which was maintained into old age and was ascribed to the high quality of their diet.
However, by the early 19th century, the dental health of Tahitians deteriorated significantly due to the introduction and impact of western civilization and its refined carbohydrate diet (Bibby 1990).

Unlike the previous lack of accessibility, highly processed, energy dense foods and beverages are now readily available. History has taught us that when food is readily available, poorer oral health ensures. Sugar sweetened beverages have been identified as the primary source of added sugar to the diet of minority groups such as Mexican; Alaskan Yup’ik and New Zealand Māori people. Excess sugar intake has been linked to poorer oral and overall systemic health (Chi et al. 2015; Murphy et al. 2015; Sanchez-Pimienta et al. 2016). The World Health Organisation (WHO) recommended guidelines encourage sugar intake to be limited to 6-10% of the recommended daily dietary energy intake. With 90% of beverages sold in New Zealand containing added sugar, this has led to the debate about the introduction of a nationwide sugar tax on sugar-sweetened beverages (Chepulis et al. 2018; Chepulis et al. 2017; Royal Society Te Apārangi 2017; Simpson 2003).

1.2 Relevance to Māori

New Zealand Māori have been identified as heavy consumers of SSB and are reported to consume up to four or more servings daily. This could be a contributing factor to the reported poorer oral and overall health seen in Māori (Murphy et al. 2015; Mackay 2012). The increase in beverage consumption could lead to repetitive acidic attack on the dentition. In conjunction with the pH decrease associated with the fermentation of the glucose additives, this can have a synergistic effect on the progression of dental caries and tooth wear. In addition to increasing the risk of dental disease, these elevated levels of beverage consumption may have broader implications for the general health of Māori. Increased sugar consumption is strongly linked to chronic diseases such as
obesity, diabetes and gout; all common major health issues that plague today’s Māori population (Murphy et al. 2015).

Māori are also over represented in the lower occupational and income groups. Studies have indicated that lower socio-economic income groups (SES) are more likely to have increased frequency of eating between meals, have lower utilisation of oral health services and greater levels of dental neglect (Gundersen et al. 2008; Jamieson and Koopu 2006; Jamieson and Thomson 2002; World Health Organisation. 2017). They demonstrated that individuals who were of lower socioeconomic income groups were reported poorer oral hygiene, and overall hygiene practices, poorer overall health and greater dental anxiety (Areai et al. 2011; Dixon et al. 1999; Traebert et al. 2010). In contrast they found the more affluent areas and individuals had lower rates of edentulism, greater self-reported oral health and higher utilisation of dental services (Jamieson and Koopu 2006; Jamieson and Thomson 2002). Northland New Zealand has the second highest population of Māori in New Zealand, with an estimated 28% of the entire Māori population residing there. Unfortunately, Northland also has one of the highest rates of dental caries in the country (Northland DHB 2018; Census NZ 2002).

There are documented ethnic differences in the prevalence of dental caries, showing a caries increase in Māori from 68% to 79.2% in 2012 (Foster Page and Thomson 2012). Māori have been shown to have particularly high rates of dental caries across all ages. In fact, nine out of ten children in Northland experience dental caries in the early stages of life (Gowda et al. 2009). In a 2009 study of Māori children in Northland (Dargaville, Kaitaia, Moerewa and Kaikohe), those aged 5 years and under were found to have a (Decayed, Missing, Filled Teeth) dmft score of 5.6, which was considerably higher than the national mean of 2.3. Adolescent Māori had a DMFT score of 3.7 which was also higher than the
national mean of 1.5 (Gowda et al. 2009). The 2009 national adult (18 years and over) DMFT was 13.9, where Māori adults (18 years and older) were shown to have a DMFT score of 12.3. However, when this was adjusted for Māori population DMFT vs non Māori, adult Māori were seen to have a significantly higher mean DMFT score; the ratio of means being 1.1 and the difference in means being 1.9 (Haisman 2010). Māori were shown to be 1.5 times more likely to have had teeth extracted due to caries. They were also less likely to have visited a dentist in the past 12 months, suggesting there are barriers to access dental health care for adult Māori (Haisman 2010; Ministry of Health NZ 2017). The findings from these studies suggest that health inequalities, both ethnic and socioeconomic, are present in New Zealand.

The prevalence of dental caries, and possibly tooth wear, could potentially be higher among the Māori population for several reasons. Such as dietary and lifestyle factors, as there is documented tendencies for Māori to be higher consumers of sugar-sweetened and carbonated beverages (Murphy et al. 2015). The higher consumption of these beverages, along with ethnic food preferences, and higher frequency of snacking between meals, are plausible risk factors for the increased risk of dental disease among Māori (Howe et al. 2015). Other factors that can contribute to dental caries include the frequency of tooth brushing and the overall attitude towards oral care (Areai et al. 2011).

1.3 Dental caries

As dental caries and tooth wear are both categorised as tooth surface loss, the distinction between the two processes are defined by their underlying mechanisms of action.

Dental caries is defined as the localised destruction of dental hard tissues by the
acidic by-products produced by bacterial fermentation of dietary carbohydrates (Selwitz et al. 2007). Weak organic acids are produced by cariogenic bacteria (primarily Strep. Mutans, Strep. Sobrinus and Lactobacilli) which reside in the biofilm surrounding the tooth. These weak acids decrease the oral pH and can tip the balance between enamel remineralisation and demineralisation resulting in localised dissociation of the calcium, phosphate and carbonate ions. This ultimately leads to dental cavitation (Featherstone 2000; Selwitz et al. 2007).

The detection of caries usually includes visual and tactile sensation as well as additional imaging in the form of x-ray radiographs. Recent advances in technology include fibre optic transillumination and laser fluorescence. Although each method has its merits, no method is absolute. Clinical examination alone, without the use x-ray radiographs has been shown to underestimate caries by approximately 40% (Bader et al. 2001; Becker et al. 2007).

Due to the world wide common occurrence of dental caries, the World Health Organisation (WHO) has developed two universal population-based measures of caries, DMFS and DMFT, both using the Decayed, Missing and Filled (DMF) systems. The difference being one measures the number of affected surfaces (DMFS) while the other measures the number of affected teeth (DMFT) (World Health Organisation, 2013).

DMFS has the ability to quantify active and incipient caries which is key for interventive treatments (Kingsman and Selwitz. 1997). Measuring DMFS, however, is a difficult and time-consuming task. As a total of 128-148 surfaces (including third molars) must be examined in each individual and the clinical detection of incipient caries is often subjective and variable between examiners. Difficulties in distinguishing between Sound teeth and incipient lesions, can lead to different measures in DMFS scores (Kingsman and Selwitz 1997). Another issue
some have encountered is the value designated to extracted teeth. Some papers have suggested assigning a maximum value/score to “Missing teeth” while others suggest omitting M from the DMFS scale altogether. However, it has been argued that “Missing teeth” are an important identifier of oral health inequalities and should not be omitted for the calculation of DMFS (Broadbent and Thomson 2005).

DMFT is a count of the teeth directly affected by dental caries. It doesn’t have the shortcomings of having to measuring individual surfaces unlike the DMFS. The DMFT system is cumulative and reflects an individual’s caries experience over their life time, therefore an individual’s DMFT cannot decrease (Haisman 2010). When conducting DMFT measurements, additional imaging techniques would be ideal. However, in field studies due to practical reasons imaging equipment is not always readily available, therefore DMFT can be measured without additional radiographic images. It is therefore an easily reproducible, internationally utilised epidemiological measure (WHO Organization, 2013).

1.3.1 Caries risk factors

There are common well-known risk factors for dental caries such as oral hygiene and the consumption of sugar sweetened foods and drinks (Greene and Vermillion 1960). Studies have also shown the importance of having set family meals within a household as these meals reduce the tendency for snacking between meals. Adolescents have been identified as the age bracket most likely to snack between meals, the snack foods of choice being highly processed, energy dense foods with a high sugar content (Dye et al. 2004).

Sugar-sweetened and carbonated beverages are widely thought to cause dental
caries due to their high content of refined carbohydrates, such as glucose, sucrose and fructose (Steinberg et al. 1972). It has also been shown that the consumption of sugar sweetened beverages has doubled in a six-year period from 2000-2006, with New Zealanders being higher consumers of sugar per capita compared to Americans, Australians and British populations (Habib et al. 2011). It is well known that there is a causal relationship between dental caries and the consumption of sugar, however with regards to SSB, there is conflicting evidence.

A longitudinal study at the University of Iowa, investigated the consumption of beverages in children aged 4-7 years, in predominantly white, financially secure families over 18 months. Participants completed a 3-day diet record (which included one weekend) at certain time periods, and the participants underwent clinical examinations. This study found a strong association between regular consumption of carbonated and powdered drinks and dental caries. The investigators also found that 100% fruit juice was less cariogenic compared to soda beverages and suggested it was in part due to the inclusion of natural sweeteners rather than readily fermentable sweetened additives. This study was based on a sample of financially secure, European children, making extrapolation of the findings difficult to the wider population with diverse ethnic backgrounds and socio-economic classes (Warren et al. 2009).

In a recent systematic review, a small positive association between SSB and dental caries was reported. However, the author was unable to identify an association between caries and diet soft drinks (no sugar) (Vartanian et al. 2007). This finding is consistent with that reported in a 4-year prospective study in an adult population, in which a positive association was made with the consumption of SSB’s consumption and DMFT. This correlation remained significant after being adjusted for age, gender, education and dental behaviours (Bernabe et al. 2014). The findings concluded that consumption of 1-2 SSB daily resulted in a 31%
increase in DMFT, and individuals with 3+ beverages daily resulted in 33% greater DMFT, when compared to those who do not drink SSB (Bernabe et al. 2014; Vartanian et al. 2007).

In a classical study of primary school children with a mean age of 5.9 years, participants were asked to complete a 24-hour recall questionnaire assessing frequency and pattern of snacking between meals. The study investigated typical sweets and beverages that are being consumed and evaluated their effects on dental caries. The results were consistent with Sovik’s findings, concluding that it is not specific sugary food and or drink consumed which contributes to dental caries, but rather the frequency at which the refined carbohydrates are consumed between meals. This frequency is directly related to the prevalence of dental caries (Weiss and Trithart 1960; Sovik, 2015).

In contrast, multiple studies have suggested that SSB have a relatively small impact on DMFT and may be considered a relatively safe way to bring sugar into the mouth. A number of studies have suggested that sugar in liquid form (that is not thick and sticky) is less damaging to the dentition for instance a somewhat controversial human study was conducted in a Swedish mental institute, in which patients were provided sugar in various forms each day to stimulate dental caries (Krasse 2001). It was found that 300 grams of sugar in liquid form (i.e. tea/coffee) resulted in half the amount of caries as did 50gm of sugar in bread (Krasse 2001). An animal study conducted by Harris et al. (Harris) supports the suggestion that sugar in solid form is more contributory to dental caries than liquid. The same amount of sugar in a solid versus liquid form was compared, with the caries score decreasing proportionately with the increased dilution of sugar in the diet. The experimental group displayed one tenth of the decay demonstrated in the solid sugar group (Harris 1953). Another study examined sugar consumption periodically every 6 months for a 3-year duration. The participants were provided
with 170gm of assorted beverages daily over the 6-month period versus a control group who were provided water with 0.4ppm fluoride. The study concluded that SSB consumption had no overall effect on the DMFT, however, greater demineralisation of the teeth in direct contact with the liquid was noted. The authors attributed the demineralisation to the acidic potential of the liquid and felt the acidity of the drink was more critical than the sugar content (Bibby 1990; Steinberg and Zimmerman 1978).

1.3.2 Measures of dietary sugars

There has been a marked increase in the consumption of sugar sweetened foods and particularly beverages in New Zealand. Traditional methods for measuring sugar consumption include the use of a dietary questionnaire or diary. Several questionnaire variants have been used and their validity tested.

