Estimating Free Sugars Intake in New Zealand

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Abstract

Background: Sugar has been implicated as a cause or risk factor in a number of diseases. Recently the focus of research and recommendations have shifted to emphasise the potential importance of free or added sugars on health. In response to the literature which suggests a negative association between free sugars and health (particularly relating to dental caries) the World Health Organisation (WHO) updated their recommendations for intake of free sugars. Monitoring the extent to which populations are achieving these recommendations is difficult, primarily because free sugars are indistinguishable analytically from sugars inherent to a food. Thus, in the New Zealand (NZ) food composition database there is currently no nutrient information for free sugars and as a result, estimates have not been possible for free sugar intakes in NZ

Objective: The first objective of this research project was to update the current New Zealand Food composition database (NZFCD) to include estimates of free sugars for every food. The second objective was to estimate intakes of free sugars in NZ adults using data from the New Zealand Adult Nutrition Survey 2008/09 (NZANS 08/09), with the intention of comparing these intakes with international recommendations for free sugars, such as those set by WHO.

Methods: Estimates of free sugars were created for each food record in the NZFCD, using a 10-step protocol. Intakes of free sugars in the NZANS 08/09 were estimated by matching free sugar estimates for each food item to the 24-hour recall data. Survey weighted estimates of free sugars intakes were calculated by age group, sex, and ethnicity. Usual intakes were estimated by adjusting for intra-individual variation using the Multiple Source Method (MSM). Population intakes were compared with the WHO recommendations for free sugars.

Results: Free sugars content (g/100g) of 2779 foods were estimated. Estimates for 2543 were calculated by objective measures and the remaining 236 foods from subjective measures. Estimated median intake of free sugars in NZ adults was 57 g/day (57g, 95%CI: 55, 59) which equated to 11.1% of total energy (TE), this was significantly higher than sucrose (48g, 95%CI: 46, 50) and added sugar (49g, 95%CI: 47, 51). Intakes were highest among younger age groups. Young males (15-18 years) had the highest intake (89g/day), and young females had the highest by %TE. An estimated 57.8% of the total population are estimated to be exceeding the WHO recommendation that free sugars intakes should be <10%TE and 90.5% of the population are exceeding the recommendation that free sugars intake should <5% TE.

Conclusions: This study offered valuable insight into the consumption of free sugars, improving the understanding of who may be at the greatest risk of poor health outcomes. It found that free sugar consumption of specific population groups (such as younger adults) was high in comparison with WHO recommendations, suggesting that public health strategies to reduce free sugars intakes would be strengthened by targeting younger adults. Updating the NZFCD to include free sugars will enable future research to investigate the relationships between consumption of free sugars and health outcomes, in a New Zealand setting.

Keywords: Total sugar, Free sugar, Added sugar, New Zealand, Estimating intakes, National Surveys

Preface

Rachael Kibblewhite (candidate) conducted this study under the academic supervision of Dr. Lisa Te Morenga (primary supervisor) and Dr. Rachael Mclean (secondary supervisor) from the Department of Human Nutrition, Otago University. Liz Fleming from the Department of Human Nutrition, and Associate Professor Winsome Parnell acted as advisors on this project. This project was undertaken in conjunction with another MDiet candidate, Alice Nettleton, who estimated added sugar intakes in New Zealand. Both candidates worked collaboratively to adapt a previously published 10 step method for deriving added sugars estimates for all foods in the Australian food composition database (Louie *et al*. 2014); to develop both free and added sugars estimates for all foods included in the New Zealand food composition database. The candidate, Rachael Kibblewhite had primary responsibility for the final estimates of free sugars. Responsibilities included:

- Performing a literature search on sugars, with a focus on free sugars and sugar politics.
- Estimating free sugars for each of 2779 foods in the New Zealand Food Composition database.
- Developed a statistical analysis plan for the statistician Dr. Jill Haszard
- Interpretation and presentation of statistical data.
- Write up of the thesis.

Results of this research were presented by the candidate in an oral presentation at the Human Nutrition department seminar on June 2nd, 2016 before the submission of this thesis.

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List of Abbreviations

CVD	Cardiovascular disease
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
g	Grams
HFCS	High fructose corn syrup
IOM	Institute of Medicine
NCD	Non-communicable disease
NHANES	National Health and Nutrition Examination Survey
NIP	Nutrition information panels
NMES	Non-milk extrinsic sugars
NZ	New Zealand
NZANS	New Zealand Adult Nutrition Survey
NZEO	New Zealand European and Other
NZFCD	New Zealand Food Composition Database
SACN	Scientific Advisory Committee of Nutrition
SSB	Sugar Sweetened Beverages
TE	Total energy
UK	United Kingdom
US	United States of America
USDA	United States Department of Agriculture
WHO	World Health Organisation
%DV	Percent daily value

1 Introduction

Sugar consumption and its effects on health are under increasing scrutiny from researchers, health professionals and the general public alike. Sugar has been implicated as a cause or risk factor in a number of conditions including obesity (1), cardiovascular disease (2), gout (3), fatty liver disease (4) and diabetes (5, 6). Although plausible mechanisms have been described regarding how sugar may be implicated in these diseases, there is continued debate relating to the strength of associations (7). Interpretation of dietary assessment of sugar can be difficult as high intakes can be characteristic of both healthy and unhealthy dietary patterns. Sugar is found in substantial quantities in both nutrient-rich foods, such as milk and fruit, as well as highly processed foods, such as baked goods and sugar-sweetened beverages (SSBs). As a result, it is difficult to determine the nature of the association between total sugars and diet quality, which is one reason why the relationship between sugar and health outcomes is so challenging to define. Consequently, discretionary sources of sugar (i.e. added or free sugars) are increasingly becoming a focus for nutritional research and interventions, as they often provide energy to the individual's diet, but are of little nutritional value (7). Excessive free sugars may dilute the nutrient content of the diet, and poor satiety recognition of high sugar foods may lead to passive overconsumption and weight gain (8, 9).

As obesity and diabetes rates have increased in NZ over recent decades, sugar intakes have also increased (10, 11). A recent review of sugar consumption trends found of 15 developed nations found that NZ adult females had the largest increase in sugar consumption over the last 20 years, with an estimated 15g increase of sucrose based on intake data (11). Current estimated intakes of mean total sugar and sucrose of NZ adults is approximately 120 g/day and 55 g/day in men, and 96 g/day and 42 g/day in women, respectively; however, the proportion of this which comes from added or free sugars is unknown (12). The links between

sugar consumption and chronic disease are of clear importance to NZ, a country which has the third highest rates of obesity in the OECD, where the leading cause of death is ischemic heart disease, and over 200,000 New Zealanders suffer from Type 2 diabetes (10, 13, 14).

In NZ, public health recommendations regarding sugar intake have remained relatively unchanged for a number of years. There are no specific recommendations regarding free or added sugars, although dietary guidelines recommend limiting sugary foods and drinks (15). Elsewhere in the world, there has been a move towards recommendations for discretionary sugars, although these recommendations vary considerably (16-20). Perhaps the most pertinent to NZ, is the World Health Organisation's (WHO) recommendations, that <10% total energy (TE) should come from free sugars, with a further conditional recommendation that this should be reduced further to <5% TE (21). Current intake of free sugars of NZ adults are unknown. However, the most recent NZ national adult nutrition survey conducted in 2008/09 (NZANS 08/09) found that median sucrose intake (used as a surrogate for free sugars) was 8.2% of TE, within the 10% WHO recommendation (11).

The aims of this thesis are to develop a systematic methodology to update the current New Zealand Food Composition Database (NZFCD) so that it includes estimates of the free sugars content for every food. Subsequently, this data in conjunction with data from the NZANS 08/09 will be used to develop estimates of usual intakes of free sugars for NZ adults, and this will be used to estimate the proportion of NZ adults are meeting WHO recommendations for free sugars.

2 Literature Review

This literature focuses on the challenges in determining sugar intake particularly that of free sugars, both within NZ and internationally. This literature review aims to:

1. Provide an overview on how sugar is defined,
2. Review current guidelines and recommendations regarding sugar intake and the basis on which they have been determined.
3. Discuss the food politics surrounding sugar.
4. Describe current sugar intakes and how these are estimated
5. Discuss the gaps which exist in the current literature regarding free sugars.

2.1 Literature review search methods

Literature searches were conducted between August 2015 and April 2016 using the electronic database Google Scholar for relevant articles, with a focus on those that described current intakes, discussed sugar intakes in relation to disease, and discussed the politics surrounding sugar. Literature regarding free sugars was of priority but the review extended to other measures of sugar, particularly added sugar, total sugars and sucrose. Further literature was identified from the reference lists of published articles which were collected. Additionally, the World Wide Web was used to access information on international recommendations and the politics surrounding sugar.

2.2 How are sugars defined?

Sugars are a class of rapidly digested dietary carbohydrates including monosaccharides and disaccharides, however the term sugar is also used to describe food sweeteners such as table sugar. Under this general umbrella, there are a number of terms frequently used to categorise sugars, such as total, added, and free sugars. However, the definitions and terms used are not standardised, which can create confusion and difficulties in interpreting research and recommendations. It is important to have some understanding as to how these definitions differ, to be able to understand recommendations implemented by health organisations.

Table 2-1 Summary of definitions for sugars and sugary foods frequently used in the literature

Type of Sugar	Definition
Total sugars	All free mono- and disaccharides such as glucose, fructose, lactose, and sucrose.
Added sugars	Sugars and syrups that are added to foods or beverages when they are processed or prepared (not including naturally occurring sugars such as those in milk and fruits)(22).
Free sugars	Mono- and disaccharides added to foods and beverages by the manufacturer, cook, or consumer; and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates(21).
Intrinsic sugars	Sugars contained in the general structure of the food, which are considered to be less available to mouth bacteria e.g. sugars found in the cells of whole fruits and vegetables (23).
Non-milk extrinsic sugars (NMES)	Includes the sugars in fruit juice and 50% of the sugars in canned, stewed, dried, or preserved fruits; as well as all

	sugars, sweeteners, and syrups that are eaten as such or used as ingredients in processed and prepared foods (23).
Natural Sugars	Currently no formal definition (24, 25). Commonly described as sugars which naturally occur in a food, rather than an additive. Often used interchangeably with intrinsic sugars(26)
Sugar-sweetened beverages (SSBs)	Drinks with added sugars including soft drinks, energy drinks, iced tea, fruit drinks and juices, and vitamin water drinks (5).
High fructose corn syrup (HFCS)	A sweetener derived from corn which is typically 55% fructose and 45% glucose, commonly used in North America particularly in SSBs (27, 28)

Due to the many terms used to describe sugar intakes, there is confusion when determining current population intakes, and the public's adherence to the recommendations. On occasion (including in peer-reviewed literature), current population intakes, measured as total sugars, are compared with dietary recommendations pertaining to added or free sugars, resulting in misleading estimates of population intakes well above recommendations (29, 30). Furthermore, reporting total sugars for free or added sugars intakes has the potential to confound or mask the effect of sugar on health or diet quality, as sugars are found in foods with variable nutritional quality i.e. both highly processed foods and 'whole' foods such as raw fruit. To determine the true impact of sugar on health, it is essential to look at the impact of free or added sugars; foods high in free sugars are often energy dense and nutrient poor and thus should be limited. In contrast people are encouraged to consume fruit, vegetables and plain unsweetened dairy foods which can contain substantial amounts of intrinsic sugars (8).

In some literature, authors use the term "added sugars" when referring to surrogates such as sucrose, fructose, or HFCS (31, 32). These surrogates are often used when researching the health implications of free sugars, due to the difficulties measuring or estimating intakes of

free sugars (2, 5, 32, 33). SSBs are also commonly used as a surrogate for free sugars, as they typically account for a large proportion of total sugar consumption, particularly in children and younger adults (12, 34). However, in the NZANS 08/09, only 17% of TE from total sugars came from non-alcoholic beverages, with a majority coming from other sources. Therefore reliance on data from SSBs may not accurately represent sugar intake in NZ (12). Furthermore, a high intake of SSBs may be an indicator of an overall poor diet (33). Research has found that liquid calories have a smaller impact on satiety than solids (including those high in sugar) which may lead to increased weight gain (with obesity being a comorbidity in many diseases associated with high sugar intakes)(28). Additionally, research suggests that people who increase SSB consumption do so in addition to their regular diet, thus adding calories, leading to an increased chance of weight gain and obesity (9, 28). Foods high in free sugars are also likely to replace foods of a higher nutrition quality (35). Therefore the use if SSBs as a surrogate for free sugars may attenuate the proposed micronutrient dilution associated with high intakes of free sugars, but may have a greater association with weight gain than free sugars (1, 8).

2.3 The impact of sugar on health

There is widespread acceptance by public health authorities that free sugars intakes should be limited, but the amount that is compatible with good health is contested, particularly by the food industry (16, 21, 27, 36). Much of this debate stems from inconsistent research findings which may be impacted by the heterogeneity of available research, created by the various measures of sugar definitions. In addition, inconsistencies between sugar intake and the related health outcomes could be due to difficulties determining whether the effect is coming from sugar itself or residual confounders; for example, the relationship between sugar and weight gain. It has been found that a higher intake of SSBs is associated with increased weight gain, which some attribute to the metabolic effects of sugar itself (33). However,

isocaloric trials exchanging sugar for another macronutrient had no effect on bodyweight, suggesting that the additional calories, not the metabolic effects of sugar affect intake regulation and therefore body mass (9).

There is strong evidence suggesting that high intakes of free sugars increase the risk of dental caries. This is one of the two central lines of evidence supporting WHO recommendations to limit intakes of free sugars to <10% TE (37). Furthermore, WHO recommendations are informed by evidence showing that the risk of dental caries continues to decrease as sugar intakes fall, even below 5% of TE intake (38).

2.4 What are the current recommendations for dietary sugars?

There is a plethora of recommendations currently used throughout the world, of which **Table 2-2** provides a summary, with a brief background behind their rationale. International recommendations for sugar intakes are generally consistent ranging from no more than 5% TE from free sugars as recommended by Scientific Advisory Board of Nutrition (SACN) and WHO (conditional recommendation), to no more than 10% TE coming from added or free sugars recommended by the USDA and WHO (strong recommendation). The major outlier is the IOM recommendation who suggest a maximal intake level of 25% TE. Most recommendations refer to individual levels of consumption, whereas the SACN recommendations refer to the entire population.

Comparing the justifications for each recommendation is beneficial when trying to understand the variation between countries and organisations. It also highlights the ambiguity of NZ's qualitative free sugar recommendations, which provide little guidance on how much sugar is appropriate for a healthy diet. In comparison, a majority of the recommendations listed are quantitative, permitting subjective analysis on whether a population is meeting the recommendations.

Table 2-2 Comparison of dietary sugar recommendations by different institutions

Institution/ country	Current recommendation	Evidence for recommendations
WHO	Strong recommendation: No more than 10% of TE should come from free sugars. Conditional recommendation: No more than 5% of TE intake should come from free sugars(21).	Strong recommendation is based on observational studies (moderate quality evidence) of dental caries and RCTs (moderate quality evidence) of association between free sugars and bodyweight in both adults and children Conditional recommendation is based on ecological studies (very low quality evidence) showing a positive dose-response relationship between free sugar intakes and dental caries when intake of free sugars was below 5% of TE (21).
NZ	Qualitative recommendation to 'Choose pre-prepared foods and snacks that are low in sugar'(15)	Based on the latest evidence reviews from the following international organisations and countries; American Dietary Guidelines, Nordic Nutrition Recommendations, 2013 Australian Guidelines, World Cancer Research Fund, American Institute for cancer research reports and WHO reports(15).
Australia	Qualitative recommendation to 'Limit intake of foods and drinks containing added sugars such as confectionary, sugar-sweetened soft drinks and cordials, fruit drinks, vitamin waters, energy and sports drinks' (39).	Based on reviews of the literature looking at the association between sugar and disease. These reviews concluded that high intakes of sugar were associated with dental caries (Grade C evidence) and that a reduction in sugar consumption prevents an increase in measures of body fat (Grade D evidence)(40).

SACN	No more than 5% of TE intake should come from free sugars on average across the population(41).	Based on a suggestion from the Calorie Reduction Expert Group to address energy imbalance (by reducing energy intake by 100kcal/person/day) (42) SACN concluded that intake of free sugars would need to be reduced to <5% of total dietary energy (16)
United States Department of Agriculture (USDA)	Limit added sugars to less than 10% of daily calories(17)	Based on evidence predominantly from cohort studies and some RCT's, that show eating patterns which include lower intakes of added sugars are associated with reduced risk of Cardiovascular disease (CVD) and there is moderate evidence that lower intakes may also reduce risk of type 2 diabetes, obesity and some cancers(17).
Institute of Medicine (IOM) (2002)	A maximal intake level of 25% of energy intake from added sugars (for both adults and children) (18)	Based on preventing micronutrient deficiencies, as foods high in added sugars such as SSBs, confectionary, pastries etc. typically are nutrient poor and may displace nutrient dense foods resulting in a lower consumption of micronutrients (18)
American Heart Association	No more than half of discretionary calorie intake from added sugars (for men this equates to approximately nine teaspoons of sugar, for women approximately six teaspoons)(26)	Based on maintaining a healthy weight, decreasing cardiovascular risk and meeting essential nutrient needs. The American Heart Association stated that energy intake has increased approximately 150-300calories per day, with approximately 50% of this coming from SSBs, so although research has been unable to confirm a direct link, it is highly likely that added sugars are playing a role, leading to recommendations for limiting added sugar intake(26).

2.5 What are sugar intakes currently?

Table 2-3 Current estimates of sugar intakes in Australia, NZ, US[1] and the UK[2]

Country	Year	Type of Sugar	Age of population (years)	Mean energy[3] MJ/d	Mean Sugar g/d	Mean sugar% TE
Australia	2011/12	Total Sugar	19+	9.9	115	18.6
(43, 44)	2011/12	Free sugars [4]	2+	8.8	60	10.9
NZ (12)	2008/09	Total Sugars	15 +	9.1	115	20.2
	2008/09	Sucrose	15+	9.1	54	9.5
US (45)	2007/08	Added sugar	2+	8.6	77	14.6
UK (34)	2008/09-2011/12	Total Sugar	19-64	8.9	106	19.1
	2008/09-2011/12	NMES	19-64	8.9	68	12.1

1. US, United States
2. UK, United Kingdom
3. Mean energy values were taken directly from respective reports- excluding free sugars values which was determined using quoted free sugar values and %TE
4. Free sugars were added to Australian Food, Supplement and Nutrient database in April 2016

When comparing intake data to Australia and the UK, NZ adults have a higher total sugar intake as %TE (US data unavailable). In contrast, %TE from sucrose (used as a surrogate for added sugars) amongst NZ adults is lower than Australia, the US and the UK. The proportion of total sugar from free sugars (or its proxies) was 47% (sucrose) in NZ, compared to 58% (free sugars) in Australia, and 64% (NMES) in the UK. Given that NZ adults have the highest total sugar intakes, this suggests that a greater proportion of these sugars originate from whole foods such as fruit and milk. Furthermore, it is likely that the proportion of intakes from free sugars would be closer to that of Australia and the UK if actual intakes of free sugars were used, rather than a surrogate, due to the inclusion of fruit juices and juice concentrates. **Table 2-1** further illustrates the variability between the types of sugar measured and reported. Some countries report intake for the entire population, whereas others report children and adults separately. Children tend to consume smaller quantities of sugars; nevertheless, this amounts to a greater %TE due to smaller energy intakes (12, 46). As one might expect, conflating all sugars and reporting total sugar intake results in a greater % TE from sugar, compared to

reported intakes which use sub-classes of sugar, e.g. sucrose. Total sugars includes all sources, from both 'healthy' foods and discretionary sources. Sucrose, which is often used as a surrogate for added sugars, is also found in significant amounts in fruits, some vegetables, and nuts. When investigating health outcomes, reporting total sugars or sucrose can attenuate any relationship between sugar and poor health, due to the inclusion of these healthy sources which are associated with health benefits. Therefore, a greater emphasis should be placed on added or free sugars exclusively from discretionary sources, as this will enable more accurate interpretations of the relationship between sugar and health outcomes.

In addition to intake data, food balance sheets are often used to describe sugar consumption. In the most recent FAO estimates (2012-2014), added sugars values were considerably higher than intake data would suggest. Consumption in NZ was estimated to be 132 g/day, which was very similar to Australia's 130 g/day, but much higher than the US intake of 91 g/day (47). Clearly, there is a large discrepancy between intake and consumption data, and it is likely that the 'actual' amount of sugars consumed sits somewhere between these values. Therefore, care must be taken when interpreting estimates of sugar intake, and it should be acknowledged that these discrepancies provide an opportunity for different stakeholder groups to portray sugar intakes in a way that fits with their agenda.

It is of increasing importance to be able to accurately measure the amount of free sugars populations are consuming. Policy changes aiming to reduce population intakes of free sugars, such as SSBs taxes or alterations to NIPs, are currently being debated worldwide and are beginning to be implemented in some countries (48-51). Although ecological data cannot prove causation, they do provide an additional piece of the puzzle when looking at a multi-factorial health outcomes such as obesity, diabetes and CVD. Some research has shown that obesity rates continue to rise although sugar intakes (included added sugars) have decreased (45, 52). Therefore, a more comprehensive examination of the types of sugar being consumed

(i.e. free sugars) may be warranted to depict how intakes are changing. However, a majority of data collected on intakes (particularly at the population level or in NZ) only estimate total sugar intakes or a surrogate for free sugars such as sucrose.

2.5.1 National Surveys

National nutrition surveys are commonly used worldwide to estimate intakes of a multitude of nutrients including sugars (34, 43, 53-61). National nutrition surveys conducted in Europe, North America and Australasia tend to report intakes of total sugars, or sugars that can be analytically determined (sucrose, lactose etc.) rather than free or added sugars. In the UK national nutrition survey, however, estimates of added sugars or NMES are also reported. However, none of these studies reported free sugar intakes as defined by WHO's definition. (34, 43, 54-61). National surveys commonly use 24-hour diet recalls or 4 or 7 day diet records to estimate intakes. In NZ, the NZANS collected information on food and drink consumption using 24-hour dietary recalls. There have been two national adult nutrition surveys conducted by the Ministry of Health (as well as two prior adult national nutrition surveys), and it is highly likely that there will be more in the future, allowing for analysis of trends of nutrient intakes. The recent NZ adult nutrition surveys included information regarding intakes of SSBs and total sugars, as well as the types of foods consumed, which enable estimations of intakes of free sugars (if free sugars estimates were added to the NZFCD).

2.6 What impact has politics had on sugar recommendations and intakes?

Consumers' attitudes towards sugar consumption are changing, with many seeking to reduce their intake of added or free sugars (62, 63). However, in the current food climate, it can be difficult to reduce intakes, due to lack of accessible information regarding the content of free

sugars. It is likely that consumers would benefit from better information allowing them to identify foods which are high in free sugars. However, any moves towards doing so have been met with resistance by the food industry (64-66). The food industry is unwilling to draw attention to the free sugars contents of food as this may deter consumers, and as sugar is highly palatable and an inexpensive ingredient with a number of functional qualities, they lack the motivation to reduce it (22, 67). This is of importance as the majority of free sugars in the diet come from processed foods, not from sugar added by the cook or at the table (68). The primary goal of the food industry is to make a profit, and processed foods high in added sweeteners (amongst other ingredients, such as fat and salt) have a greater profit margin than unprocessed alternatives (69). Therefore, it is in the food industry's best interest to continue to sell highly processed foods. This is evident when observing their extensive efforts to oppose any policy that may lead to an increased cost of these ingredients (such as a tax on SSBs) or increase the consumer's awareness of these additions to their food (66, 70-73). This strong opposition coupled with lobbying from other highly vested interests places a lot of pressure on the government and often counteracts public health efforts. The following discussion on food politics is intended to highlight the importance of being able to evaluate intakes of free sugars in a systematic, impartial way outside of the vested interests of the food industry. With a further aim of increasing the understanding of the importance of objective guidelines for intakes of free sugars (such as those of the WHO) by placing these guidelines into the larger context of the current food environment.