Food frequency questionnaires (FFQ) provide a dietary intake recall over an extended period of time and are useful for measuring dietary habits or consumption of certain foods and beverages. The advantage of a FFQ is that it is easier to use than a food record, however, it is less precise and tends to overestimate macronutrient consumption and under-estimate caloric intake (Jahren et al. 2014).

A New Zealand food frequency study was conducted by Metcalf and colleagues (2003). It evaluated the repeatability of the 117-item Children’s Nutrition Survey FFQ among 130 New Zealand children aged 1-14 years (Metcalf et al. 2003). Participants completed the FFQ on two occasions, on average 13 days apart. Among the 71 Māori children, the strength of the associations between the first and second FFQ ranged from 0.4-0.81 and the involvement of a parent or caregiver improved the reproducibility of data collected for younger children.
The relative validity and reproducibility of Furter’s 33-item FFQ was tested among 72 Māori adults (24 males, 48 females) living in Gisborne (Furter, 2014). While the primary outcome is frequency of intake, results from a sub-set of items in this adult FFQ can be used to rank individuals according to their usual intake of total sugars and sucrose. FFQ results for total sugars and sucrose intakes were compared with values obtained from repeat-24 recalls (n=3) over the same one-month period. In summary, FFQ results showed moderate agreement with the test method for classifying participants into the same quartile of intake, and the strength of rank-order associations was strong (Furter, 2014). FFQ results tended to over-estimate mean intakes, although differences were not statistically significant for total sugars when all items were used (Furter, 2014). Finally, participants completed the FFQ on two occasions (one month apart) to assess reproducibility. Intraclass correlation coefficients showed excellent reproducibility for total sugars and sucrose (Furter, 2014).

Although self-reported dietary assessment is a simple method, it is potentially subject to recall bias. A more accurate process is to record a continuous dietary log for the entire month. However, this can be difficult and impractical in some study populations. In such situations, an objective measure may provide a more precise measure of dietary intake.

In the human body all carbon (C) and nitrogen (N) is derived from our diet, and the body is constantly metabolising C and N. However, in structures such as the finger nails and hair, the C and N are incorporated into their incremental growth and can thus be used to assess dietary intake. As hair grows approximately 1 centimetre per month, the portion closest to the follicle represents a snapshot of an individual’s most recent diet. However, the rate of isotopic turnover from diet to tissue can be slow, and potentially take up to 5.5 months in certain tissues
(O'Brien 2015). Multiple studies have found that red blood cells, blood plasma and hair samples are an accurate medium to measure C and N isotopes with hair having the advantage due to the non-invasive nature of specimen collection (Chi et al. 2015; Choy et al. 2013; Nash et al. 2013).

Finally, a study of the Yup’ik population in Alaska, found that the majority of added sugars in their diet was by consumption of sugar sweetened beverages. The analysis of the hair sample found a statistically significant relationship between dental caries and total overall sugar intake (Chi et al. 2015).

1.4 Tooth wear

Tooth wear is defined as non-caries tooth surface loss. It is a complicated multifactorial process which occurs progressively throughout life (Mahoney and Kilpatrick 2003). Tooth wear can occur due to mechanical processes such as attrition, abrasion, abfraction and parafunction or as a result of the erosive potentials of endogenous and exogenous sources (Mahoney, 2003; Kydd, 1985). These factors all contribute to tooth wear and although they can occur independently, the mechanisms are said to coexist. They can synergise and accelerate the tooth wear process (Kaidonis 2012; Mahoney and Kilpatrick 2003).

Measurement of tooth wear differs from dental caries in the sense that a universally accepted method is not available. A new 4-point ordinal scale has been devised to assess past and potentially future indices (Bartlett et al. 2008). The Basic erosive wear examination (BEWE) was compared to the traditional 5-point tooth wear index (TWI) by Dixon et al. (2012). They found that BEWE was comparable to the TWI for severe wear. It was accurate with a sensitivity of 90.9% and a specificity of 91.5%, however, for moderate tooth wear BEWE had a sensitivity score of 48.6% but a specificity of 96.1% (Dixon et al. 2012). The BEWE can therefore be considered an effective screening method for the measurement
of tooth wear, particularly in severe cases.

The development of 3D intra-oral scanners has revolutionised dental record-taking and reduced the storage requirements for dental casts and models. A study by Alaraudanjoki (2017), investigated the use of 3D intra-oral scans and the accuracy of the BEWE to measure tooth wear. Measurements in the upper posterior sextants had greater accuracy due to the improved visibility of the digitized models (Alaraudanjoki et al. 2017). Intra-and inter-examiner reliability was excellent, with increased sensitivity to early erosive lesions compared their clinical examinations, and found that the use of 3D scanners is just as reliable as stone casts when measuring tooth wear (Alaraudanjoki et al. 2017).

1.4.1 Tooth wear and sugar sweetened beverages

Tooth wear is multi-factorial, multiple variables must be considered when investigating tooth wear. For instance, attrition is common and can be attributed to tooth clenching and grinding. Attrition in conjunction with an erosive potential such as an acidic beverage or oesophageal reflux, could reduce the oral pH below the critical value of 5.5 and presents clinically as cupping in the dentine (Kaidonis 2012; Lopez-Frias et al. 2012).

The direct effect of beverages on the dentition is difficult to observe unless consumed is excessive or abnormal amounts (i.e. excessive frequent consumption). Numerous studies investigating the erosive potential of beverages have been conducted. These studies have shown that, the erosive potential of acidic drinks is not dependent upon the pH value alone, but also the manner in which the drink is consumed, the titratable acidity and the modification or fortification content of the beverages (Barbour and Lussi 2014; Sovik et al. 2015).
An in vitro study investigated the enamel resulting from the exposure to 18 soft drinks, mineral water and orange juice over a 7-day (mineral water) and 24-hour (orange juice) period being agitated each hour (Larsen and Nyvad 1999). It was reported that the erosive effects of beverages are minimal when the pH is 4.2 or higher, which was lower than Kaidonis (2012) critical value of 5.5. However, the erosion was minimal until a pH of 4 or lower, the penetration of the enamel and hydroxyapatite solubility increased significantly with the decrease in pH (Larsen and Nyvad 1999). Another in vitro study demonstrated that the increased frequency of low pH fruit beverage consumption increased erosion of the enamel and dentine in the both deciduous and permanent dentition. The deciduous dentition (both enamel and dentine) was more susceptible to erosion, which is concerning given that young children are the target audience of many juice company’s marketing (Hunter et al. 2000).

One study found that overall beverage consumption was highest in adolescent children, with 85% of adolescent school aged children being consumers of sports, energy and carbonated beverages (Gambon et al. 2011). Dental erosion was significantly higher in the male participants which was attributed to increased participation in extracurricular activity (Gambon et al. 2011).
Tooth wear is a prevalent problem in New Zealand, and specific dietary and oral habits may predispose some groups. In a study of 104 New Zealand children, it was reported that up to 82% of New Zealand children, aged 5-8 years, have tooth wear extending into the dentine layer (Ayers et al. 2002). An association between tooth wear and consumption of solids or liquids was not found; however, there was an association between tooth wear and age of time of weaning, with increased duration of bottle feeding resulting in greater dental erosion (Ayers et al. 2002). In contrast to these findings, Millward et al (1994) found a highly statistically significant association between tooth wear and the consumption of carbonated and fruit beverages in children with a mean age of 9.8 years (Millward et al. 1994). Those children consuming 5.8 beverages per week had moderate wear, while 13.9 beverages a week resulted in severe wear. Severe wear was also associated with bedtime consumption of fruit juices.

1.5 Challenges working with Māori communities

Admittedly, investigating oral disease and identifying relevant risk factors to Māori has a number of unique challenges. In working with Māori health providers, Trust is paramount to establishing a humble working relationship. Conducting research using Kaupapa Māori methodology is imperative for Māori participants and giving health providers governance and autonomy within the study is of major importance. When working with Māori health providers, Māori tradition and customs are a major priority. Having appropriate cultural protocols for the management of their tissue sample will avoid causing offence (Best 2005; Lea and Chambers 2007). Māori’s perception of health differs to the traditional western perspective. The Māori’s view of health is holistic, with a perspective that embodies the physical (Mackay), mental (hinengaro), spiritual (wairua) and family (whanau) aspects of an individual (Broughton 1993; Robson and Te Rōpū Rangahau Hauora a Eru 2011). It is important to conduct research within the
context of the Māori culture (Broughton et al. 2016). Individuals need to be treated with a whanau collective (family involvement) and bonds/ties with the organisations which are built on trust and are mutually beneficial. Respect for cultural practise and must be maintained, and individuals are empowered when they understand their rights, *roles and responsibilities* (Simmonds 2015).

1.6 Aims of the study

To investigate the impact of sugar sweetened beverages on dental health in a Northland, New Zealand Māori sample. The objectives of the study were: 1) to describe self-reported oral health, caries experience, tooth wear and dietary sugar intake in a Māori sample; and 2) to investigate for possible associations between oral health and sugar consumption.

1.7 Hypothesis of the study

1) That Māori will have a greater overall mean DMFT score than the New Zealand national mean.
2) Māori will have high levels of tooth wear
3) Sugar sweetened beverage consumption is associated with caries experience (DMFT) and tooth wear (BEWE)
Chapter 2

Methodology
2.0 Experimental Approach and Methods

2.1 Study design

The study was designed as a cross-sectional family aggregation study in a sample of Māori families (parents and children) residing in Northland, New Zealand. This study was conducted in a kaupapa Māori methodology, which embraced and empowered self-determination of the participants and ensured cultural integrity, and sensitivity was upheld in all aspects of the study. The study design, method, and results were reported according to the STROBE guidelines (Von Elm et al. 2007).

2.2 Study Setting

The study was conducted at three Northland primary health care services:
- Te Whare Ora o Tikipunga (Tikipunga)
- Te Puawaitanga o Otangarei health care centre (Otangarei)
- Paihia Medical Services (Paihia)

The chairpersons of these health centres were initially contacted by a phone call followed by a face-to-face consultation. A PowerPoint presentation of the study design was presented to the chairs, and their feedback was collected. It is noteworthy that the health services own the rights of the collected data and sharing the rights of the data is at discretion of these organisations.

Data collection was conducted at the health providers services, which the participants were enrolled in for ease of accessibly. Data were collected over two visits in February 2017 and April 2017.

2.3 Study participants recruitment
This study consisted of 131 participants recruited from 2 suburban suburbs of Whangarei

- 87 Participants recruited from Tikipunga
- 17 Participants recruited from Otangarei

and 1 provincial Northland town

- 27 participants recruited from Paihia

Study participants were identified by:
1) Searching the practice patient databases;
2) Word of mouth by the general practitioners and community health nurses.

The eligibility criterion was being a member of a family self-identified as Māori. Firstly, females of Māori ethnicity, aged between 25-44 years were identified on the patient database as these individuals had a high likelihood of having children residing at the same address. The number of family members enrolled with the service to the same address were identified and ages checked for eligibility of the study. The general practitioners and community health nurses were also encouraged to identify and recruit eligible participants into this study. For those who did not have a home or mobile phone, domiciliary visits with the community health nurses and a researcher (CL) were organised.

Once eligible participants were identified, initial contact was made either by a phone call or face to face contact with the researcher and their health care worker. The study design and objectives were thoroughly explained, and once a commitment to participate in the study was obtained, an allocated time was provided for the whānau for data collection at their nearest health provider.

2.3.1 Inclusion and exclusion criteria
Participants were included if they had a family (*i.e.* have children); Self-identified as Māori; Lived in the Northland community; were willing to participate in a clinical examination; and were willing to provide an informed consent. Participants were excluded if they had a physical or intellectual impairment that could hinder oral hygiene tasks. Children under 5 years were also excluded from the study. All the other children of selected adult participants were included, as members of the family unit.

Written informed consent was collected from all adult participants prior to final enrolment in the study.

2.4 Study Procedure

The study was carried out in a single session by two investigators: Caleb Lawrence (CL) collected the clinical data and Courtney Brierly (CB) collected all the questionnaire data.

The study participants were greeted with a hongi (tane/men) and kihi (wahine/woman) and after a brief introduction, the nature and objectives of the study were explained extensively, with time provided to answer and discuss any queries the participants had. Once verbal and written consent was obtained, data collection was started (Appendix 1).

2.4.1 Study variables

The data collected included: participants’ demographics; self-reported information on tooth brushing, dental health and jaw habits; self-reported data on drink and food intake; clinical data on dental health and hair samples
(biomarker of cane/corn sugar intake). An intraoral scan was taken at the end of the dental clinical examination in order to assess tooth wear severity at a later stage.

2.4.2 Demographic data

Participants’ age, sex, residential address, iwi and hapu were collected by a questionnaire (Appendix 2). Addresses were used to determine the socioeconomic status (SES) of study participants according to the 2006 NZ deprivation area-based index (Salmond et al. 2007).

2.4.3 Self-reported oral hygiene, dental health, and jaw habits

Participants were requested to report on their oral health and tooth brushing utilising a questionnaire developed by (Areai et al. 2011)). Frequency of tooth brushing; time since last dental visit; inability to see a dentist in the last 12 months; experience of dental pain, i.e. keeping them awake at night in the last 12 months; previous dental restorations and history of tooth extraction were investigated. This information was collected using dichotomous or categorial scales (Areai et al. 2011).

Clenching habits, grinding behaviours and snacking between meals were assessed with the oral behaviour checklist (Appendix 3) (Markiewicz et al. 2006)). These questions were assessed on a five-point Likert-type scale, which included: “None of the time”; “A little of the time”; “Some of the time”;” Most of the time”; and “All of the time”. The response was dichotomised, by collapsing all positive responses.
2.4.4 Food frequency questionnaire

Participants’ dietary intake over the past month was assessed using a modified version of two existing New Zealand Food Frequency Questionnaires (FFQs); Kai Māori (Furter, 2014) and the 2003 New Zealand Children Nutrition Survey FFQ (Metcalf et al, 2003; Parnell. 2003).

With the help of the University of Otago’s Department of Human Nutrition, two FFQs were formulated to recall the past month intake for adults (15+yrs) and children (5-14yrs). All the questions were related to one of seven food categories of interest: sugar sweetened foods, sugar sweetened beverages, citric fruit, milk and cheese (no added sugar), total dairy and corn products (for hair sample analyses). As sugar cane and corn (corn syrup) are the most common sources of added dietary sugar, these two plant sources are classified as C4 plants which are higher producers of delta carbon 13, the isotope marker of dietary sugar intake.

2.4.5 Adult food frequency questionnaire (ages 16+)

The adult FFQ was based on the Kai Māori FFQ, which had been previously validated to estimate usual total sugars intake in adult Māori participants (Furter 2014). This FFQ was altered to remove alcohol consumption and include citric fruit, dairy (milk, cheese) and corn products (corn chips, popcorn).

This semi-quantitative 34-item questionnaire consisted of measuring both usual frequency of consumption and estimated quantities of consumption over the past month. Participants were asked open-ended questions with a photograph or diagram to provide a visual representation of portion size. For
each item, the average daily frequency was calculated for each participant, “average number of times consumed per day”. Relevant figures were summed to calculate the average daily frequency of consuming each food category (Appendix 4). Frequency and amount data were also converted to an average usual daily intake of sucrose (g) and total sugars (g) for each item, but these data were not reported in this thesis as these results will be reported in a study by investigator CB. (Appendix 4).

2.4.6 Child food frequency questionnaire (ages 5-15 years)

Comparable to the adult FFQ, the child FFQ was based on the 2003 New Zealand Children’s Nutrition Survey FFQ (Metcalf et al. 2003; Parnell. 2003). This qualitative questionnaire consisted of 49 closed-ended questions ranging from: “Never or less than once a month”; “1-3 times a month”; “1-2 times a week”; “3-4 times a week”; “Once a day”; “2 or more times a day”.

Participants were only asked to record the frequency an item had been consumed over the past month, not the portion size. A subset of items from the original FFQ was used, including fruit (fresh, dried); corn products (corn, popcorn, corn chips); dairy (milk, yoghurt, cheese, ice cream); spreads (Nutella, jam, honey); sugary foods (biscuits, muesli bars, cakes, muffins, puddings, doughnuts); sweets (chocolate, lollies) and beverages (carbonated beverages, fruit juice/drinks) (Appendix 5). The average daily frequency of consuming each item, and each food category, was calculated as per the adult FFQ.

2.4.7 Clinical examination

A chair-side dental examination was conducted by a trained dental
professional (investigator CL) using a dental mirror, a dental probe and medical loupes with LED illumination light (EyeMag Pro F, Zeiss, Oberkochen, Germany) to assess each participant’s oral hygiene and caries experience. An intraoral 3D scan of the dentition was done to assess tooth wear (Trios, 3Shape, Copenhagen, Denmark).

2.4.8 Oral hygiene

Participants’ oral hygiene was measured using Greene and Vermillion’s simplified oral hygiene index (OHI-S) (Greene and Vermillion 1964). Six surfaces in the mouth were assessed: The buccal surface of the upper first molars (tooth 16 and 26), the labial surface of the upper right central incisor (tooth 11), the lingual surface of the lower first molars (tooth 36 and 46) and the labial surface of the lower left central incisor (tooth 31). In cases where these specified teeth were absent, the next erupted molar was measured, and the adjacent central incisor (across the midline) were used in their place.

Each tooth was individually examined and measured and allocated a scored from 0-3 for soft (plaque) and hard (calculus) debris, respectively. Soft debris was measured using 0= no debris present; 1= soft debris covering <1/3 of the tooth; 2= soft debris covering >1/3 but < 2/3 of the tooth; 3=soft debris covering >2/3 of the tooth.

Hard/calculus debris was measured using 0= no calculus present; 1= calculus covering <1/3 of the tooth; 2= soft debris covering >1/3 but < 2/3 of the tooth and/or flecks of subgingival calculus at the cervical margins of the tooth; 3= Calculus covering >2/3 of the tooth and/or a continuous band of subgingival calculus at the gingival margin of the tooth.
The soft and hard debris indices were independently calculated by combining the buccal and lingual scores, and then dividing it by the total number of surfaces measured. The overall simplified oral hygiene index (OHI-S) for the participant was then calculated by summing the soft debris and calculus debris together.

2.4.9 Dental caries

Dental caries experience was assessed using the Decayed Missing Filled Teeth (DMFT) index (Organization 2013). This index quantifies the total number of teeth affected by dental caries (both present and extracted). Third molars, congenitally missing teeth and supernumerary teeth were not assessed. Thus, a maximum DMFT score of 28 (excluding third molars) could be achieved for the permanent dentition (Organization 2013). For children, the total primary and permanent dentition affected by caries was calculated. An inquiry was made for teeth which were crowned, missing or exfoliated and whether this was due to caries. Therefore, all participants DMFT/dmft values were calculated by summing the teeth affected by dental caries.

2.4.10 Intraoral scan

A portable intraoral scanner (Trios, 3Shape, Copenhagen, Denmark) was used to digitize the study participants’ dentition. Before taking the scan, participants were asked to swallow and inhale through their mouth to expel excess saliva. The maxillary teeth were digitised first by scanning all occlusal surfaces; followed by the buccal surfaces and finally the palatal surfaces. Similarly, to the maxilla, the occlusal surfaces of mandibular teeth were scanned in first instance followed by the lingual surfaces and finally the buccal surfaces. Lastly, the bite registration was recorded by scanning the posterior buccal surfaces
bilaterally with the teeth in maximum inter-cuspal position.

2.4.11 Tooth wear

The intraoral scans were analysed off-line, after data collection. Using the digitized scans of the dentition, each arch was independently examined under magnification using the Basic Erosive Wear Examination (BEWE) (Bartlett et al. 2008). According to BEWE, the mouth was divided into 6 sextants (sextants: teeth 17-14, 13-23, 24-27, 37-34, 33-43, 44-47) where each sextant was given a score from 0-3 based on the severity of the worst affected tooth in the allocated region. 0= No tooth wear; 1= Initial loss of surface texture; 2= Hard tissue loss < 50% of the surface area; 3= Hard tissue loss >50% of the surface area. The scores for each sextant were then summed to provide an estimated overview of the severity of tooth surface loss and interpreted as follow: 0-3 no wear, 4-8 low wear, 9-13 medium wear, 14+ heavy wear.

2.4.12 Hair sample

After the clinical examination a hair sample was requested to objectively measure the participants’ consumption of sugar sweeteners derived from sugar cane and corn (maize) over the previous three months. As the hair is destroyed during its analysis process (via combustion), participants were given the option to opt out of providing a hair sample due to its sensitive nature in the Māori culture. A University of Otago Division of Science Kaumatua (respected elder), provided a karakia to bless all participant hair samples and the Isotope Ratio Mass Spectrometry Unit where analyses were performed.

Following consent, 10 strands of hair were collected. Participants were given the option to collect the samples themselves or via their parents, otherwise
the hair was cut as close to the scalp as possible. The cut end of the collected hair samples was attached to the adhesive side of a labelled post-it note, wrapped in aluminium foil and stored in sealed plastic bags by household ID. The hair samples were stored at room temperature in a secure office at the University of Otago.

The Nash et al (2009) technique was used to analyse hair samples. To prepare the samples for analysis, each hair sample was cut to 3cm in length (from the end cut closest to the scalp) and placed into a test tube. The samples were then cleaned by two 30-minute baths of chloroform:methanol (2:1 ratio) solution while placed in an ultrasonic bath. The samples were then bathed in deionised water for an additional 30 minutes in the ultrasonic bath.

Cleaned samples were then placed in a pottle and allowed a few days to dry. Once dried, 0.8mg of hair was cut and placed into a tin capsule, and the precise weight was recorded. Up to 3 tin capsules per participant were prepared to allow for replicates. These samples were then transferred to a labelled tray and analysed using the CX machine (EA-IRMS, Thermo Scientific) to measure $\delta^{13}$Carbon (‰) and $\delta^{15}$Nitrogen (‰). Data were checked for intra-personal variability; samples with less than 10% variation were averaged.

2.5 Statistical analysis

Data were analysed using conventional descriptive methods and mixed model analysis. Type I error was set at 0.05. All the analysis was carried out using the Statistical Package for Social Sciences (SPSS v19.0, IBM, Chicago IL, US) and STATA statistical software (STATA v15.0, StataCorp LLC, Texas, US). A negative binomial model was fitted to the data, instead of a Poisson regression because of the overdispersion of DMFT data.
The model was firstly run using DMFT as the outcome and a random effect on family cluster (to allow for the likely correlated observations within a family). The covariates included in the model were frequency of sweet food and beverage intake, parent or child status, and oral hygiene index (OHI-S). Multiple linear regression was used to model wear index (BEWE) and a random effect on family cluster. The covariates entered in the model were frequency of sweet food and beverage intake, parent or child status, and oral hygiene index (OHI-S). Family pattern were investigated using intraclass correlation coefficients (ICC) where appropriate, and visual observation of scattergrams for DMFT/dmft, BEWE, and OHI-S by family cluster and child/parent status.

2.6 Data storage

Hard-copy baseline questionnaires filled out by all participants were kept in secure storage within the Faculty of Dentistry, University of Otago. These questionnaires will be retained for up to 10 years at the above location. Only the investigators involved in this study were able to access these questionnaires.