Internationally, there are a number of examples which highlight how 'Big Food' fight to prevent regulations which may impact consumer acceptance of their product, particularly in regards to the labelling of added sugars on food labels. In 2015, the US Food and Drug Administration (FDA) proposed the inclusion of added sugar content, as a % daily value (%DV) on NIPs of processed foods. The recommended percent value was to be based on

added sugars not exceeding 10% TE (74). There was opposition from the food industry as well as the IOM, who stated that including added sugars to labels would confuse consumers as they might interpret such a label as a target, rather than an upper limit (75). Currently %DV are already listed on NIPs for nutrients for which upper limits are recommended, such as sodium and certain fats. Research has shown that consumers could understand that these values are not targets, and most consumers welcome %DV on labels, therefore, there is no evidence to support the view that consumers would interpret a %DV for added sugars differently (76). Additionally, research by Kyle and Thomas examined consumers' perceptions of a %DV label for added sugars (n=500) (77). They found that 63% of consumers believed it would be helpful for determining the added sugar content of food, and only 18% thought it was confusing, suggesting that consumers may benefit from better labelling of added sugars (77). These results are supported by the research of Vanderlee *et al.* who found that improved labelling enhanced consumer understanding of added sugars in food products (78). Although these findings do not conclusively show benefit in including an added sugar label to NIPs, they demonstrate that claims made by the food industry may be unsubstantiated as current research does not support the argument that consumers will not understand such labelling.

An additional argument by food industry groups (such as American Bakers Association, American Beverage Association, and Corn Refiners Association) is that there is no evidence to justify an added sugar label (65). In April 2016, the FDA officially announced that added sugar will be added to NIP's within the next two years (50), the US Sugar Association who represent a majority of sugar producers, has threatened to sue the FDA claiming the new guidelines "are not based on significant scientific agreement" (79). Although there is some debate as to the extent added sugars play in non-communicable diseases (NCDs), there is a large body of evidence underpinning recommendations made by international bodies to limit

sugars intakes, which the sugar industry deflects attention from (16, 21, 26). For example in 2003 when WHO first recommended that free sugars be limited to <10% TE, the US Sugar Association called on the US government to cancel its annual $177 million contributions to WHO (73). The Sugar Association claimed that WHO's recommendations were "scientifically flawed" and pointed out the IOM's recommendation (added sugar intakes should be <25% TE) were not considered in the paper (73). However, the sugar association failed to mention that recommendations by the IOM were based on preventing micronutrient deficiencies, not providing dietary recommendations for overall health.

From these actions, it is clear that the food industry is fighting to protect their products and their profit margins using very similar techniques to the tobacco industry (70, 80, 81). Both have placed emphasis on personal responsibility and raised fears of a 'nanny state' if governments use policy to reduce public risk. Both criticise research which may negatively impact public perception by labelling it as "junk science", often funding their own research which disputes other findings (70).

The focus on obesity and nutrition as a personal responsibility has been used by food and advertising industries to support continued self-regulation in food and advertising environments (64, 82). Often governments or health agencies attempt to implement policies in order to create healthy environmental changes, such as SSB taxes or healthy foods in schools programmes, but are often met with cries of 'meddling' (81-83). However, the idea of personal responsibility promoted by the industry has some public health merit; in fact, it may the best place to start to satisfy both the health sector and the food industry's ideologies. When considering this concept of personal responsibility, it is essential to acknowledge that consumers need to be provided with the right tools in order to make informed decisions, which could include more informative food labelling, including information on free sugars. Consequently, there would be a benefit in the food industry supplying information on free

sugar quantities in foods. If they are unwilling to do so, academics and policymakers must look for accurate ways of estimating free sugars, to allow for estimations of intakes, particularly in relation to recommendations.

Currently, there is no legal requirement in any country to list free or added sugars on NIPs. Furthermore, the level of these nutrients cannot be determined analytically; thus researchers face significant challenges when investigating the relationship between free sugars and health outcomes. A key method used to estimate added sugar consumption is food balance sheet data; however, it can be unreliable. A recent journal article regarding the 'Australian Paradox' that used food balance sheet data sparked debate with some claiming it was misleading research. It reported that Australians' intake of refined sugar was decreasing whilst the obesity rates have increased dramatically, suggesting that sugar may not play a substantial role in the Australian obesity epidemic (84). The researchers Jennie Brand-Miller and Alan Barclay received criticism for using data that was incomplete to arrive at their conclusion (85). Furthermore, there were claims that the two nutritionists involved have tight links with the sugar industry, including Barclay receiving money from Coca-Cola to give a presentation on sugar (86). Although the researchers have refuted all claims that their research is misguided or that their links to the sugar industry had any effect on their research outcomes, this highlights a significant question that plagues research: how do associations between industry and researchers influence research results(86)? A study by Lesser *et al.* found that 'scientific articles about commonly consumed beverages funded entirely by industry were approximately four to eight times more likely to be favourable to the financial interests of the sponsors than articles without industry-related funding' (87). If more effective methods of assessing free sugars intakes are made available, relationships between sugars and health outcomes will be easier to define. Using predefined methods to determine intakes of free

sugars could increase transparency, which may prevent such controversies from playing into the hands of the sugar industry.

Although the terms added and free sugars are sometimes used interchangeably, free sugars can provide a better understanding of how food formulations can add to unnecessary sugar consumption. As the public has become increasingly wary of added sugars in their diet, the food industry has been forced to develop creative ways of promoting sugary products to the health conscious consumers. The industry uses fruit juice and fruit juice concentrates to create products which are perceived as natural or healthier, as their source of sweetness comes directly from fruit (88). Research by Munsell *et al.* looked at parents' perceptions of sugary drink options and found that fruit drinks were six times more likely to be seen as healthy compared to soda, even though the average calorie and sugar content was identical (88). The use of fruit juice and its concentrates is not confined to beverages but extends to other products such as to add sweetness to baked goods. This trend is not limited to the food industry, with "sugar- free" recipes encouraging the home cook to use fruit juice concentrates as an alternative to traditional sugar, when in reality there is little or no difference in sugar content (89). WHO recommendations address this by defining free sugars to include fruit juice and its concentrates, capturing the use of these products as sweeteners, which had previously been missed by the 'added' sugar definition. Some may argue that consuming fruit juice does have some benefits, research by O'Neil *et al*. using the NHANES data (2003-2006) found a positive association between diet quality and the consumption of 100% fruit juice across all age groups, they concluded that fruit drink consumption should be encouraged in moderation as part of an overall healthy diet (90). As it is not yet clear the extent, the effect of free versus added sugars on health and diet quality are, it is essential that we continue to investigate the effect of these individually. Particularly as the food industry has the tendency to exploit ambiguities, for example, changes of labelling to include added sugars (such as

recently announced in the US) may result in increased use of juices and concentrates. Therefore, the difference in intakes between added and free sugars may be set to grow.

2.7 Rationale for research

Although there is an abundance of research surrounding sugar and its impact on health, it is still unclear exactly which diseases are most influenced and to what extent. As sugar is ubiquitous within the food supply, there is a potential for any relationships with health outcomes to be attenuated, due to positive health effects from some sources (fruits, vegetables and dairy products). To overcome this, there has been a move by health agencies and researchers to focus on sugars from discretionary foods, i.e. free sugars when creating recommendations or performing research (67). However, current research is limited by the lack of free sugars data for foods within food composition databases, both within NZ and internationally. This study has the potential to provide researchers in NZ with information on free sugars within foods that is currently lacking. This may enable research relating to free sugars and health to be more readily performed, particularly in the context of NZ. Thus, having a flow-on effect, impacting on the political climate surrounding sugar, as progressive policy changes are often prevented due to lack of supporting evidence.

Furthermore, it will provide much needed information about current NZ intakes of free sugars, providing insight into which population groups may be at the greatest risk of some of the adverse health effects relating to high sugar intakes. Information on intakes of free sugars will also help clarify whether changes in total sugar intakes are due to a reduction in discretionary foods, or other changes, such as the reduction of fruits or dairy. It will enable comparison between NZ intakes and international recommendations, (such as WHO's), and help to inform discussion regarding implementing similar recommendations in NZ.

3 Objective Statement

The New Zealand food composition database does not currently contain information on free sugars content of foods. As a result, there have been no previous estimates of free sugar intakes in New Zealand. The aim of this study was to develop a free sugar estimates for all foods contained in the NZFCD from 2006 until present to enable estimation of free sugar intakes of NZ adults and the proportion meeting the current WHO recommendations for free sugars.

The study objectives are:

- To modify a previously developed systematic methodology created by Louie *et al*. to ensure its appropriateness for estimating free sugars.
- To develop estimates for all foods contained in the NZFCD from 2006 until present (FOODFiles 2006 and 2010 databases).
- To create estimates for intakes of NZ adults of free sugars based on data from the NZANS 08/09 in conjunction with the created free sugar database.
- To compare estimated intakes of free sugars for NZ adults with WHO recommendations.

4 Methodology

4.1 Study design

Estimates of free sugars were created for each food record in the NZFCD, using a modified version of the method created to estimate added sugars by Louie *et al.* (91). Adaptions were made due to the differences in definitions between free and added sugars and to increase accuracy when being used on NZFCD. To determine estimates of NZ free sugar intakes, secondary data analysis of the NZANS was performed on individuals who provided a 24-hour diet recall. As this study involves secondary analysis of the NZANS, no ethical consent was required.

In this work the term 'free sugars' was defined based on WHO's definition which is 'all monosaccharides and disaccharides added to foods by the manufacturer, cook, or consumer, plus sugars naturally present in honey, syrups, and fruit juices', including fruit juice concentrates (21).

4.1.1 Free Sugars Database Development

A 10 step method was used to estimate free sugars based on the published methods of Louie *et al.*, **Table 4-2** describes the decision-making process used (91). Two researchers collaboratively developed added and free sugars estimates for all food items. Researchers met weekly to check for consistency in decision-making processes. Where discrepancies existed, decisions were adjudicated by the study supervisors. Once estimates had been completed, a fourth expert reviewed the data to ensure assumptions and estimates were as accurate as possible. For subjective decisions where a foods ingredient list was required, researchers attempted to locate the item in local food stores. If it was not possible to find a product locally, then further product information food items were sourced from company websites.

FOODfiles data on macronutrients, moisture retention factors, and a breakdown of individual sugar types for each food designed by Plant and Food Research Ltd was accessed using the Kai-calculator dietary assessment software (Version 1.12, Department of Human Nutrition, University of Otago) (92). FOODfiles also listed brand information, so it was possible to determine which foods were available; foods no longer available were estimated using a substitution of a similar product.

Free sugars values were estimated for all 2779 foods and recipes contained in the 2006 and 2010 FOODfiles using the 10-step method outlined below. Steps 1-6 were objectively determined and steps 7-10 were objectively determined.

4.2 10 Step Method to estimate free sugars

The following process outlines the methodology used to estimate free sugars content of foods from the NZFCD. **Figure 4-2** shows a flowchart of this decision making process.

1. **All foods with a total sugar content of 0g were assigned 0g free sugars.**
2. **All foods in the following groups were assigned 0g of free sugars;**
    a) All spices and herbs.
    b) All fats and oils.
    c) All plain cereal grains, pasta, oats, rice and flours.
    d) All plain breads, including pizza bases, pita, naan, English muffins (excluding gluten free breads).
    e) Unfilled plain pastries which do not contain, chocolate, nuts or dried fruits.
    f) Eggs and egg products (except egg-based desserts).
    g) Fresh fruit, unsweetened dried fruit and fresh vegetables.

h) Nuts and seeds (excluding nut/seed bars and coated nuts/seeds).

i) Fresh meat, fresh seafood, tofu and unsweetened legumes (fresh, dried or processed).

j) Non-sweetened coffees, tea and alcohol (excluding liqueurs and mixers).

k) Non-sugar-sweetened milk and dairy products (including those sweetened with artificial sweeteners only).

3. All foods in the following groups had 100% of sugar assigned to free sugars;

(a) All sugars and syrups.

(b) All confectionary (excluding chocolate) and potato chips.

(c) Coffee and beverage bases.

(d) All fruit juices, purees, concentrates and jams – both sweetened and unsweetened varieties. Including tomato pastes, sauces and purees.

(e) Sugar sweetened soft drinks, sports drinks, flavoured waters and energy drinks.

(f) Non-cream based liqueurs.

(g) All baked goods such as biscuits, cakes, buns and crackers which did not contain fruit, chocolate or dairy products.

(h) Gluten free breads.

(i) All breakfast cereals and cereal bars with do not contain fruit pieces, chocolate or dairy products.

(j) Stock powder, dry or made up with water.

(k) Sauces and dressings, excluding pasta sauces and those which are vegetable based such as pickles.

(l) Processed meats including, pies, pastries, crumbed/battered meat AND seafood.

(m) Soy beverages and soy yoghurt without added fruits.

Step 4a: Calculation based on standard recipe used in the food composition database where added sugar contents of ALL ingredients were available from steps 1 to 4

OR

Step 4b calculation based on known proportions of canned fruits and their juices/syrups.

Step 4a) Free sugars per 100g (FS_{100g}) is given by the following formula:

$$FS_{100g} = \frac{\sum_{i=1}^{j} W_i \times FS_i}{\sum_{i=1}^{j}(100\% + \%W_\Delta)}$$

Where W_i equates to the weight of the ith ingredient of the recipe. FS_i is the quantity of free sugars in the ith ingredient of the recipe and % WΔ is the percentage weight change of the recipe from cooking (91).

Example of Step 4: *R159, Banana Cake, NZ recipe (NZR)*

This food was a recipe based food in NZFCD which a moisture retention of 95% therefore the percentage weight change was 5%

Ingredients	**Weight(%)**	**Added sugars (g/100g)**
Butter, Salted	13.4	0
Egg, whole, raw	10.5	0
Baking Soda	0.5	0
Sugar, white	17.2	99.6
Flour, wheat, white, standard	29.4	0
Milk, fluid, whole	3.3	0
Banana, flesh, fresh	25.4	0
Baking powder	0.4	0

FS_{100g} of the recipe = (13.4 × 0, + 10.5× 0, + 0.5× 0, + 17.2 × 99.6, + 29.4× 0,+3.3×0, +25.4×0, + 0.4× 0) / ((13.4+10.5+0.5+17.2+29.4+3.3+25.4+0.4) × (100%-+5%))

=18.03g

Canned Fruit

Step 4b) FS_{100g} of undrained canned fruits were determined using the following formula:

$$FS_{100g=}S_{T-(S_R}\times\%_R)$$

Where S_T is the total sugar, S_R is the sugar content of the raw fruit and $\%_R$ is the proportion of raw fruit in the can of fruit.

See **Table 4-1** for worked example.

Step 5: Calculation based on comparison with values from the unsweetened variety.

Free sugars per 100 g (FS100g) is given by the following formula:

$$FS_{100g} = \frac{100 \times (S_{US}) - (S_T)}{S_{US} - 100}$$

Where S_{us} is the total sugar content per 100 g of the unsweetened variety of the food and S_T is the total sugar listed for the food which free sugars value is to be determined.

Example of step 5: L137 Pears, cooking with sugar, stewed contains 16.9g of total sugar per 100g

A comparable unsweetened variety is available:

L138 Pears,cooking,fl&jui,w/o sugar,stewed with 8g total sugars per 100g and no added sugars.

FS_{100g} = (100 x (8 – 16.9))/(8 – 100) = 9.68g

Step 6: Analytically determine the content of free sugars using the various subclasses of sugar.

Foods containing lactose (that contained no fruit or nuts) were classified using this step, for example, cakes or yoghurts without fruit pieces. Lactose was removed from the total sugar content to determine sugars which were coming from milk or milk solids.

See **Table 4-1** for worked example.

Step 7: Estimated using borrowed values from similar foods that had previously been determined using steps 1 to 6 OR using an overseas database.

Free sugars were estimated by determining the proportion of free sugars to total sugar from the borrowed food, then using this proportion on the food to be estimated with the equation total sugars × %FS (from the borrowed food). Values borrowed from similar product(s) that have previously been determined using steps 1-6 of this method should be preferably chosen in this step. However, if there were no appropriate foods in the NZFCD, then borrowed values were obtained from either the Australian food composition database (AUSNUT 2007) or from recipes within the FOODfiles database. See **Table 4-1** for worked example.

Step 8: Subjective estimation based on the best available information regarding ingredients and/or common recipes and/or assumptions.

The following diagram describes which subjective methods were utilised and in which order as to maximise the reliability of the estimates being made.

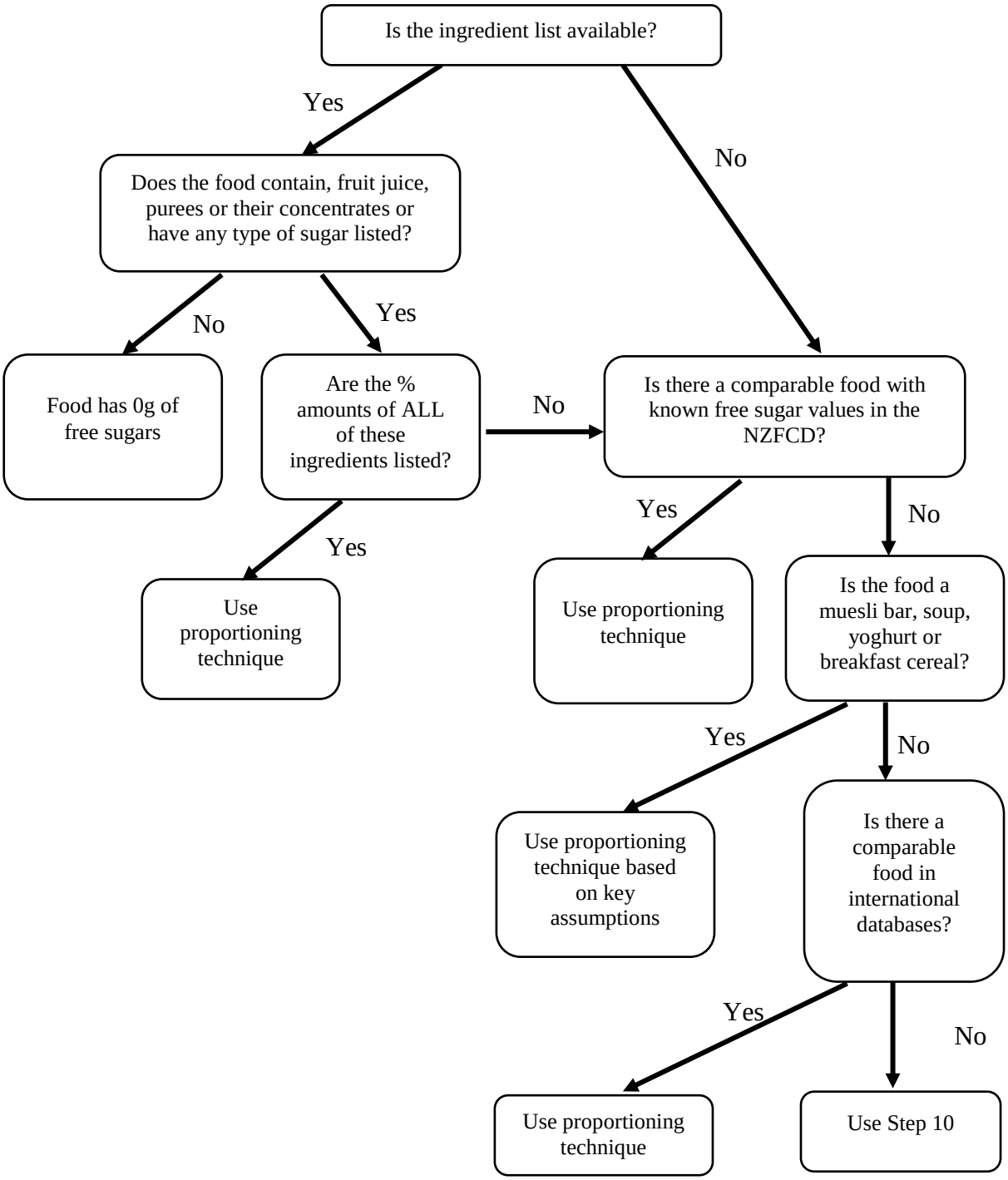

Figure 4-1 Decision making process for subjectively estimating free sugars based on ingredient list, common recipes or further assumptions

Step 9: Calculation based on standard recipe used in the food composition database where content of free sugars of ANY of the ingredients was determined by using steps 5-10

Step 10: 50% of total sugars were assumed to be free sugars.

Step 10 was used when it was not possible to determine content of free sugars in any of the prior steps. This step was predominantly used for takeaways, such as pizzas and burgers. Additionally, it was used on some soups, sauces and miscellaneous foods

4.3 Additional assumptions:

If there was insufficient information available on a food product to accurately determine the content of free sugars additional assumptions were made **(Table 4-1).**

Muesli bars, yoghurts and soups were foods which are frequently reformulated. Many varieties included in the 2006/2010 FOODfiles are no longer available and so if it was not possible to accurately match with currently available varieties. Thus, a standardised percentage for fruit content was created for muesli bars and yoghurt based on averages of those currently available for purchase. These items were categorised on the basis of pictures of the listed products available online via Google search. Dried and stewed fruits not listed in FOODfiles were substituted with appropriate fruits that had similar sugar contents, for example, tropical fruits were compared with dried apricots.

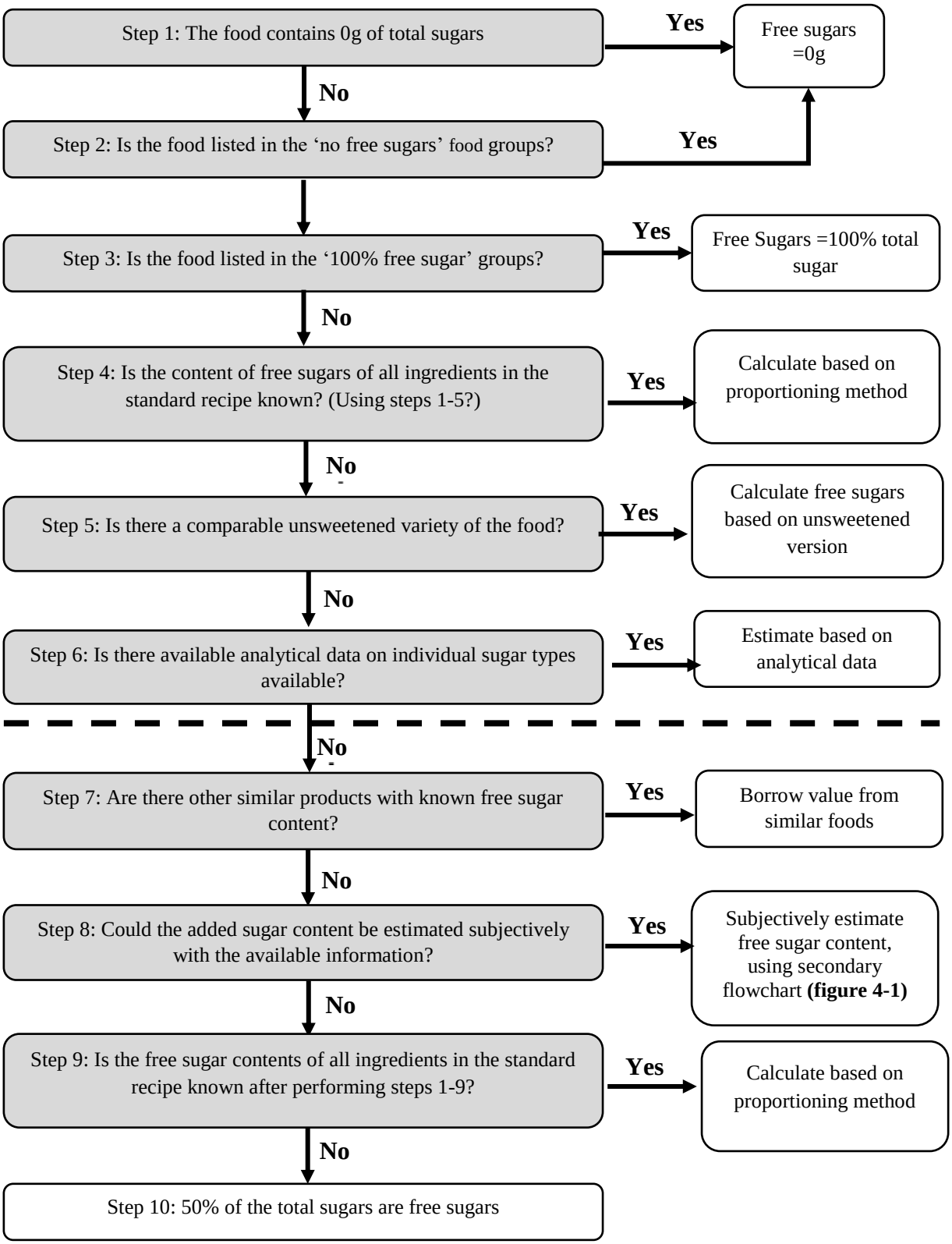

Figure 4-2 Flow chart of decision making process for estimating free sugar intakes