All hair samples obtained during the study were securely stored in such a way that only the investigators of the study were able to gain access to them. Hair delta carbon 13 is a stable isotope and analysis was conducted within 3 months of collection, any remaining hairs samples were disposed of in the appropriate manner with the blessing of a Kaumatua. No other external source, commercial or non-commercial, had access to any of this information without the permission of the study designated primary health providers and the research participants/parents.
2.7 Māori consultation

Consultation with the Ngāi Tahu Research Consultative Committee was completed on the 4th of October 2016. Face-to-face discussions with Ngāti Hine (a Northland iwi) and Northland Māori health providers took place in late 2016 and early 2017. (Appendix A)

2.8 Ethical approval

Ethical approval was granted by the Health and Disabilities Ethics Committee (HDEC) on the 24/11/16 (H16/124). Written and informed consent was collected from all adult participants. Parental consent was obtained for study participants under the age of 17 years. (Appendix B)

2.9 Funding

Sir John Walsh Research Institute Fuller scholarship at the university of Otago for a total of $4000
Chapter 3
Results Part 1
Results part 1: Understanding the oral health conditions of Māori families and assessing family associations in Northland New Zealand.

3.1 Study objectives

1. Investigate the sociodemographic characteristics and self-reported oral health condition in a sample of Northland Māori families
2. To assess oral hygiene, caries experience and tooth wear levels in the families
3.2. Sociodemographic

All parents of the study sample self-identified themselves as being of Māori heritage.

The socio-demographics characteristics of our sample are shown in Table 1.

Table 1 - Socio-demographic characteristics of the Māori sample. Unless otherwise indicated, cell numbers represent counts while numbers between brackets represent column percentages.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8 (19.5)</td>
</tr>
<tr>
<td>Female</td>
<td>33 (80.5)</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td>39.9 (8.1)</td>
</tr>
<tr>
<td>NZDep*</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>6</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>8</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>9</td>
<td>9 (22.0)</td>
</tr>
<tr>
<td>10</td>
<td>26 (63.4)</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td>41 (100.0)</td>
</tr>
</tbody>
</table>

* Mean value and standard deviation in brackets
The mean age of the parent participants was 39.9 years (SD = 8.1 years) with a greater number of adult female (mothers) participants (80.5%) compared to males (fathers) (19.5%). The mean age of our child participants was 11.1 years (SD = 4.5 years), with a similar distribution of both male (53.5%) and female (46.7%) child participants. According to the 2007 NZDep classification, about 95% of study participants lived in an area with deprivation scores of 8-10, based on their home address.

3.3.2 Self-reported oral hygiene and dental health

Parents reported greater self-care of oral hygiene with 70.8% of them brushing twice or more a day, in comparison to only 38.8% of children reporting to brush twice or more daily. Children reported less dental pain (23.3%) and dental extractions (27.8%) and greater access to dental care (77.8%) than parents. Parents demonstrated an overall greater caries experience, with the vast majority having had dental restorations (90.2%) and tooth extraction (65.9%). They experienced higher levels of severe dental pain, with around half of them being unable to seek dental treatment (Table 2).

Table 2 – Prevalence of self-reported oral hygiene, oral health, access to dental care services (brackets contain column percentages unless otherwise indicated).

<table>
<thead>
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<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>Daily Brushing</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>One</td>
<td>8 (19.5)</td>
</tr>
<tr>
<td>Two or more</td>
<td>29 (70.8)</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Sample</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Dental Pain</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>24 (58.5)</td>
</tr>
<tr>
<td>No</td>
<td>16 (39.0)</td>
</tr>
<tr>
<td>I don’t know</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Dental restorations</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37 (90.2)</td>
</tr>
<tr>
<td>No</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>I don’t know</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Missing</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>Dental extractions</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>27 (65.9)</td>
</tr>
<tr>
<td>No</td>
<td>12 (29.3)</td>
</tr>
<tr>
<td>I don’t know</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Missing</td>
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</tr>
<tr>
<td>Inability to attend a dentist</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>20 (48.8)</td>
</tr>
<tr>
<td>No</td>
<td>20 (48.8)</td>
</tr>
</tbody>
</table>
3.3.3 Self-reported jaw behaviours

There was a high tendency of snacking/grazing between meals in both the parent (87.8%) and child (86.7%) sample. The vast majority of parents did not report (31.7%) clenching or grinding their teeth, while approximately one out of two children did (45.6%) (Table 3).

Table 3 – Frequency of self-reported jaw behaviours in the sample. Data indicated the number of study participants reporting the habit at least some of the time. Brackets contain column percentages unless otherwise indicated.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>I don’t know</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (2.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>Snack between meals</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>36 (87.8)</td>
</tr>
<tr>
<td>No</td>
<td>4 (9.8)</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (2.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tooth</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clenching/grinding</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13 (31.7)</td>
</tr>
<tr>
<td>No</td>
<td>27 (65.9)</td>
</tr>
</tbody>
</table>
### Table 4

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>OHI-S</td>
<td>0.9 (0.7)</td>
</tr>
<tr>
<td>DMFT/dmft</td>
<td>9.8 (5.6)</td>
</tr>
<tr>
<td>BEWE</td>
<td>6.3 (2.9)</td>
</tr>
</tbody>
</table>

Scatter plots of OHI-S and DMFT values by family clusters and by Child/Parent status are presented in Figure 1 and Figure 2. There was no detectable relationship of OHI-S and DMFT within the family clusters (Figure 1).

Figure 1 – Descriptive plot (scattergram) for OHI-S values by family clusters and by parent/child status.

---

3.3.4 Oral hygiene, caries and tooth wear

Parents had higher DMFT scores than their children. Descriptive statistics of parents and children’s oral hygiene, DMFT/dmft and basic erosive wear examination are presented in Table 4.

Table 4 – Parents and children’s mean scores for surface oral hygiene (OHI-S), caries experience (DMFT/dmft) and tooth wear (BEWE). Brackets contain standard deviations unless otherwise indicated.
Figure 2 – Descriptive plot (scattergram) for DMFT values by family clusters and by parent/child status.
Results part 2: Sugar consumption in Māori in Northland New Zealand, familial associations and its relationship with oral health.

4.1 Study objectives

1. Investigate the frequency of sugar sweet beverage and food consumption in a sample of Northland Māori families
2. To explore for possible associations between dietary sugar intake and oral health in the families
4.4 Dietary effects upon the dentition

Parents tended to consume more sugar sweetened beverages and soft drinks than children, while children had higher consumption of sugar sweetened foods. Parents and children consumed similar levels of citric fruit, and dairy products. The frequency of consumed foods and beverages per day are presented in the Table 5.

Table 5 – Descriptive statistics for the frequency of consumption (units per day) of sweet food, sweet beverages, sweet food and beverages, fruit, cheese, dairy and corn. Data represent means and standard deviations between brackets.

<table>
<thead>
<tr>
<th></th>
<th>Sample (131)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (41)</td>
</tr>
<tr>
<td>Sweet Food</td>
<td>2.9 (1.8)</td>
</tr>
<tr>
<td>Sweet Beverage</td>
<td>2.1 (3.3)</td>
</tr>
<tr>
<td>Sweet Food &amp; Beverage</td>
<td>5.0 (4.1)</td>
</tr>
<tr>
<td>Soft Drinks</td>
<td>1.0 (2.1)</td>
</tr>
<tr>
<td>Citric Fruit</td>
<td>0.8 (1.5)</td>
</tr>
</tbody>
</table>
Hair biomarker for sugar consumption (Delta Carbon 13) in parents and children were very similar, while the nitrogen content was higher in parents than in children (Table 6).

### Table 6 – Descriptive statistics for the hair biomarker for Delta carbon 13 and Delta Nitrogen 15 molecule.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sample (131)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parents (17)</td>
</tr>
<tr>
<td>Delta Carbon 13</td>
<td>19.1 (0.3)</td>
</tr>
<tr>
<td>Delta Nitrogen 15</td>
<td>9.6 (0.2)</td>
</tr>
</tbody>
</table>

#### 4.4.1 Dietary sugar intake and caries

There was no evidence that drinking sweetened beverages were associated to DMFT after adjusting for sex, parent/child status, and oral hygiene, as
represented by OHI-S (Table 7). The incidence rate of parents for DMFT is 4.7 times the incidence rate of children (with all other variables remaining constant). There was evidence of a weak association between DMFT and oral hygiene. The incidence rate related to a single unit increase in OHI-S and is around 1.4 times the incidence rate of no increase (with all other variables remaining constant).

Table 7 – Negative binomial regression model for the relationship between caries (DMFT/dmft), and sugar sweetened beverages, sex, parent/child status, and surface oral hygiene index (OHI-S).

<table>
<thead>
<tr>
<th></th>
<th>DMFT overall</th>
<th>Sample (131)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR$^a$</td>
<td>Std. Err.</td>
</tr>
<tr>
<td>Sweet Beverages</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sex male</td>
<td>1.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Parent/Child</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td>4.7</td>
<td>0.8</td>
</tr>
<tr>
<td>OHI-S</td>
<td>1.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Cons</td>
<td>1.4</td>
<td>0.3</td>
</tr>
<tr>
<td>lnalpha</td>
<td>-1.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Family cluster</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

$^a$IRR= Incidence Rate Ratio
When replacing the model covariate “Sweet Beverage” with the total consumption of sugar (i.e. “Sweet Food and Beverage”), the coefficients of the model were mostly unchanged (Table 8). Similar results were also obtained after replacing the covariate “Sweet Beverage” with the levels delta Carbon 13 in the hair samples (table not reported).

Table 8 – Descriptive model for DMFT and sweet food and beverages

<table>
<thead>
<tr>
<th></th>
<th>Sample (131)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR</td>
<td>Std. Err.</td>
<td>P value</td>
<td>95% conf. interval</td>
<td></td>
</tr>
<tr>
<td>Sweet Food &amp; Beverages</td>
<td>1.0</td>
<td>0.0</td>
<td>0.738</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>1.1</td>
<td>0.2</td>
<td>0.438</td>
<td>0.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Parent/Child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td>4.6</td>
<td>0.8</td>
<td>0.000</td>
<td>3.3</td>
<td>6.4</td>
</tr>
<tr>
<td>OHI-S</td>
<td>1.4</td>
<td>0.2</td>
<td>0.005</td>
<td>1.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Cons</td>
<td>1.4</td>
<td>0.3</td>
<td>0.092</td>
<td>0.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

4.4.2 Dietary sugar intake and tooth wear

The descriptive model for tooth wear and sugar sweetened beverages is
summarised in Table 9. There was no evidence that drinking sweetened beverages was related to wear index after adjusting for gender, oral health (measured by OHI-S) and being a parent. There was evidence of an association between tooth wear (BEWE) and oral hygiene. The wear index of parents was 2.5 higher than that of children (with all other variables remaining constant). The wear index increased by 0.9 for a single unit increase in OHI-S (with all other variables remaining constant) (Table 9).

Table 9— Linear regression model for tooth wear and sugar sweetened beverages

<table>
<thead>
<tr>
<th>Tooth wear index</th>
<th>Sample (131)</th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>P value</th>
<th>95% conf interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet Beverages</td>
<td>-</td>
<td>0.9</td>
<td>0.481</td>
<td>0.481</td>
<td>-0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>-</td>
<td>0.5</td>
<td>0.055</td>
<td>0.055</td>
<td>-2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Parent/Child</td>
<td>Parent</td>
<td>2.5</td>
<td>0.5</td>
<td>0.000</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>OHI-S</td>
<td>0.9</td>
<td>0.4</td>
<td>0.028</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Cons</td>
<td>3.8</td>
<td>0.7</td>
<td>0.000</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.2</td>
</tr>
</tbody>
</table>

When replacing the model covariate “Sweet Beverage” with the total consumption of soft drink (i.e. “All Soft Drinks”), the coefficients of the model remained substantially unchanged (Table 10). Using these models, it was
possible to estimate the intraclass correlation coefficient (ICC) within the family clusters, which was equal to 0.23, thus indicating only a weak family pattern for the severity of tooth wear.