Table 4-1 Assumptions developed for estimating free sugars

Food Category	Sub Category	Assumptions	Step	Rule	Example
Canned Fruit	Undrained (syrup or juices)	Intake of free sugars of canned fruit was estimated by working out the average proportion of fruit per can (looking at various brands i.e. Watties, Oak, Golden Circle, Pams, Budget and Dole) Proportion was multiplied by the amount of sugar found in the whole fruit and then this total amount was taken away from the total sugars, all the rest of the sugars was assumed to come from fruit juice or other free sugars.	4b		L205 Pineapple canned in Light Syrup L205 contains 16.3g of total sugar. A raw pineapple (L144) contains 11.4g of total sugar. Pineapple in syrup was found to have an average of 65% fruit on average, across all brands. Therefore; FS= 16.3-(11.4 x 0.65)= 8.91g
	Drained (syrup)	Compared with raw version of the fruit	5		
	Drained (Juice)	Assume that after draining the juice that there are zero free sugars	2		
Soup	With recipes	Free sugars determined through recipe proportions	4		
	Containing only lactose	Soups only containing sugar from lactose assumed to have zero free sugars	6	Total sugar - lactose	V1005 Soup, seafood chowder, ready to serve, pouch. Contains 1.5g of total sugar and 1.5g of lactose 1.5-1.5 = 0g Free sugars
	Commercial soups	Commercial soups that were comparable to homemade varieties were determined via the proportion of free sugars in the homemade variety,	7		Content of free sugars of commercial pumpkin soups i.e. V1001 assumed to be 7% based on homemade pumpkin soup V34
	Tomato soups	Based on the ingredients list of a number of tomato soups, which stated approximately 90% tomatoes in ingredients.	8	10% free sugars	

Food Category	Sub Category	Assumptions	Step	Rule	Example
	Condensed tomato Soups	Based on 'regular' tomato soups, the proportion of free sugars was increased based on the increased concentration of ingredients.	8	20% free sugars	
	'Other soups'	Soups not covered in above categories assumed to be 50% free sugars	10	50% free sugars	
Yoghurt	With puree	Such as 'fruit corners', assumed to be all free sugar minus lactose	6	100% free sugars	
	'Other'	Flavoured with fruit pieces- assumed to be apricot (stewed without sugar) unless otherwise stated due to apricot flavours popularity and similarity (sugar content) to other flavours such as mango or peach. Fruit proportion was based on yoghurts currently available for purchase	8	7% Fruit	F55 Yoghurt,asst fruits & flvr,red fat,swt. Total sugars = 14.1 Lactose =3.9/100g Assumed 7% stewed apricot (L25 with 5.4/100g of sugar) =14.1-(5.4*0.07)-3.9 =9.82/100g free sugars
Muesli bars	With fruit pieces OR fruit and nut bars	Assumed to have 20% dried fruit based on current muesli bars available for purchase. Total sugars from dried apricots (L26, 44.9/100g total sugar) were used if the fruit was not specified	8	20% dried fruit	U1 Muesli bar,apricot Total sugar =15.51 Lactose=0.4 =15.51-(0.20*44.9)-0.4 =6.13/100g free sugars
	Fruit filled	Treated as a puree so assumed to be all free sugars (minus any lactose)	3	100% free sugars	
Currant breads	All	Assumed to have zero added sugars as once a standardised % of dried fruit was removed (20%) the remaining sugar level was comparable to that of normal bread.	8	0% free sugars	

Food Category	Sub Category	Assumptions	Step	Rule	Example
Discretionary foods		Such as confectionery (excluding chocolate) potato chips etc. were considered to be 100% free, even if derived from food ingredients such as milk	3	100% free sugars	
	Chocolate	Milk solids were assumed to be an inherent part of the product i.e. not being utilised as a sweetener. Therefore, content of free sugars of plain chocolate was total sugar-lactose. Any fruit or nut varieties were determined via Step 8 through proportioning	6	Total sugar-lactose for plain chocolate	
Flavoured drink powders	E.g. Milo, Ovaltine	Considered a drink sweetener therefore 100% of sugar was free sugars (including lactose)	3	100% free sugars	
Breakfast cereals	All cereals	Determined by ingredients listed and their proportions Cereals no longer still available were matched to a similar currently related product All dried fruits (excluding dried purees) which were not available on FOODfiles were matched to one of four dried fruits (sultanas, raisins, dried apricots and cranberries). Sugar in dried purees was assumed to be 100% free sugars If proportions of fruit were not broken down into each individual food type, then it was assumed to have equal proportions of each fruit, e.g. Ingredient list stating 'dried fruit 20% (dried apricots and sultanas)' would be assumed to have 10% of both dried apricots and sultanas, respectively.	8		D1019 Muesli,'Natural fruit & five grains',Sanitarium 20.5/100g of total sugar 0g of lactose Listed as having 22% dried apricots and sultanas however proportions of each is not listed. Assumed 11% dried apricots (L26 with 44.9/100g sugars) Assumed 11% sultanas (L173 with 73.2g/100g sugars) =20.5-(44.9*0.11)-(73.2*0.11) = 7.5/100g free sugars

4.4 Estimation of intake of free sugars in NZ adults

Data for all foods included in the NZANS 08/09 were analysed using Kai-culator, (version 1.12, Department of Human Nutrition, University of Otago) dietary assessment software, that uses the NZFCD (The New Zealand Institute for Plant & Food Research Limited, 2010)(92)

4.4.1 NZANS Methodology

The following provides a brief overview of the methodology behind the NZANS 08/09. This detail should be sufficient for understanding the survey in regards to its importance to this project. A full account of the methodology used is outlined in the '*Methodology Report for the 2008/09 New Zealand Adult Survey'* (93).

The NZANS 08/09 was a national population based nutrition survey. The target population was individuals that were civilian residents, 15 years and older who lived in permanent private dwellings in NZ. In total, there were 4721 adult participants, including 1040 Maori and 757 Pacific Islanders. To obtain a representative sample, 'screening' occurred to ensure oversampling of certain ethnic groups and older and younger age groups.

The survey was carried out from October 2008 to October 2009. The interviews were carried out in the participants' homes. Data collected included the following; sociodemographic information, 24-hour diet recall, and questionnaires on dietary habits, dietary supplement use, nutrition related health. A Multiple-pass 24-hour diet recall was collected from 4721 participants and a second recall from 25% of these (93). Interviews were conducted on all days of the week, aiming for a relatively even spread on each day – including a minimum of 10% of interviews occurring during the weekend.

Foods and beverages from the 24-hour recall were matched to foods in the NZFCD which was then converted to nutrient data using the electronic database of NZFCD called FOODfiles. In

total, there were 11,850 unique food descriptors reported by all participants, wherever possible these foods were matched to a nutrient line in FOODfiles (approximately 25% of foods). When a direct match could not be made in FOODfiles, international databases such as the USDA or NUTTAB 2006 were considered. If it was inappropriate to use an international database and if a food was consumed in high frequency or contributed significantly to energy or nutrient intake, then it was considered for analysis by Plant and Food Research.

4.5 Statistical analysis

The statistical software package STATA v13 was used to analyse the data. The NZANS 08/09 24-hour recall data was reanalysed in Kai-caluator to produce a new nutrient line for each participant including free sugars. Nutrient intakes were adjusted for intra-individual variability using the multiple source method (MSM) using data from second 24-hr recall collected from 25% of participants (94).

To ensure results were representative of the total NZ adult population, data from each participant was weighted in all analyses of means, medians, percentiles and proportions. Population means and standard deviations were estimated using the survey command in STATA. Intakes for the whole population and specific demographic categories (age, ethnicity and sex) were reported in grams and %TE by mean, 10^{th}, 50^{th} and 90^{th} centiles. Age was determined using the participant's date of birth in conjunction with the interviews start date or participants reported age. Participants were then grouped into four age categories. For the purpose of analysis priority ethnicity (prioritised in order of Maori, Pacific and NZEO). NZEO was a combination of NZ Europeans and Other (mainly Latin-American, African, Middle-Eastern and Asian). 'Other' ethnicities were grouped with 'European' due to the small numbers of participants from these groups.

Subsequently, the percentage of the population (by ethnicity, sex and age class) meeting the WHO 5% and 10% recommendations for free sugars were then reported.

Differences between sugars estimates reported for the NZANS and this report can be attributed to a number of factors: 1) we assigned participants to three ethnic groups based on the prioritised ethnicity method where the NZANS using the total response method, and 2) the NZANS used a different method to calculate intra-individual variability (PC-side). The MSM method is simple and reliable and has also been used in similar studies evaluating free sugar intakes from a national survey (46, 95).

5 Results

5.1 Estimation of content of free sugars of NZFCD foods

Overall 2779 foods from the NZFCDB were assigned a free sugar value, of which 2543 (91.5%) were estimated based on objective criteria (Steps 1-6) and 236 (8.5%) were estimated based on subjective (Steps 7-10) criteria **(Table 5-1)**. Typical foods types that used subjective steps to estimate free sugars included breakfast cereals, muesli bars, soups, yoghurts and fast foods. 76.3% of foods were calculated using the first three (objective) steps.

Table 5-1 Steps used to estimate free sugars in the NZFCD

Step used	n	%
Step 1	685	24.6
Step 2	1017	36.6
Step 3	419	15.1
Step 4	203	7.3
Step 5	39	1.4
Step 6	180	6.5
Step 7	39	1.4
Step 8	113	4.1
Step 9	7	0.3
Step 10	77	2.8
Total objective (Step 1-6)	2543	91.5
Total subjective (Step 7-10)	236	8.5
Total	2779	100%

5.1.1 Estimated intakes of free sugars

In the NZ adult population, the median estimated intake of free sugars was 57 g/day, which equated to 53% of estimated total sugar (107 g/day) **(Table 5.2, Appendix A)**. Men consumed significantly more free sugars than women (64g 95%CI: 60,68g, and 51g 95%CI: 48,53g; respectively). When examining intakes by age categories, older men (31+ years) had significantly higher intakes than women, however amongst younger age class categories (15-30 years), there were no differences in intakes between men and women **(Table 5-2)**. Men

also consumed a statistically significantly higher quantity of total sugars, sucrose and added sugars **(Appendix A, C, E)**. Pacific men aged 19-30 years consumed the highest amount of free sugars (median intake of 91g/day) **(Table 5-2)** and Maori men aged 19-30 years consumed the highest amount of total sugars (median intake of 136g/day) **(Appendix A)**. The lowest intakes of both total sugars and free sugars were amongst Pacific females aged 51 years and older (median intake of 70g/day and 28g/day, respectively) **(Appendix A and Table 5-2)**. There were no significant differences between absolute intakes of free sugars between the different ethnicities; however, **Figure 5-1** shows there was a trend for Maori men and women to consume higher quantities compared to NZEO or Pacific people. When comparing younger age groups (15-18 and 19-30 years) with older age groups (31-50 and 51+ years), younger age groups had statistically significantly higher intake of free sugars **(Table 5-2)**.

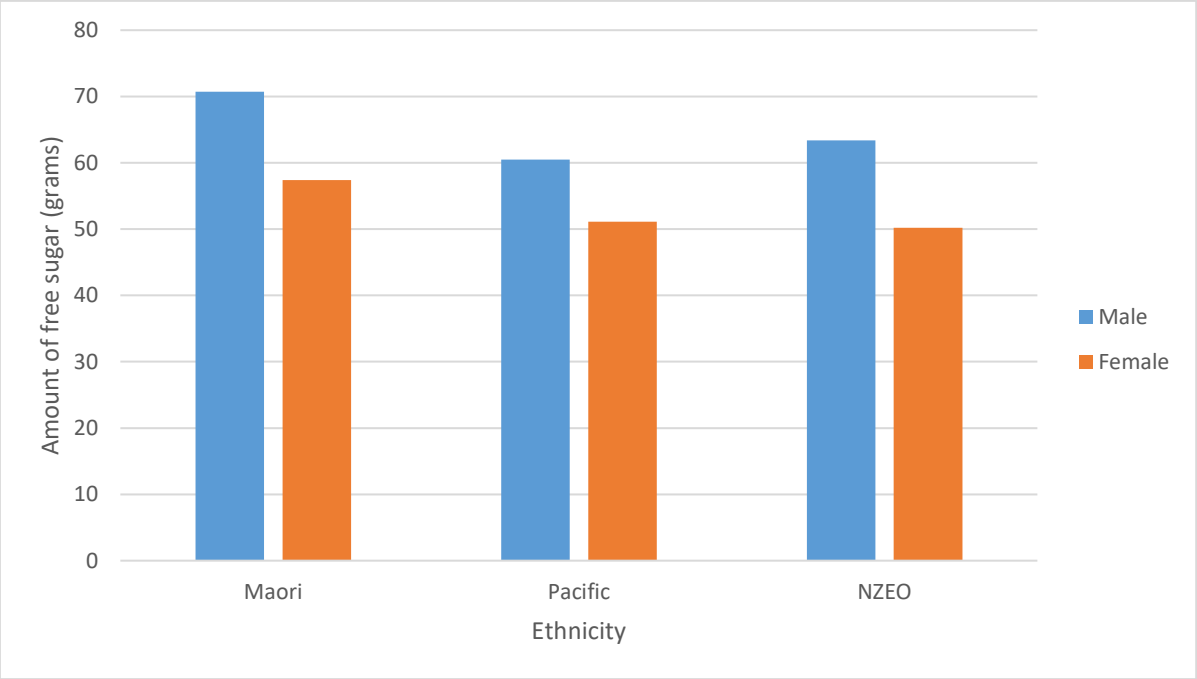

Figure 5-1 Median intake of free sugars (g/day) by ethnicity in the NZANS 08/09

Table 5-2 Intake of free sugars (g/day) by age group, ethnic group and sex for NZANS 08/09

		Free sugars (g/day)[1]			
		Mean	10th[2]	Median(50th)[2], 95% CI	90th[2]
Total population		66	20	57 (55, 59)	121
By age group (years)					
Males	15-18	89	27	84 (76, 91)	150
	19-30	91	31	75 (67, 83)	167
	31-50	76	26	68 (62, 73)	134
	51+	58	16	51 (48, 54)	104
	Total	73	22	64 (60, 68)	134
Females	15-18	80	26	71 (66, 76)	137
	19-30	78	25	65 (58, 72)	143
	31-50	57	21	50 (46, 53)	104
	51+	48	17	42 (39, 46)	87
	Total	59	19	51 (48, 53)	110
Maori					
Males	15-18	92	34	88 (70, 106)	150
	19-30	99	26	85 (66, 105)	172
	31-50	78	27	64 (51, 78)	153
	51+	48	11	42 (33, 51)	93
	Total	79	20	71 (62, 79)	150
Females	15-18	82	22	75 (56, 93)	136
	19-30	81	24	69 (58, 80)	146
	31-50	64	21	57 (49, 66)	112
	51+	45	12	36 (29, 43)	87
	Total	67	20	57 (51, 63)	132
Pacific					
Males	15-18	74	17	62 (47, 76)	156
	19-30	96	38	91 (63, 119)	155
	31-50	64	21	53 (44, 62)	130
	51+	65	14	52 (44, 61)	132
	Total	75	21	61 (53, 68)	154
Females	15-18	75	26	66 (48, 83)	116
	19-30	77	23	62 (49, 80)	129
	31-50	59	22	52 (46, 58)	111
	51+	44	10	28 (23, 33)	88
	Total	63	19	51 (46, 56)	114

		Free sugars (g/day)[1]			
		Mean	10th[2]	Median(50th)[2], 95% CI	90th[2]
NZEO					
Males	15-18	60	25	86 (80, 93)	145
	19-30	90	31	72 (63, 82)	167
	31-50	76	27	69 (63, 75)	133
	51+	58	17	52 (48, 55)	105
	Total	73	22	63 (59, 67)	128
Females	15-18	80	27	71 (64, 78)	141
	19-30	77	26	64 (56, 72)	143
	31-50	55	21	49 (45, 53)	101
	51+	48	17	43 (40, 47)	82
	Total	58	20	50 (47, 53)	105

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

The median intake of NZ adults by %TE was 11.1% with a trend towards lower % TE from free sugars in both men and women as age increased, with the highest intakes being in the 15-18 year age group and the lowest intakes being in the 51+ years age group **(Figure 5-2, Table 5-3)**. There was no difference in % TE from free sugars between men and women; however, there was a trend towards higher intakes amongst younger women (15-30 years) compared with younger men **(Figure 5-2). Figure 5-3** shows Maori consume the highest and Pacific people consumed the lowest %TE from free sugars **(Table 5-3).**

Table 5-3 Total free sugars as a percentage of total energy by age group, ethnic group and sex for NZANS 08/09

		Free sugars (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], (95% CI)	90th[2]
Total population		11.8	5.0	11.1 (10.7, 11.4)	19.4
By age group (years)					
Males	15-18	13.8	5.7	13.0 (11.9, 14.1)	21.7
	19-30	13.7	6.1	12.1 (10.9, 13.3)	23.2
	31-50	11.5	5.0	10.9 (10.2, 11.7)	18.2
	51+	10.5	4.0	10.1 (9.5, 10.7)	16.7
	Total	11.8	4.9	11.0 (10.5, 11.4)	19.1
Females	15-18	15.6	7.1	14.7 (13.6, 15.8)	24.9
	19-30	14.2	6.7	13.7 (12.7, 14.7)	22.1
	31-50	11.3	5.1	10.6 (9.8, 11.5)	18.7
	51+	10.5	4.4	9.7 (9.2, 10.2)	17.3
	Total	11.9	5.1	11.1 (10.7, 11.5)	19.6
Maori					
Males	15-18	14.1	6.7	13.8 (10.8, 16.7)	20.2
	19-30	13.7	5.2	13.3 (12.2, 14.5)	21.8
	31-50	11.7	5.4	10.6 (9.3, 11.9)	19.8
	51+	9.7	3.0	8.4 (6.9, 9.9)	16.6
	Total	12.1	4.9	11.7 (10.8, 12.6)	20.2
Females	15-18	16.5	7.1	17.3 (13.7, 20.9)	25.4
	19-30	14.1	5.2	13.7 (12.1, 15.3)	22.6
	31-50	12.5	6.0	12.2 (10.7, 13.7)	21.4
	51+	9.9	3.2	8.9 (7.5, 10.4)	17.7
	Total	12.9	5.3	12.1 (11.2, 13.0)	21.4
Pacific					
Males	15-18	11.7	4.4	9.1 (5.6, 12.6)	20.5
	19-30	14.3	6.4	13.0 (10.5, 15.6)	25.4
	31-50	10.3	4.3	9.1 (7.6, 10.5)	16.9
	51+	11.0	4.0	10.2 (8.6, 10.8)	17.6
	Total	11.7	4.8	10.6 (9.7, 11.6)	20.1
Females	15-18	15.3	5.5	14.7 (12.1, 17.4)	26.4
	19-30	13.4	5.5	12.8 (11.6, 14.1)	27.6
	31-50	11.0	5.5	10.3 (9.2, 11.4)	17.0
	51+	9.4	3.0	7.9 (6.4, 9.3)	18.5
	Total	11.8	4.6	10.8 (10.0, 11.7)	20.5

		Free sugars (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], (95% CI)	90th[2]
NZEO					
Males	15-18	13.9	5.5	13.1 (12.0, 14.3)	22.2
	19-30	13.6	6.1	11.8 (10.5, 13.2)	22.4
	31-50	11.5	5.1	11.1 (10.2, 12.0)	17.9
	51+	10.6	4.4	10.2 (9.6, 10.8)	16.7
	Total	11.7	4.9	10.9 (10.5, 11.4)	18.9
Females	15-18	15.3	7.4	14.1 (13.0, 15.3)	23.6
	19-30	14.3	6.9	14.3 (13.2, 15.4)	22.0
	31-50	11.2	5.0	10.6 (9.5, 11.7)	18.3
	51+	10.6	4.6	9.8(9.2, 10.4)	17.1
	Total	11.8	5.1	11.0 (10.6, 11.5)	19.2