Table 10 – Descriptive model for tooth wear and all soft drinks

<table>
<thead>
<tr>
<th>Tooth wear index</th>
<th>Sample (131)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
</tr>
<tr>
<td>Soft drinks (all)</td>
<td>0.0</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>-1.0</td>
</tr>
<tr>
<td>Parent/Child</td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td>2.5</td>
</tr>
<tr>
<td>OHI-S</td>
<td>0.9</td>
</tr>
<tr>
<td>Cons</td>
<td>3.7</td>
</tr>
</tbody>
</table>
Chapter 5

Discussion
5 Discussion

This pilot study was a cross-sectional, family aggregate design which assessed the family as a unit. The aims of this study were to: 1) describe self-reported oral health (hygiene, dental health, jaw habits), clinical oral health (hygiene, caries, tooth wear) and dietary sugars intake (self-reported frequency, hair biomarker) in a sample of Māori whanau; and 2) investigate possible family cluster associations between oral health and sugar consumption.

Thirty-three Māori family units from Northland participated, and nearly all of them lived in an area with high deprivation. The self-reported caries experience was high in parents, as the vast majority of them received dental restorations and/or tooth extractions, with fair oral hygiene in both parents and children. Both parents and children had relatively high caries experience while tooth wear was mostly confined to enamel in both the parents and children. Oral hygiene, as represented by OHI-S, was significantly associated with both DMFT/dmft and BEWE scores. Dietary sugar intake, as represented by frequency of consuming sugar sweetened beverages and/or foods and hair delta $^{13}$C content, was not significantly associated with DMFT/dmft and BEWE scores.

5.1 Study limitations

While the interpretation of the data is important, we must first consider the limitations and strengths of this study. The main weakness of this study was its small sample size (33 family units, 131 participants). Caries studies are generally conducted in large populations and samples in excess of 300 participants. My aim was to recruit 50 family units (180-200 participants) which would have increased the power of the study and the ability to detect
significant associations.

A significantly greater amount of time must be assigned for future research, with the investigators situated within the Māori community. The basis of this principle is to build trust and rapport with the Māori community, to let them know of your presence and how this would benefit their community. In talking to a local kuia (respected elder) in the community, suggestions of additional hui/meeting at the local Marae and local schools to help with the project could have been organised. Unfortunately, due to funding and clinical constraints residing in the community for extended periods of time was not feasible. However, this would have greatly increased the participation and strength of the study.

Having an additional researcher assistant would have alleviated the work load of the examiners and improved the quality and quantity of collected data. Having large families participating in the study led to multiple errors in data collection due to time constraints and lack of quality control checks of the data. The use of the intraoral scanner added significant chair time to the data collection, in combination with all the variables being collected.

Finally, securing additional financial support for the project would have improved the outcome of the study. The limited funding affected Māori partnerships, recruitment and participation, data collection and analysis, particularly the delta carbon 13 samples. These constraints limited potential outcomes and the power of the study to find significant associations. Future research should take this into consideration.

An additional limitation of this study was the use of self-reported data and the amount of missing data from the questionnaire data. For instance, one question was unanswered by 8 individuals which was 6% of the sample. The
missing data could have a significant effect on outcomes because this has the potential to further reduce the study power and introduce bias. In addition, by using self-reported questionnaires, recall bias was unavoidable, which could have led to unreliable data in regard to over or underestimating their results.

An additional constraint of the study was the lack of calibration of the investigators. Calibration for both DMFT and tooth wear would have provided a systematic methodology and improved intra-rater reliability.

5.2 Study strengths

Working with kaupapa Māori protocols required the development and maintenance of a working, mutually beneficial and culturally respectful relationship with Northland iwi and Māori health providers. Additional time and resources were required to fully nurture and develop a rapport with Māori health leaders through hui/meeting and face-to-face contact before, during and after the study. Nevertheless, the study had a number of strengths. First, the study was well received by the regional community due to the relationship the author forged with the Northland Māori health services. Their support was invaluable as they offered their time, facilities and services to assist in the research. As researchers were manuhiri/visitors to the Northland community, the health services’ good will, name, and community relationships enabled the willing participation in the study. The active recruitment from the medical staff and support of the community health nurses enabled researchers to utilise their relationships with whānau in the community. They provided us the opportunity to access homes within the community that were not readily accessible due to extenuating circumstances and provided services to help willing whānau participate in the study. A limitation of this approach was the convenience sampling method which may have introduced selection bias,
rendering the sample unrepresentative of the wider Māori community.

The integration of the family as a unit was another strength of this study as it embraced collectivist Māori ideals. The whānau perspective provided an insight into the oral health and dietary habits of the family entity instead of individuals. Though not every member could participate, every effort was made to include the majority of family members.

Another strength of the study was fully informing the participants of the nature of the study. There is a lot of distrust with Māori participation in research due to past injustices; an example of this being a study in 2007 where genetic testing was conducted without fully informing participants of the purpose of the research. Māori felt the outcome victimised Māori, with media and politicians adjusting the interpretations of the results to match their perspective of a Māori stereotype. The results claimed an aggression gene was present in higher levels in Māori and is the reason they are violent and likely to be criminal offenders (Hook, 2009, Lea and Chambers, 2007). Thus, participants were fully informed and reassured that the hair samples will not be DNA or drug tested, and an opt out option form provided to participants who were willing to contribute to the study but unwilling or able not provide a hair sample.

Many Māori customs and traditions need to be honoured when dealing with research partnerships and participants’ bodily samples (Best 2005; Lea and Chambers 2007). For example, the head is tapu/sacred in the Māori culture, so hair is also tapu as it can be seen to contain part of an individual’s wairua (spirit)/mana. In Māori customs burning of hair is considered a bad omen and many feared that in doing so this will result in harm falling upon them (Best 2005). This issue became evident when asking for 10 strands of hair for the combustion analysis, resulting in multiple whānau turning down participation in the study. Therefore, appropriate steps were taken. First, an opt out option
was provided to participants who were willing to contribute to the study but not give a hair sample. Second, a kaumatua from the University of Otago blessed the isotope ratio mass spectrometry unit for all the past, current, and future hair samples. Upon completion a verification letter was sent to the Northland Māori health services. Participants were reassured that the hair samples would not be DNA or drug tested.

An additional strength of this study was the use novice techniques. The hair delta carbon 13 isotope is a recent development in the measure of dietary sugar intake. Few studies have used this biomarker to great success and could have provided great insight into this population sample. Also, the use of modern digital scanning as opposed to conventional stone models provided greater accuracy in the measurement of tooth wear.

5.3 Oral health of Northland Māori

5.3.1 Self-reported data

The majority of adult participants were female. Though we encouraged the participation of the family unit as a whole, some fathers were not readily available or declined to participate in the study. This may have contributed to potential outcomes as it is well known male Māori have poor oral health, high caries experience, greater extraction rates and poorer utilisation of dental services (Ministry of Health NZ 2017; Jamieson, 2002; Thomson, 2000). The low utilisation of dental services by Māori is well known. Our results are concurrent with previous literature suggesting accessibility issues for Māori, in particular adults seeking dental treatment (Jamieson and Koopu 2006; Jamieson and Thomson 2002). In the present study, approximately half of the parents reported accessibility issues while 78% of children had access to care. This infers that one in five children in this study may be unable to access
dental care, despite free dental treatment for children under 18 years of age. In contrast, half the adults were unable to attend the dental services when in pain. This is a higher rate than previously reported (Areai et al. 2011; Jamieson and Koopu 2006; Thomson et al. 2000). The cost of treatment is most likely the limiting factor to accessing dental care for these adults of low SES. Further research is needed to identify barriers preventing the uptake and utilisation of dental services.

Māori children tend to have poorer oral hygiene practices than children of other ethnic backgrounds. As reported by Jamieson (2006), Māori children are almost four times more likely to not brush their teeth compared to their European counterparts (Jamieson and Koopu 2006). Our study found the percentage of children who did not brush daily was slightly higher than that found by Areai et al (2011). Although this study did not compare Māori and European children, our sample of children had relatively poorer oral hygiene practices than those reported in the literature (Jamieson and Koopu 2006). Māori adults had slightly better oral hygiene practices with a higher proportion of individuals brushing twice or more daily, suggesting they may have a greater urgency to retain their remaining dentition (potentially due to their higher caries experience) or social desirability bias was present.

The study’s findings suggest that this sample of children had a greater overall experience of dental caries and pain. In comparison to other studies, this study found that children had higher level of pain that kept them awake at night. However, they demonstrated higher levels of extractions, with approximately one in three children having dental extractions due to caries (Ministry of Health NZ, 2017; Areai, 2011). They also have a greater severity of caries experience, with 1 in 2 children having experienced severe dental pain, keeping them up at night (26.5% vs 58.5%) (Areai et al. 2011).

Snacking is common in New Zealand culture. The self-reported data suggests
there is a potential association of grazing within each household as snacking was consistent throughout the family unit. Our data indicated a high proportion of both parents and children snack between meals (~88%). Although the frequency of snacking between meals was not investigated in this study, it is a clear risk factor for caries (Dye et al. 2004; Weiss and Trithart 1960). The literature has shown in a cross-sectional study that snacking more than three times a day results in more than five teeth affected by caries (Weiss and Trithart 1960). Snacking could be indicative of a lack of staple meals in the household such as breakfast, lunch, and dinner. It is suggested that when such meals are skipped, this encourages snacking on energy dense foods. Further investigation of snacking frequency and its impact on caries within the family unit is warranted, also household food security may also have a role to play (Gundersen et al. 2008).

5.4 Clinical measures

5.4.1 OHI-S

According to Greene OHI-S scoring system, both parents and children had fair oral hygiene (0.9 and 1.3 respectively) (Greene and Vermillion 1964), which is consistent with self-reported oral hygiene practices being lower in children than parents. Our results are equivalent to other New Zealand studies where lower SES groups have poor oral hygiene. Parents had higher levels of plaque in comparison to another New Zealand study (Thomson et al. 2000).

5.4.2 DMFT

DMFT is the overall caries experience of the individual, this is an accumulative
measure which increases with age. One of these studies hypotheses was that Māori would have an overall higher DMFT compared to the National mean. The results did not support this hypothesis as our results suggests that Caries experience of Adult Māori has improved, while the Māori children’s scores were similar when compared to the national means.

This study found that our parents’ DMFT score of 9.8 is a significant reduction of 4.1 from the national mean score (Haisman 2010). The mean age of children in our sample was 11 years old. When compared to the national mean for that age group, our children’s DMFT score was 0.2 higher, suggesting there has been no significant change (Haisman, 2010; MOH, 2015).

In comparison to Gowda et al (2009) findings, our results suggest there is an improvement at an ethnicity level of Māori oral health. Our results suggest there is also a reduction of adolescent Māori DMFT of 1.6 over a nine-year period. However, Gowda et al. (2009) utilised posterior bite wing radiographs in their study and Becker et al (2007) stated there is an under estimation of dental caries by approximately 40% with clinical examination alone. If an additional 40% increase in caries is factored into consideration, our dmft in our children’s sample could increase to 3.2, which is closer to Gowda’s finding of 3.9. Therefore, one could argue there has been minimal improvement throughout the years.

However, this small convenience sample may not be representative of the overall Māori population, so the results cannot be extrapolated. Another factor is the family clustering, children could potentially be older than 17 and still be classified as a child. DMFT studies usually stratify individuals according to their respective age groups; however, low numbers in the present study prevented this.
5.4.3 BEWE

Due to the lifestyle and behavioural factors that affect the incidence of tooth wear and erosion, it can be suggested that our sample is an at-risk population for tooth wear. Therefore, an additional hypothesis of this study was that Māori would have high levels of tooth wear. Again, our results did not support this hypothesis as our results indicated low levels of tooth wear, being largely confined within the enamel. This coincides with participants’ low levels of self-reported parafunction, which is consistent with literature regarding limited duration of tooth-tooth contact (Kydd and Daly 1985). Our findings are consistent with reports of tooth wear being more evident with age (Donachie and Walls 1995). Therefore, it is not surprising that there is little wear in our parent sample where the mean age was 40 years. This is younger than the reported age (45-55 years) in previous research (Donachie and Walls 1995). The amount of wear may become more obvious in the aging population, as a sample of individuals 75 years and older had less or equal to one third of all the surfaces extended into dentine (Donachie and Walls 1995; Lee et al. 2012). Therefore, it is a possibility that tooth wear is an issue in the elderly Māori population. Furthermore, lifestyle factors could expose one to additional tooth wear with increasing age.