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

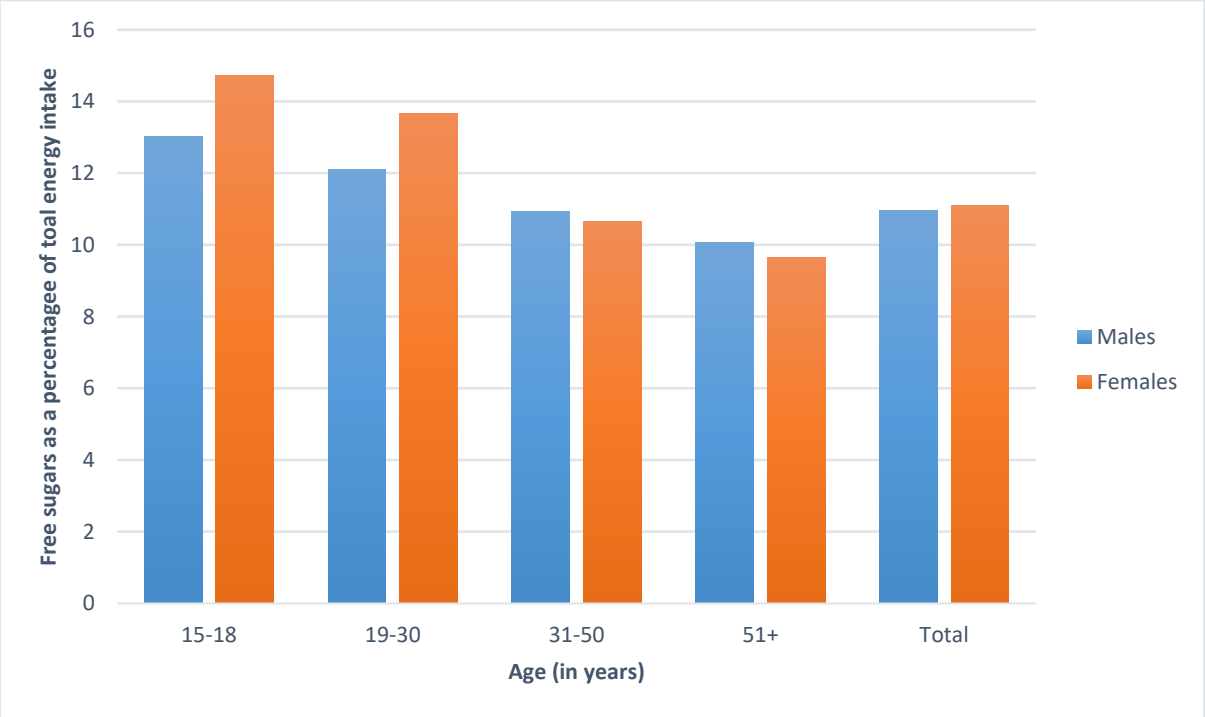

Figure 5-2 Percentage of total energy intake from free sugars in the NZANS 08/09

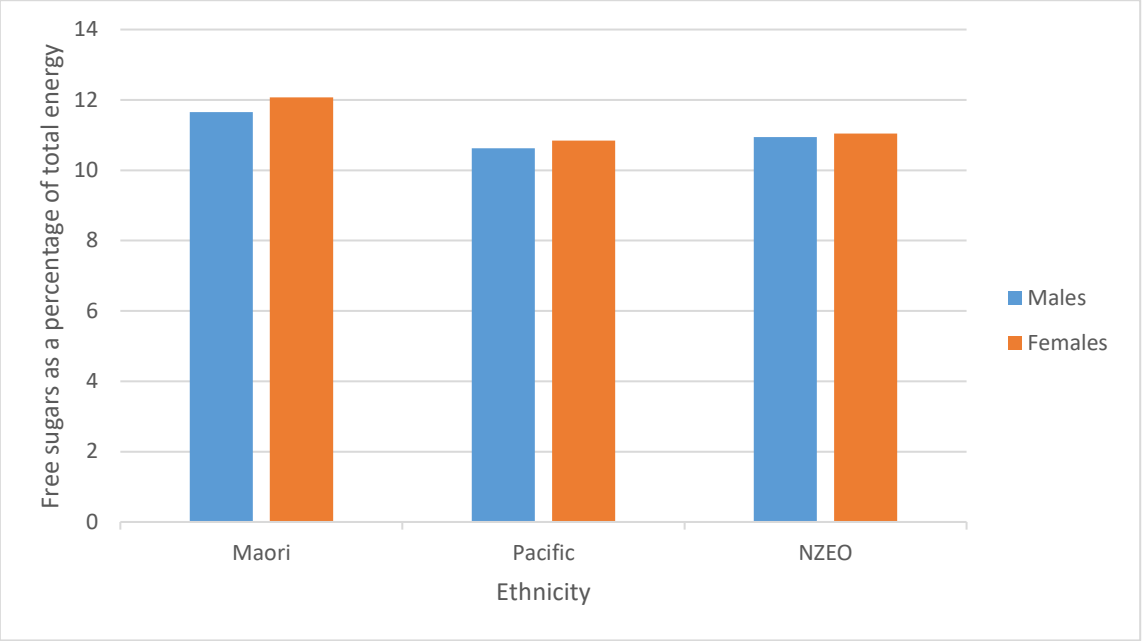

Figure 5-3 Free sugars by % of TE and ethnicity in the NZANS 08/09

5.1.2 Comparison between sugar categories

Median total sugars intakes were approximately twice that of the various sugar sub-categories (sucrose, free sugars, and added sugars) **(Figure 5-4, Figure 5-5)**. Free sugars estimates were significantly higher than both sucrose and added sugar estimates, in terms of both absolute intakes and as a percentage of total energy intake. There was a significant difference between the median population intake (g/day) of free sugars (57g, 95%CI: 55, 59) compared with added sugar (49g, 95%CI: 47, 51) and sucrose (48g, 95%CI: 46, 50) **(Table 5-2, Appendix C, Appendix E).** However, there was no statistical difference between sucrose and added sugar estimates. Likewise, the median % TE of free sugars (11.1%, 95%CI: 10.7, 11.4) was also significantly higher than both added sugar (9.5%, 95%CI: 9.3, 9.8) and sucrose (9.6%, 95%CI 9.4, 9.8) but was not statistically different between sucrose and added sugars **(Table 5-3, Appendix D, Appendix F)**.

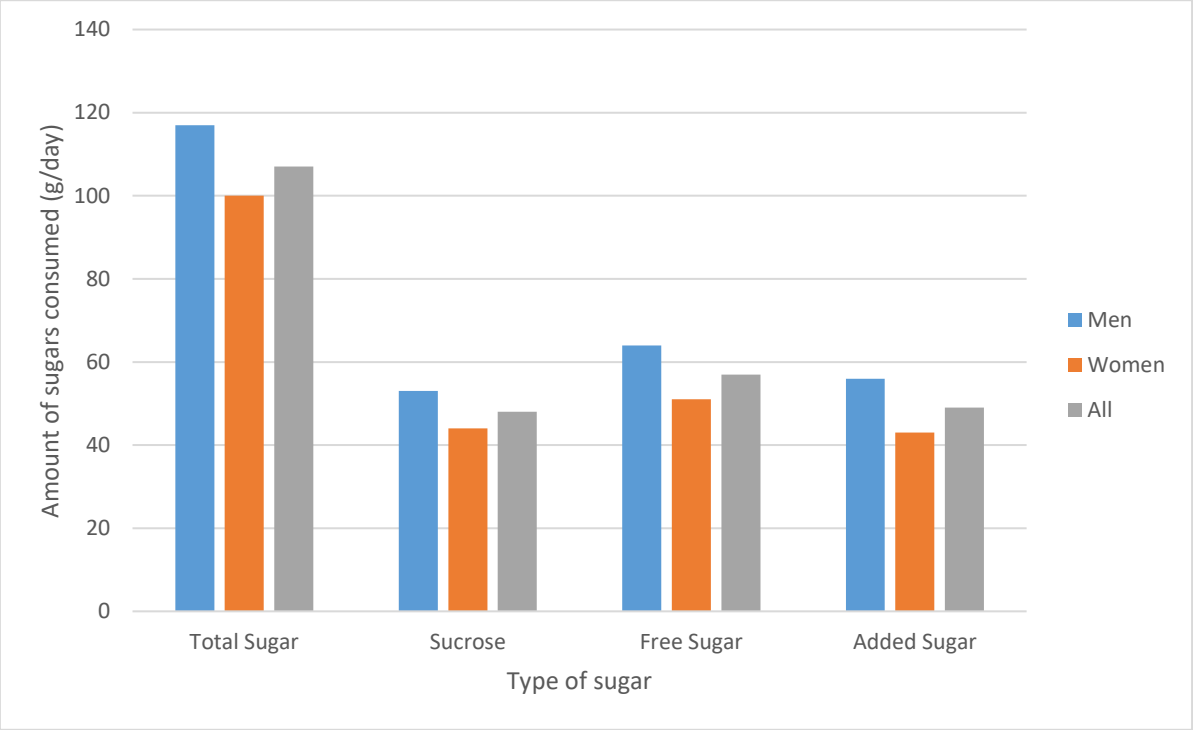

Figure 5-4 Comparisons of median sugar intakes (in g/day) across the different sugar types in the NZANS 08/09

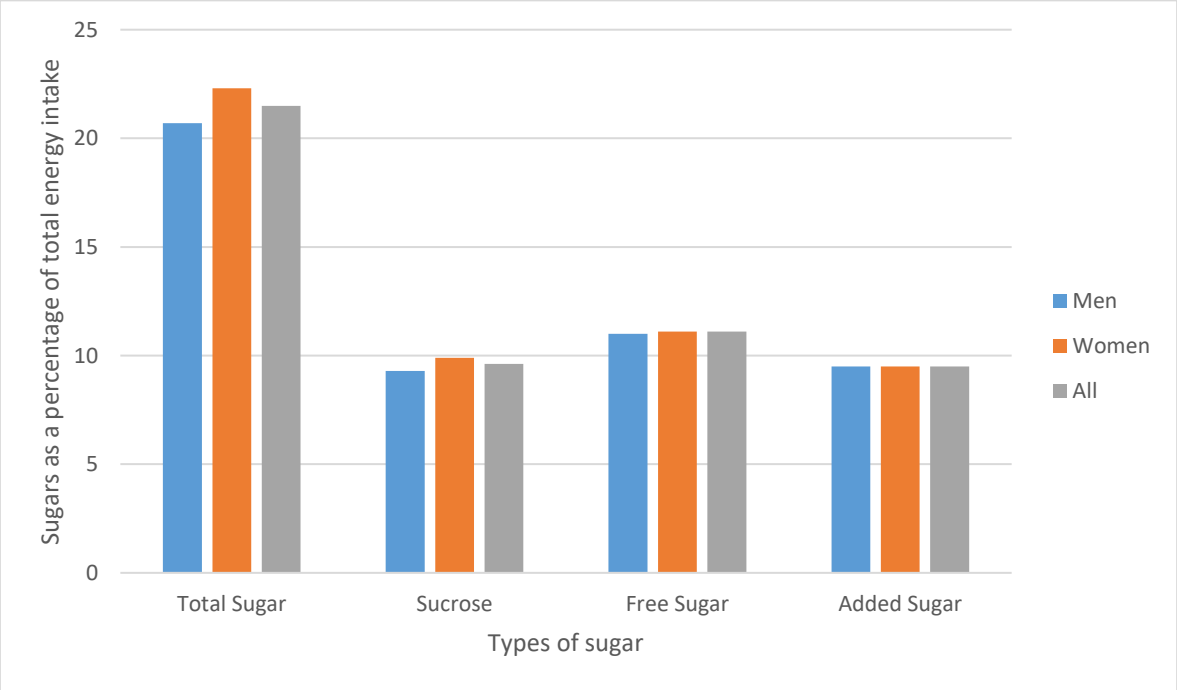

Figure 5-5 Comparisons of median sugar intakes (%TE) across the different sugar types in the NZANS 08/09

5.1.3 Comparisons of intakes of free sugars with WHO recommendations

Of the total NZ adult population, 42.2% met WHO recommendations that intakes of free sugars should be <10% TE intake, and only 9.5% of subjects met the conditional recommendation that free sugars intakes should be <5% TE intake **(Table 5-4)**. There is little variability between the sexes with 42.7% of men and 42.1% of women meeting WHO's recommendation for free sugars <10%TE, and 10.0% of men and 9.1% of women meeting WHO's recommendation for free sugars < 5%TE. The group with the poorest adherence to WHO's recommendations was NZEO females aged 15-18 years with 21.6% meeting the <10% TE from free sugars recommendation and 3.3% meeting the <5% TE from free sugars recommendation. The group most likely to meet WHO's recommendation for free sugars <10%TE were older Pacific females aged 51+ years (64.0%), whereas Maori males aged 51+ years were the most likely to meet WHO's <5% TE from free sugars recommendation (23.8%). The median intake of free sugars (%TE) for the entire population was higher than WHO's 10% recommendation (11.1%). Intakes in the lowest 10^{th} centile were 5%TE or less (at the upper limit of WHO's recommendation that free sugars intakes are <5%TE) **(Table 5-3).**

Table 5-4 Proportion of the population from the NZANS 08/09 meeting WHO recommendations for intakes of free sugars

		% meeting WHO recommendation free sugars < 10% TE intake	% meeting WHO recommendation free sugars < 5% TE intake
Total population		42.2	9.5
By age group (years)			
Males	15-18	28.5	6.8
	19-30	30.3	7.4
	31-50	45.2	10.4
	51+	49.4	11.8
	Total	42.7	10.0
Females	15-18	22.3	3.5
	19-30	27.4	5.8
	31-50	45.4	8.7
	51+	52.4	12.5
	Total	42.1	9.1
Maori			
Males	15-18	28.6	4.1
	19-30	31.9	9.6
	31-50	41.6	10.6
	51+	63.4	23.8
	Total	43.2	12.8
Females	15-18	24.2	3.2
	19-30	26.6	4.5
	31-50	39.6	8.4
	51+	58.9	19.9
	Total	38.9	9.5
Pacific			
Males	15-18	46.2	15.4
	19-30	34.3	5.7
	31-50	57.2	13.2
	51+	53.6	15.9
	Total	50.6	12.4
Females	15-18	23.7	5.3
	19-30	33.6	9.4
	31-50	51.0	6.4
	51+	64.0	22.7
	Total	45.9	10.3

		% meeting WHO recommendation free sugars < 10% TE intake	% meeting WHO recommendation free sugars < 5% TE intake
NZEO			
Males	15-18	26.7	6.4
	19-30	26.7	6.7
	31-50	40.3	8.6
	51+	47.0	9.6
	Total	39.9	8.5
Females	15-18	21.6	3.3
	19-30	24.0	4.7
	31-50	47.2	10.0
	51+	50.3	10.4
	Total	42.4	8.6

6 Discussion

The purpose of this study was, firstly to update the current NZFCD to include estimates of the content of free sugars in each food. This, in conjunction with data from the NZANS 08/09 allowed for estimates of intakes of free sugars for NZ adults to be created, with the intention of comparing these intakes with WHO recommendations.

Free sugars were estimated for 2779 foods in the NZFCD and 2543 (92%) were estimated by objective methods. As only a small percentage of free sugar values were estimated using objective steps (8%) this decreases the likelihood of bias and increases the reliability of free sugar estimates for the NZFCD. In comparison, Louie *et al* estimated 72% of foods in the Australian food composition database subjectively (91). The increased use of subjective steps in this study may be the result of the differences in definition between free and added sugars, as foods which had 100% of their sugars derived from fruit juice, fruit juice concentrates or honey could be objectively determined under a free sugars definition, but may require subjective decision making for added sugars. Furthermore, as the Australian food composition database contains more foods, it is likely that there was a greater amount of processed foods requiring subjective estimations.