5.5 Intake of sugar sweetened food and beverages and their association with oral health

The children reported more frequent consumption of sugar sweetened foods in comparison to their parents. Highly palatable, high-sugar foods are widely available and marketed to children, and parents and children may be unaware of their high sugar content. Older children who have greater autonomy over their choice of foods may select these foods, whereas the younger siblings may have greater parental control over their food consumption.
Parents and children usually consumed sugar sweetened beverages twice per day, which is less than a recent report stating a Māori population consumed more than four servings of sugar sweetened beverages per day (Murphy et al. 2015). However, it should be noted that the Māori population studied in this recent report consisted of more medically compromised individuals. Considering a single can of coke contains 9.5 teaspoons of sugar (Royal Society Te Apārangi 2017), our findings suggest that participants may be exceeding the recommended daily dietary sugar intake if we assume each serving a was a standard 330ml beverage, therefore, increasing the risk of caries and other systematic diseases such as obesity, gout and diabetes. The World Health Organization (World Health Organisation 2010) recommends that total sugars intake should equate to less than 10% of an individual's total energy intake, roughly 50 grams/12 teaspoons a day (Simpson 2003).

The evidence for a causal relationship of sugar sweetened beverages with caries is contradictory. In this study, we hypothesised that sugar sweetened beverages will be associated with DMFT, our results suggested there is no relationship with SSB consumption and DMFT. Although participants consumed sugar sweetened beverages twice per day, which was in accordance with Bernabe et al (2014) findings, I would expect a correlation similar to Bernabe et al's (2014) 31% increase incidence of dental caries. However, our findings suggest there is no association between the frequency of consuming sugar sweetened beverages and DMFT/dmft. This supports previous studies suggesting sugar consumed in a diluted, liquid form is much less cariogenic than in solid form (Bibby 1990; Steinberg and Zimmerman 1978; Weiss and Trithart 1960). Though no associations can be drawn, participation in the present study may have been biased as some parents reported high sugar sweetened beverage consumers within their whānau were too whakama (embarrassed) or had no interest in participating in the study. These
individuals were generally young teenagers. If a sugar tax is introduced in New Zealand, this tax could raise prices of sugar sweetened beverages and reduce purchases and consumption. This tax could impact Māori populations who are higher consumers of these beverages and predominantly in the lower SES groups.

5.6 Hair biomarker

No association could be determined with Delta Carbon 13 and DMFT which contrasts with recent findings by Chi et al (2015). This could be due to our small sample size as funding permitted less than half of the data to be analysed, thus significantly reducing the number of observations and potential outcomes. In addition, Chi et al conducted their study in an isolated Yup’ik population where accessibility to fluoridation, and a wide range of highly processed foods, may not have been readily available. Therefore, it could imply that the Yup’ik sample has a limited diet and potentially less recall bias compared to our sample.

5.7 Sugar sweetened beverages and tooth wear

Our final hypothesis was that the consumption of sugar sweetened beverages was associated with an increased levels of tooth wear. According to our findings, no associations were made with the frequency of consuming sugar sweetened beverages and tooth wear. This is in contrast to the literature as certain citric and soft drink beverages have been associated with tooth wear in adolescent studies (Ayers et al. 2002; Millward et al. 1994). However, the wear was largely confined to the early primary dentition (Hunter et al. 2000). Our sample was predominantly late mixed to full adult dentition and any potential
association in the primary teeth may have been lost with the exfoliation of the primary teeth. Greater tooth wear has also been reported in sipping behaviours and in the consumption of citric juices before bed (Gambon et al. 2011; Millward et al. 1994). Hence, the type of beverage and manner in which it is being consumed may influence tooth wear, more so than frequency of intake.

5.8 Family associations

There is no familial association with DMFT and a weak association with tooth wear. No associations were present between parents and children for both oral hygiene and DMFT/dmft (Figure 1 and Figure 2). Therefore, it could be suggested that the lack of association indicates some levels of intervention potentially with the school dental services. The increase in parental caries experience may have amplified the vigilance of parents with their children’s oral health. This can be demonstrated by the higher child utilisation of dental services and lower DMFT/dmft.

There was a weak familial association between the consumption of sugar-sweetened beverages and tooth wear. This may be related to the household beverage access within the entire family unit, but a larger sample size would be required to test this hypothesis.

Although associations between oral hygiene and DMFT and BEWE was not a primary investigation of this study, a small yet significant association was noted. Anecdotally good oral hygiene is associated with increased tooth wear (i.e. due to overzealous brushing), while strong acids are seen to remove plaque. Therefore, our associations could potentially be due to confounding socioeconomic factors, where lower SES groups consuming higher levels of acidic beverages.
5.9 Conclusion and future direction

This study investigated 33 Māori family units for possible associations in family oral hygiene and dietary habits and behaviours and observed oral hygiene, dental caries experience and tooth wear. Although a weak familial tendency for the pattern of tooth wear was found, a significantly larger sample size is required to confirm a true association.

The self-reported caries experience was high in both parents and children, with parents reporting greater dental barriers. Both parents and children had minimal tooth wear with high frequency of snacking between meals. Oral hygiene was associated with both DMFT/dmft and BEWE scores, while no associations were found between the frequency of consuming sugar sweetened beverages and/or foods with Hair delta carbon 13, DMFT/dmft and BEWE scores.

In conclusion, the study results failed to support the hypotheses of the study and in future studies, additional efforts and time should be put into forging the bonds with Māori health providers and their community. In dealing with these local health providers, it is through their reputation that investigators gain access to the Māori community. If the investigators were to cause offence, it will look unfavourable upon the health providers and potentially result in a lack of trust and loss of faith of the provider within the community. As more research is undertaken to improve Māori health and reduce health disparities, it is important that researchers focus on building key relationships with health providers as these represent an essential gateway for connecting with local Māori communities.
References


Sanchez-Pimenta TG, Batis C, Lutter CK, Rivera JA. 2016. Sugar-sweetened beverages are the main sources of added sugar intake in the mexican population. The Journal of Nutrition. 146(9):1888s-1896s.


Appendices

Appendix A

Māori consultation

Thursday, 06 October 2016.

Professor Maure Farella,
Faculty of Dentistry - Department of Oral Diagnostic and Surgical Sciences,
DUNEDIN.

Teni Koe Professor Maure Farella,

Relationship between sugar sweetened drinks, tooth wear and dental caries in Māori people, we are looking to change the title to a Māori title to make it more relevant to the Māori people any advice or help with this would be greatly appreciated.

The Ngāi Tahu Research Consultation Committee (the committee) met on Tuesday, 04 October 2016 to discuss your research proposal.

By way of introduction, this response from the Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outlined in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee bases consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; inviting the others how to say with an open mind [so that there is] room to be persuaded against the proposal; undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

As this study involves human participants, the Committee strongly encourage that ethnicity data be collected as part of the research project. That is the questions on self-identified ethnicity and descent, these questions are contained in the latest census.

The Committee suggests dissemination of the findings to relevant Māori health organisations, for example the National Māori Organisation for Dental Health, Oranga Tauhono and to Professor John Broughton and Malcolm Dackor, who are involved in Māori Dental Health, University of Otago.
We wish you every success in your research and the committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 04 October 2016 to 4 April 2018.

Nahau noa, na

Mark Brunton
Kawhikahare Rangahau Miari
Research Manager Miari
Research Division
Te Whare Wānanga o Otago
Ph: +64 3 479 8738
Email: mark.brunton@otago.ac.nz
Web: www.otago.ac.nz
Appendix B

Ethics approval

H16/124

24 November 2016

Professor M Farella
Department of Oral Sciences
Faculty of Dentistry

Dear Professor Farella,

I am again writing to you concerning your proposal entitled "Relationship between sugar sweetened drinks, tooth wear and dental caries in Maori people", Ethics Committee reference number H16/124.

Thank you to Caleb Lawrence, student investigator on the above project, for his e-mail of 21st November 2016 with attached revised ethics application and for his e-mail of 24th November 2016 with the revised consent form for children attached.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committee Office no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.
Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

gary.witte@otago.ac.nz

jo.farrandofisz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page http://www.otago.ac.nz/council/committees/committees/HumanEthics/Committees.html.

Yours sincerely,

[Signature]

Mr Gary Witte
Manager, Academic Committees
Tel: 479 6256
Email: gary.witte@otago.ac.nz

cc. Professor W M Thomson    Department of Oral Sciences
Appendix 1

Consent forms

Te taunekeneke i waenganui i te inu reka, te ngawhere niho me te whakapopo niho Māori

(Relationship between sugar sweetened drinks, tooth wear and dental caries in Māori people)

CONSENT FORM FOR CHILD PARTICIPANTS

I have been told about this study and understand what it is about. All my questions have been answered in a way that makes sense.

I know that:

1. Participation in this study is voluntary, which means that I do not have to take part if I don’t want to and nothing will happen to me. I can also stop taking part at any time and don’t have to give a reason.

2. Anytime I want to stop, that’s okay.

3. Courtney will be giving me a questionnaire to complete and I do not have to answer if I feel uncomfortable
4. Caleb will collect a small sample of hair from the back of my head and take a quick scan of my mouth. I can stop at any stage if I feel uncomfortable.

5. If I don’t want to answer some of the questions, that’s fine.

6. If I have any worries or if I have any other questions, then I can talk about these with either Caleb or Courtney.

7. The paper and computer file with my answers will only be seen by Caleb and Courtney and the people they are working with. They will keep whatever I say private.

8. Caleb and Courtney will write up the results from this study for their University work. The results may also be written up in journals and talked about at conferences. My name will not be on anything that is written up about this study.

I agree to take part in the study.

...............................................................................

Signed

...............................................................................

Date
Te taunekeneke i waenganui i te inu reko, te ngawhere niho me te whakapopo niho Māori

(Relationship between sugar sweetened drinks, tooth wear and dental caries in Māori people)

Principal Investigator: Prof. Mauro Epeloa
caleb.lawrence@otago.ac.nz

CONSENT FORM FOR PARTICIPANTS

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant: ..........................................................

1. I have read the Information Sheet concerning this study and understand the aims of this research project.

2. I have had sufficient time to talk with other people of my choice about participating in the study.

3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.

4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.

5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.

6. I know that as a participant I will be required to undergo a quick clinical examination and provide a small hair sample (10 strands) which will be disposed of appropriately.

7. I know that the questionnaire, will explore the (briefly describe the question line) and that if the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s), and/or may withdraw from the project without disadvantage of any kind.
8. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.

9. I understand that the results of the project may be published and be available through your health provider and in the University of Otago Library, but that either (i) I agree that any personal identifying information will remain confidential between myself and the researchers during the study, and will not appear in any spoken or written report of the study.

10. I know that there is no remuneration offered for this study, and that no commercial use will be made of the data.

11. I understand that the (tissue, blood or other body fluid) samples will be (provide details of storage, and disposal with opportunity to ask for sample, is appropriate).

Signature of participant: □ □ □ □ Date: □ □ □ □

Name of person taking consent: □ □ □ □ Date: □ □ □ □
Appendix 2

Demographics

What is your full name?

Are you?
  • Male
  • Female

When were you born?

Where do you usually live?

Which country were you born in?

What ethnic group do you belong to?

In which language(s) could you have a conversation about a lot of everyday things?

Are you descended from a Maori (That you have a Maori birth parent, grandparent or great-grandparent)?
  • Yes
  • No

Do know the name(s) of your iwi (tribe or tribes)?

Iwi:
  Roho:

Iwi:
  Roho:

Iwi:
  Roho:
Appendix 3

Self-reported questionnaires

1) Have you ever had a filling (by this we mean when you have a hole in your teeth that a dentist or dental nurse had to fill)
   Yes, No, Don’t know

2) Have you ever had a filling (by this we mean when you have a hole in your teeth that a dentist or dental nurse had to fill)
   Yes, No, Don’t know

3) Have you ever had any teeth removed because of tooth decay or gum boil (abscess) or infection?
   Yes, No, Don’t know

4) How many times did you brush your teeth yesterday?
   None, Once, Two times, Three or more times

5) How long has it been since you last visited a dentist, dental nurse or other dental health worker?
   Within the past year (less than 12 months ago)
   Within the past 2 years (more than 1 year but less than 2 years ago)
   Within the past 5 years (more than 2 years but less than 5 years ago)
   I have never seen a dentist or any other dental health worker
   Don’t know! Not sure

6) In the last 12 months, has there been any time you needed to see a dentist or dental nurse about your teeth or gums, but weren’t able to?
   Yes, No, Don’t know

(Areai et al. 2011)
<table>
<thead>
<tr>
<th>BEHAVIORS DURING SLEEP</th>
<th>None of the time</th>
<th>A little of the time</th>
<th>Some of the time</th>
<th>Most of the time</th>
<th>All of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Clench or grind teeth when asleep</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2 Sleep in a position that puts pressure on the jaw (e.g., on stomach, on the side)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>BEHAVIORS DURING WAKING HOURS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Grind teeth together during waking hours</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4 Clench or press teeth together during waking hours</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5 Touch or hold teeth together other than while eating (i.e., contact between upper and lower teeth)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6 Hold, tighten, or tense muscles without clenching or bringing teeth together</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7 Hold or jut jaw forward or to the side</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8 Press tongue forcibly against teeth</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9 Place tongue between teeth</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10 Bite, chew, or play with your tongue, cheeks, or lips</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11 Hold jaw in rigid or tense position, such as to brace or protect the jaw</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12 Hold between the teeth or bite objects such as hair, pipe, pencil, pens, fingers, fingernails, etc</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13 Use chewing gum</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14 Play musical instrument that involves use of mouth or jaw (e.g., woodwinds, brass, string instruments)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15 Lean with your hand on the jaw, such as cupping or resting the chin in the hand</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16 Chew food on one side only</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17 Extruding between teeth (i.e., food that requires chewing)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18 Sustained talking (e.g., teaching, sales, customer service)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19 Singing</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20 Yawning</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>21 Hold telephone between your head and shoulders</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Appendix 4
Adult Food Frequency Questionnaire

Oranga Niho a Kai
(adult questions)

Kia ora whānau! We would like to learn more about eating patterns, for example:
- **How often** do you usually eat or drink certain foods, and
- **How much** do you usually eat or drink each time?

**How can you help?**
- Answer each question as best as you can.
- Please tell us about YOU
- Tick or fill in **ONE** answer for EACH question. (Erase or scribble out mistakes.)
This is an example of how to answer the questions

Think about your usual eating pattern over the past month...

Tena koe, I am Ryan.
In the last month you say...
I drink water around 4 times a day.
I have about a cup each time.

For this question:
Over the last month, on average, how often do you drink water?

Ryan writes:
4 times [ ] a day
[ ] a week
[ ] a month

How much do you drink usually each time?

[ ] 1 cup OR
[ ] ml OR
[ ] litre

PLEASE NOTE: Each item has 2 questions:
• “how often”
• “how much”
Think about your usual eating pattern over the past month...

1. Over the last month, on average, **how often** did you drink **fruit DRINK** (not 100% fruit juice)
   (eg. Golden Circle, Thaxtons, Ribena)?

<table>
<thead>
<tr>
<th>times</th>
<th>a day</th>
<th>a week</th>
<th>a month</th>
</tr>
</thead>
<tbody>
<tr>
<td>never (go to next question)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   **How much** did you usually drink each time?  ____ cup (photo on page 3) OR
   ____ ml (photos on page 3) OR
   ____ litre

2. Over the last month, on average, **how often** did you drink **100% fruit JUICE** (no added sugar)
   (eg. Just Juice, Charles, NZ Natural)?

<table>
<thead>
<tr>
<th>times</th>
<th>a day</th>
<th>a week</th>
<th>a month</th>
</tr>
</thead>
<tbody>
<tr>
<td>never (go to next question)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   **How much** did you usually drink each time?  ____ cup (photo on page 3)
   ____ ml (photos on page 3)
   ____ litre
3. Over the last month, on average, how often did you drink regular cordial (e.g., Raro, Refresh, Vitafresh)?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

How do you prepare the cordial?

- strong (less water added)
- following packet instructions (1 packet = 1 litre)
- weak (more water added)

How much do you usually drink each time? _____ cup (photo on page 3)

_____ ml OR

_____ litre

4. Over the last month, on average, how often did you drink low-calorie cordial (e.g., Thriltee, Vitafresh low calorie)?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

How much do you usually drink each time? _____ cup (photo on page 3)

_____ ml

_____ litre
5. Over the last month, on average, **how often** did you drink low-calorie/diet soft drink (e.g., Coke Zero, Diet lemonade) or **sugar-free energy drink** (e.g., Sugar-free V or Sugar-free Red Bull)?

   never (go to next question)

   ____ times a day

   ____ a week

   ____ a month

   **How much** do you usually drink each time?

   ____ cup (photo on page 3) OR

   ____ ml (more photos on page 3)

   ____ litre

6. Over the last month, on average, **how often** did you drink regular soft drink (e.g., Coke, lemonade)?

   never (go to next question)

   ____ times a day

   ____ a week

   ____ a month

   **How much** do you usually drink each time?

   ____ cup

   ____ ml (more photos on page 3)

   ____ litre

7. Over the last month, on average, **how often** do you drink **spirits with mixer** (e.g., RTDs, gin and tonic, rum and Coke)?

   never (go to next question)

   ____ times a day

   ____ a week

   ____ a month

   **How much** do you usually drink each time?

   ____ small bottle/can (330ml)

   ____ spirit glass (150ml) with 1 nip

   ____ spirit glass (150ml) with 2 nips

   ____ tall glass (200ml) with 1 nip

   ____ tall glass (200ml) with 2 nips

   ____
8. Over the last month, on average, how often did you drink regular energy drink (eg. V, Red Bull, Mother)?

   never (go to next question)

   _____ times a day
   a week
   a month

   How much do you usually drink each time?
   _____ small can (250 ml)
   _____ medium can or bottle (375 ml)
   _____ large can (500 ml)

9. Over the last month, on average, how often did you drink sports drink (eg. Gatorade, Powerade)?

   never (go to next question)

   _____ times a day
   a week
   a month

   How much do you usually drink each time?
   _____ cup (photo on page 3)
   _____ ml
   _____ litre
Think about your usual eating pattern over the past month...

10. Over the last month, on average, how often did you drink flavoured milk [e.g. Primo, Calci Yum]? never (go to next question)

   _____ times a day
   _____ times a week
   _____ times a month

How much do you usually drink each time?

   _____ cup OR _____ ml OR _____ litre

250ml 390ml 600ml

11. Over the last month, on average, how often did you drink milk, including adding to coffee, tea, MLo, cereal, etc. [e.g. standard blue top, lite, trim green top]? never (go to next question)

   _____ times a day
   _____ times a week
   _____ times a month

How much do you usually drink each time? _____ cup (photo on page 3)

250ml 500ml

_____ ml

_____ litre
12. Over the last month, on average, how often did you add sugar or honey to your tea or coffee?

   never (go to next question)

   ____ times /day
   ____ times /week
   ____ times /month

   How much do you usually add each time?   ____ teaspoon
                                               ____ tablespoon

   How much is on each spoon? (please circle ONE)

13. Over the last month, on average, how often did you add sugar or honey to Milo, hot water/chocolate or other drink?

   never (go to next question)

   ____ times /day
   ____ times /week
   ____ times /month

   How much do you usually add each time?   ____ teaspoon
                                               ____ tablespoon

   How much is on each spoon? (please circle ONE)
Think about your usual eating pattern over the past month...

14. Over the last month, on average, how often did you add Milo, powdered drinking chocolate or other milk mix to your drink?

never (go to next question)

____ times a day

____ times a week

____ times a month

How much do you usually add each time?  ____ teaspoon

____ tablespoon

How much is on each spoon? (please circle ONE)

---------------------------------------------------------------------------------------------------

15. Over the last month, on average, how often did you eat jam, honey, syrup, chutney or Nutella on bread / toast?

never (go to next question)

____ times a day

____ times a week

____ times a month

How many slices of bread do you usually eat each time?  ____ slices

How much do you usually add each time? (Please circle) Photo A

Photo B

Photo C
16. Over the last month, on average, how often did you add tomato sauce, BBQ or sweet chilli sauce to your foods?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

How much do you usually add each time? 

_____ teaspoon

_____ tablespoon

_____ ml

How much is on each spoon? (please circle ONE)
Think about your usual eating pattern over the past month.

17. Over the last month, on average, how often did you eat dried fruit (e.g., sultanas, prunes, dried apricots)?

   Never (go to next question)
   ______ times a day
   ______ times a week
   ______ times a month

   How much do you usually eat each time? ______ cup
   ______ level handful

18. Over the last month, on average, how often did you eat canned fruit, stewed or baked fruit or frozen fruit?

   Never (go to next question)
   ______ times a day
   ______ times a week
   ______ times a month

   How much do you usually eat each time? ______ cup (photo on page 3)
   ______ can (425 grams)

19. Over the last month, on average, how often did you eat fresh raw fruit (e.g., apple, banana, orange, pear, grapes)?

   Never (go to next question)
   ______ times a day
   ______ times a week
   ______ times a month

   How much do you usually eat each time? ______ whole piece(s) of fruit
   ______ handful(s)
   ______ cup
20. Over the last month, on average, how often did you eat fresh citrus fruit (e.g., orange, lemon, lime, mandarin, tangelo)?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

How much do you usually eat each time?

_____ whole piece(s) of fruit

_____ handful(s)

_____ cup (photo on page 3)

21. Over the last month, on average, how often did you eat yoghurt, dairy food, milk pudding, mousse or custard?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

Yoghurt potsize
125 grams

How much do you usually eat each time?

_____ pot(s)

_____ cup (photo on page 3)

22. Over the last month, on average, how often do you eat ice cream, ice blocks, jelly or frozen yoghurt?

never (go to next question)

_____ times a day

_____ times a week

_____ times a month

How much do you usually eat each time?

_____ Photo A

_____ Photo B

_____ Photo C

_____ ice block
Think about your usual eating pattern over the past month...

23. Over the last month, on average, how often did you eat breakfast cereals?

never (go to next question)

____ times

a day

a week

a month

Which type of cereal do you eat most often?

☐ Weetbix

☐ Cornflakes

☐ Tincies

☐ Coco pops

☐ Nutra-grain

☐ Spoonage

☐ Other: ___________

How much do you usually eat each time?

____ Photo A OR

____ Photo B OR

____ Photo C OR

____ Weetbix

24. Over the last month, on average, how often did you add sugar, honey or sweet sauce (chocolate, strawberry) to other foods (e.g., cereal, ice cream, pancakes)?

never (go to next question)

____ times

a day

a week

a month

How much do you usually add each time?

____ teaspoon

____ tablespoon

____ ml/s
25. Over the last month, on average, how often did you eat muesli bars, cereal bars or nuts bars?

never (go to next question)

_____ times a day

a week

a month

How much do you usually eat each time? _____ bar(s)

_____ grams

26. Over the last month, on average, how often did you eat chocolate biscuits (e.g. Tim Tam, Toffee Pop) or cream filled sweet biscuits (e.g. cameo cream)?

never (go to next question)

_____ times a day

a week

a month

How much do you usually eat each time? _____ biscuit(s)

_____ packet (200 grams)

27. Over the last month, on average, how often did you eat other sweet biscuits (e.g. wine biscuits, gingernuts)?

never (go to next question)

_____ times a day

a week

a month

How much do you usually eat each time? _____ small biscuit (e.g. wine)

_____ large biscuit (e.g. Cookie Time)

_____ packet (200 grams)
28. Over the last month, on average, how often did you eat iced buns, sweet buns, sweet pastries or doughnuts?
   never (go to next question)
   ____ times a day
   ____ times a week
   ____ times a month
   How much do you usually eat each time?  ____ doughnut(s)
   ____ bun(s)
   ____ sweet pastry

29. Over the last month, on average, how often did you eat cake, sponge, muffins or baked pudding?
   never (go to next question)
   ____ times a day
   ____ times a week
   ____ times a month
   How much do you usually eat each time?
   ____ Photo A
   ____ Photo B
   ____ Photo C or
   ____ grams
Think about your usual eating pattern over the past month...

30. Over the last month, on average, how often did you eat lollies (e.g., jet planes, mints, lollies, licorice)?

   never (go to next question)

   ____ times a day
   ____ times a week
   ____ times a month

   How much did you usually eat each time? ____ lollies
   ____ family packet (200 grams)

31. Over the last month, on average, how often did you eat chocolate or chocolate bars (e.g., More, Crunchie)?

   never (go to next question)

   ____ times a day 45 grams
   ____ times a week
   ____ times a month 50 grams

   How much do you usually eat each time? ____ squares
   ____ grams

   106 grams 200 grams 360 grams
Think about your usual eating pattern over the past month...

32. Over the last month, on average, how often did you eat cheese (e.g. mild, edam, tasty, cheddar, cheese slices, bike, etc.)?  
   never (go to next question)
   ____ times a day
   ____ times a week
   ____ times a month
   **How much** did you usually eat each time?  ____ cheese slice (20 grams)
   ____ grams
   ____ cup (photo on page 3)

33. Over the last month, on average, how often did you eat **cereals or chips** (e.g. Doritos, Burger Rings, Rashuns, Cheezels, Twisties)?  
   never (go to next question)
   ____ times a day
   ____ times a week
   ____ times a month
   **How much** do you usually eat each time?  ____ small packet (170 grams)
   ____ party value packet (300 grams)
   ____ grams

34. Over the last month, on average, how often did you eat **popcorn** or kettle corn?  
   never (go to next question)
   ____ times a day
   ____ times a week
   ____ times a month
   **How much** do you usually eat each time?  ____ microwave packet (85 grams)
   ____ small packet (150 grams)
35. Have you **changed your eating or drinking habits in the past 5 years?**

   No (go to end of page)

   Yes

   **How has it changed?** (Tick all that apply)

   - O I eat less food.
   - O I eat less sugar.
   - O I eat less fat.
   - O I eat less fruit.
   - O I drink less fruit juice.
   - O I drink fewer sugary drinks.
   - O I drink less alcohol.
   - O Other: ______________________________

   **Why did you change your eating and/or drinking habit(s)?**

   ______________________________________

   ______________________________________

   ______________________________________

   ______________________________________

---

**Ka pai! You made it to THE END...please check every page to see if you have answered every question.**

**Tēnā rawa atu koe for helping us with this important project!**
Appendix 5:
Child Food Frequency Questionnaire

**Oranga Niho a Kai**
(tamariki questions)

Kia ora tamariki! We would like to learn more about your eating patterns:

- **How often** do you usually eat or drink certain foods?

**How can you help?**

- Answer each question as best as you can.
- Please tell us about YOU.
- Tick or fill in **ONE answer for EACH question.**
  (Erase or scribble out mistakes.)
This is an example of how to answer the questions.

To help us understand your eating patterns, we would like you to think back over the past 4 weeks and answer the following questions about the foods you usually eat or drink.

Put a tick in the box which best tells **HOW OFTEN** you usually eat each food.

---

**Example**

If you eat apples on 3 or 4 days each week, put a tick in the '3-4 times a week' box.

![Apple chart](chart.png)

If you never or rarely eat a food, tick in the box ‘never or less than once a month’ and go to the next question.

It may be helpful to ask the person who does the cooking and shopping in your household to help you fill in the questions.

**Please do not skip any foods**
Put a tick ☑️ in the box which best tells HOW OFTEN you eat the food.

### Fruit

1. **Banana, raw**
   - Never or less than once a month
   - 1-2 times a month
   - 1-2 times a week
   - 3-4 times a week
   - 5-6 times a week
   - Once a day
   - 2 or more times a day

2. **Apples or pears**
   - Never or less than once a month
   - 1-2 times a month
   - 1-2 times a week
   - 3-4 times a week
   - 5-6 times a week
   - Once a day
   - 2 or more times a day

3. **Oranges or mandarins**
   - Never or less than once a month
   - 1-2 times a month
   - 1-2 times a week
   - 3-4 times a week
   - 5-6 times a week
   - Once a day
   - 2 or more times a day

4. **Kiwifruit**
   - Never or less than once a month
   - 1-2 times a month
   - 1-2 times a week
   - 3-4 times a week
   - 5-6 times a week
   - Once a day
   - 2 or more times a day
Put a tick ✔️ in the box which best tells HOW OFTEN you eat the food.

5. Fresh or frozen strawberries or other berries

<table>
<thead>
<tr>
<th>Frequency</th>
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<tbody>
<tr>
<td>Never or less than once a month</td>
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6. Canned or cooked fruit, eg. canned peaches

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<th>Frequency</th>
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<td>Never or less than once a month</td>
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7. Dried fruit, eg. raisins

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<th>Frequency</th>
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<td>Never or less than once a month</td>
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</table>

8. Other Fruit (1) If you often have another fruit, not listed - give the name and tick a box to show how often you eat it

<table>
<thead>
<tr>
<th>Frequency</th>
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<tbody>
<tr>
<td>Never or less than once a month</td>
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9. Corn

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<th>Frequency</th>
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<td>Never or less than once a month</td>
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</table>
Put a tick ✓ in the box which best tells HOW OFTEN you eat the food.

10. Breakfast cereal

<table>
<thead>
<tr>
<th>How often</th>
<th>Once a month</th>
<th>1-2 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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10a. What type of cereal do you usually have? (Tick up to 3 boxes)
- Wheaties type
- Cornflakes type
- Rice bubbles
- Coco pops
- Muesli
- Multi-grain type
- Porridge
- Other (Please give name)

10b. What kind of milk was usually added to your cereal?
- None
- Light blue
- Extra calcium
- Standard milk/dark blue
- Trim (green)
- Soy milk
- Other (Please give name)

10c. Was sugar, honey or syrup added to your cereal?
- Yes
- No
Put a tick ☑ in the box which best tells HOW OFTEN you eat the food.

**Spreads, sauces**

11. **Jam or honey**

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-2 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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12. **Nutella**

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<tr>
<th>Never or less than once a month</th>
<th>1-2 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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13. **Tomato sauce or ketchup**

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<th>Never or less than once a month</th>
<th>1-2 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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14. **Other item of the ‘Spreads, sauces’ group** If you often have another item from this group, not listed - give the name and tick a box to show how often you eat it

<table>
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<tr>
<th>Never or less than once a month</th>
<th>1-2 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
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Put a tick ✓ in the box which best tells HOW OFTEN you eat the food.

### 15. Baked beans

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<tr>
<th>Frequency</th>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
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### 16. Canned spaghetti with tomato sauce

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<th>Frequency</th>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
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**Dairy**

### 17. Ice cream

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<th>Frequency</th>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
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### 18. Cheese, eg. cheddar, colby, etc.

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<th>Frequency</th>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
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### 19. Yoghurt or Dairy food (all types)

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<th>Frequency</th>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
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Put a tick ✔️ in the box which best tells HOW OFTEN you eat the food.

### Biscuits/cakes

#### 20. Chocolate coated or cream filled biscuits

<table>
<thead>
<tr>
<th>Frequency</th>
<th>0 times a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>1-4 times a week</th>
<th>1-6 times a week</th>
<th>Over a day</th>
<th>2 or more times a day</th>
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#### 21. Biscuits, eg. plain, chocolate chip, semi-sweet, ginger nut, shortbread

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<th>Frequency</th>
<th>0 times a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>1-4 times a week</th>
<th>1-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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#### 22. Bars, eg. muesli

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<th>Frequency</th>
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<th>1-2 times a week</th>
<th>1-4 times a week</th>
<th>1-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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#### 23. Cake or slice

<table>
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<tr>
<th>Frequency</th>
<th>0 times a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>1-4 times a week</th>
<th>1-6 times a week</th>
<th>Over a day</th>
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#### 24. Doughnuts or croissants

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<th>Frequency</th>
<th>0 times a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>1-4 times a week</th>
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</table>
Put a tick ☑️ in the box which best tells HOW OFTEN you eat the food.

<table>
<thead>
<tr>
<th>Food Type</th>
<th>Frequency Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Scones, muffins or sweet buns</td>
<td></td>
</tr>
<tr>
<td>26. Fruit pie, fruit crumble or tart</td>
<td></td>
</tr>
<tr>
<td>27. Pudding, eg. sponge pudding or steamed pudding</td>
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<tr>
<td>28. Custard or custard puddings</td>
<td></td>
</tr>
<tr>
<td>29. Other item of the ‘Biscuits/cake’ group</td>
<td>If you often have another item from this group, not listed - give the name and tick a box to show how often you eat it</td>
</tr>
</tbody>
</table>
Put a tick ☑️ in the box which best tells HOW OFTEN you eat the food.

### Snacks and sweets

#### 30. Corn snacks or chips, eg. Doritos, Burger Rings, Raisbuns, Cheezels, Twixels, etc.

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
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#### 31. Popcorn

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
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#### 32. Chocolate, eg. Moro bar

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
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</table>

#### 33. Candy coated chocolate, eg. pebbles

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
<th>5-6 times a week</th>
<th>Once a day</th>
<th>2 or more times a day</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
</table>

#### 34. Other sweets

<table>
<thead>
<tr>
<th>Never or less than once a month</th>
<th>1-3 times a month</th>
<th>1-2 times a week</th>
<th>3-4 times a week</th>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
Put a tick ☑️ in the box which best tells HOW OFTEN you eat the food.

### Milks

<table>
<thead>
<tr>
<th>35. Milk (not flavoured)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never or less than once a month</td>
<td></td>
</tr>
<tr>
<td>1-3 times a month</td>
<td></td>
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<tr>
<td>1-2 times a week</td>
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<tr>
<td>2 or more times a day</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>36. Flavoured milk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never or less than once a month</td>
<td></td>
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<tr>
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<table>
<thead>
<tr>
<th>37. Milk shake</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Never or less than once a month</td>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>38. Food drink, eg. Milo powder, Nesquik</th>
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<tbody>
<tr>
<td>Never or less than once a month</td>
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</table>

38 a. With this drink did you use?

- [ ] All milk
- [ ] 1/2 milk
- [ ] 1/4 or less milk

Was sugar added?

- [ ] Yes
- [ ] No
Put a tick \( \checkmark \) in the box which best tells HOW OFTEN you eat the food.

### Other drinks

39. Juice, eg. fresh orange juice, juices such as McCoys, Robinson's, Keri

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<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
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40. Powdered fruit drink, eg. Refresh, Raro

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41. Fruit drink from concentrate or cordial, eg. Just Juice, Ribena

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42. Soft drinks, eg. lemonade, orange, cola, etc.

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43. *New Age* drinks, eg. V, E, Red Bull

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Put a tick ✓ in the box which best tells HOW OFTEN you eat the food.

44. Sports drinks, eg. Gatorade, Powerade

45. Ice blocks

46. Other Item of the 'Other drinks' group: If you often have another item from this group, not listed - give the name and tick a box to show how often you eat it

Ka pai! You made it to THE END...
please check every page and fill in any questions you have skipped.

Tēnā rawa atu koe for helping us with this important project!

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Based on FFQ used in the NZ Children's Nutrition Survey (2003).