Median intakes of free sugars were 64 g/day in men and 51 g/day in women equating to 11.0% and 11.1% TE from free sugars, respectively. Young males (15-18 years) had the highest intake with the top 10^{th} centile consuming 150g or more of free sugars daily - the equivalent to 37.5 teaspoons of sugar. Median intakes of free sugars in NZ were higher than recommendations set by WHO, particularly in certain sub-groups of the population, such as young adults. It was estimated that over 90% of the population were not meeting the WHO's conditional recommendation that free sugar intakes are <5% TE and a further 58% were not

meeting the WHO recommendation that free sugars are <10% TE. Young females (15-18 years) had the highest intakes by %TE (14.7%).

The youngest age group were the least likely to meet recommendations, with approximately 95% of 15-18 year olds failing to meet WHO's conditional recommendation free sugars intakes <5% TE. It is concerning that younger age groups have a much higher consumption of free sugars (for both absolute intakes and as %TE) than older age groups, as research indicates that eating habits formed early in life are typically maintained throughout the life course (96, 97). If higher consumption is maintained into older adulthood, we may see an increase in NCDs associated with high intakes of free sugars.

When comparing estimates from the current study with research relating to health outcomes, there is some cause for concern, particularly for people at the upper end of intakes. A study by Yang *et al.* (using NHANES data) investigated the relationship between consumption of added sugars and CVD mortality, found that those who consumed between 16.7% and 21.3% TE from added sugars had an increased risk of mortality of 49% (52). In the current study intakes of free sugars in the 90th centile were within this range (19.4% TE), which could equate to a substantially increased risk of CVD mortality for a considerable proportion of the population. Furthermore, Yang *et al.* found a dose response effect of increasing risk of CVD with increases in free sugars above 10%TE. The median intake of free sugars by %TE for NZ adults of the current study was 11.1%, suggesting that over half of the participants are at an increased risk of CVD mortality due to sugar consumption.

There are very few published studies regarding intakes of free sugars at a population level. A study by Lei *et al.* published in 2016 estimated Australian added sugar intakes using the same method proposed by Louie *et al.*, with similar results to the current study (46). Mean total and added sugar intakes were 114g/day and 65g/day, which was virtually identical to the estimated NZ mean total and free sugars intakes of 114g/day and 66g/day, respectively (91).

Sugars contributed 20% TE (total sugars) and 12% TE (added sugars) to the Australian diet which is comparable to the NZ mean total and free sugars estimates of 22% TE and 12% TE respectively; however, the Australian estimates included participants over 2 years old. As children had higher estimated percentage intakes of sugars, this would have increased the mean reported value for the total population. When adults in the Australian study were compared with the current study, %TE intakes were very similar across all age categories, most likely due to similarities in food and food patterns between the countries (98).

International studies comparing intakes of free sugars to WHO recommendations suggest that these targets will be challenging for most populations to meet. The study by Lei *et al.* found 55.7% of the population (aged over 2 years) did not meet WHO's 10% recommendation (added sugars were used as a surrogate for free sugars). The authors noted that the <5% TE from free sugars recommendation set by WHO might be too restrictive for the Australian population to reach. Similar comments by Erickson and Slavin based on added sugar intakes in the US population stated that it was unlikely to be "sustainable" for the general population (99). Only one other study was found that compared intakes of free sugars to WHO recommendations. The Dutch National Food Survey 2007-2010 found only 4% of adults aged 19-69 years consumed less than 5% TE from free sugars, reiterating how difficult reaching WHO's recommendation may be (95). Thus, it appears in the current food climate it is challenging to meet WHO recommendations, and that more action is needed at a policy level, to help create a food environment that promotes lower intakes of free sugars. Further support for policies that could reduce intakes of free sugars, such as taxation of SSB or changes to food labelling systems to provide consumers with information on free sugars content may be beneficial to reducing intakes in line with recommendations.

Sucrose intakes have often been used as a surrogate for free sugars in NZ and Australia, and it is often not clarified that a proxy is being used (32). It has been previously estimated that

over half of the Australian population is likely to be meeting the WHO guideline recommending that free sugars equate to <10%TE and that NZ has a similar 'added sugar' intake to Australia; therefore, a similar proportion should be meeting this target- however this was based on sucrose intakes (100). Results from the current study using free sugars instead of sucrose show intakes were higher than indicated by using sucrose as a surrogate for free sugars. Using estimates of free sugars (rather than surrogates) may prevent future misclassifications, allowing for clearer comparisons with recommendations. In addition, as sucrose encapsulates sugar from 'healthy' sources e.g. whole fruits, as well as processed foods, it can be insensitive to certain changes in food patterns. For example, if a population reduced fruit intake while increasing SSB consumption, sucrose consumption may remain the same whereas consumption of free sugars would increase. Having created a database which contains free sugars, it will now be substantially easier to investigate associations between sugar intakes and health outcomes. Such associations may have previously been confounded by intrinsic and free sugars having opposing effects on health. Thus this database will help determine stronger associations between free sugar and health outcomes.

Comparing NZ free sugar intakes to WHO recommendations emphasises the importance of the assessment of free sugars by %TE rather than the absolute amount of sugar consumed. Other recommendations also focus on %TE however, absolute consumption of sugars (including free sugars) consumed are also of importance (16-18, 26). The WHO based their recommendations for free sugar intakes to be <5% TE on reducing the risk of dental caries, however, they have also stated that frequency of consumption of sugar impacts on the likelihood of dental caries (101). Clearly, frequency, absolute consumption, and consumption in terms of %TE are closely linked, with those who consume sugar more frequently expected to consume greater amounts (leading to higher %TE) (101). However, groups of the population who consumed free sugars in the greatest quantity did not have the highest %TE,

due to higher overall energy consumption. This serves as a reminder that dietary patterns are complex and focusing on sugars as a %TE is not the only approach to reducing NCD risk. In conjunction with current recommendations which pertain to free sugars as a %TE intake, upper limits based on absolute amounts of free sugars consumed are also required. However, as yet there is a lack of strong evidence showing a clear dose-response relationship between free sugars with health outcomes(7). Further research can now be undertaken using the database created in this study to investigate such a dose-response relationship.

6.1.1 Under-reporting

Under-reporting of food and beverages by participants in the NZANS 08/09 has the potential to impact on estimates of intakes of free sugars of NZ adults substantially. Research by Gemming *et al*. investigated under-reporting in the NZANS 08/09 by comparing reported energy intake to estimated basal metabolic rate and estimated that 23% of participants underreported food intakes (102). Groups within the population who were more like to under-report generally corresponded with the groups of the population who reported the lowest free sugar intake in this project, such as Pacific people and the elderly. Gemming *et al.* also found that those who were overweight or obese were more likely to be low energy reporters, which is in line with international research (94, 102, 103). Furthermore, as under-reporting is associated with awareness of desirable or socially acceptable dietary patterns, it is likely that discretionary foods are more likely to be under-reported than more socially desirable foods (104). These foods often contain high amounts of free sugars; thus under-reporting may lead to increased underestimation of intakes of free sugars, compared with other food components of food, such as fruits and vegetables which have the potential to impact on the %TE coming from free sugars (104). Therefore, results should be interpreted with caution, particularly when comparing different groups within the population as many psychological, social, and demographic factors may influence the accuracy of estimations. It is likely that fewer NZ adults are meeting WHO recommendations than currently estimated. Therefore, a greater

proportion of the population may be at risk of associated health effects. However, further research is necessary to determine the impact of under-reporting on estimates of free sugars intake.

6.1.2 Strengths and Limitations

A major strength of the present study was that it was the first in NZ to estimate intakes of free sugars, filling a gap in currently available research. It enabled the comparison of current NZ intakes to international recommendations, i.e. WHO recommendations, as well as comparisons with other countries for which estimates of free or added sugar intakes have been reported (21). This project shows that in NZ, there is a significant difference between intakes of free sugars and sucrose (often used as a surrogate for free sugars), thus emphasising the importance of monitoring free sugars. The ability to differentiate between the types of sugars may become increasingly useful in the near future as the inclusion of fruit juice, and concentrates used as sweeteners may rise, as consumers look for alternatives to added sugars.

Methodological strengths include the use of data from the NZANS 08/09, enabling estimates to be performed on a relatively large sample size. Due to sample design, there was an over-representation of certain age and ethnic groups which ensured enough statistical power to compare sub-groups of the population (93). This drew attention to groups at greater risk of poor health due to high sugar consumption and sample weighting enabled the findings to be extrapolated to the wider NZ population. Furthermore, as 25% of participants provided two 24-hour dietary recalls it was also possible to account for intra-individual variability and increase the reliability of the data.

As free sugars cannot be determined analytically, using a methodological approach allowed for repeatability. This approach has not been formally validated; however, it has passed a rigorous peer review process and has been used successfully prior to this project in Australia (105). As a vast majority of the foods were determined objectively (92%), with 76% of all

foods determined using steps 1-3 (steps with the greatest confidence), this significantly reduces the risk of bias compared with more subjective methods. Having a methodological process enables the NZFCD free sugars database to be updated quickly in the future and applied to future NZANS's, allowing monitoring of changes in intakes of free sugars. This database will facilitate more in-depth research into relationships between free sugars and health outcomes in the future, particularly within a NZ setting.

A limitation of the current study is that due to the constant reformulations of processed foods and drinks which are available for purchase, estimates of free sugars may quickly become out of date. This should not influence our estimates of free sugars intakes in the NZANS 08/09; however, free sugar values that have now been applied to the NZFCD will need to be generated each time new foods are added or reanalysed by Plant and Food Research Ltd, to ensure the database remains accurate and relevant. A second limitation was that although the method chosen limited the amount of subjective decisions that needed to be performed, some subjective decisions were inevitable. However, a majority of the free sugars contents of foods were estimated using objective methods (91.5%), which reduced opportunities for bias. Furthermore, having two persons separately estimate free sugars contents of each food, with an additional adjudicator to help resolve any discrepancies, further reduced any risk of bias. To further develop the findings from this study, additional research could investigate the relationships between free sugar consumption and common metabolic diseases in NZ, such as obesity, diabetes or CVD.

6.1.3 Conclusions

This was the first study to estimate intakes of free sugars in NZ, providing essential information required to evaluate NZ intakes against WHO recommendations. It offered valuable insight into sugar consumption, such as drawing attention to groups who may be at the greatest risk of poor health outcomes. The results of this study show that consumption of

free sugars of specific population groups (such as younger adults) was high in comparison with WHO recommendations, suggesting there may be benefits in reducing intakes. The free sugars database that was created for this project will allow future research to investigate specific foods or food groups that are the greatest contributors of free sugars to the NZ diet. This analysis has been performed in international studies and is useful to determine which specific foods could be targeted to reduce intakes of free sugars (46, 68, 95). This database will also allow for more in-depth investigation of the relationship between free sugars and health outcomes, particularly in the NZ setting. Further research on free sugars specifically (rather than surrogates such sucrose or SSB) will help clarify current ambiguities relating high intakes of sugar to poor health outcomes. Filling these evidence gaps is essential to enable promotion of policy changes, which may help alter the current food environment to one which is less obesogenic and supportive of metabolic disease.

7 Application to dietetic practice

When dietitians consider the impact of free sugars on health the focus is often on excessive weight gain and the associated comorbidities, such as CVD or the lower nutritional quality of foods high in free sugars. International recommendations such as that of the USDA (based on the reduction of CVD and diabetes) or the WHO, recommending <10% TE from free sugars are currently met by less than half the adult population of NZ. This suggests that reduction of free sugars should be promoted by dietitians to reduce the risk of chronic diseases in NZ.

However, in addition to this risk, the link between intakes of free sugars and dental caries is an issue which dietitians could give greater attention too. In June 2016 Dietitians NZ stated that intake of free sugars should be limited "because they provide energy without other beneficial nutrients" with no mention of the impact on the effects on dental health (106). Yet, an even smaller section of the population (<10%) are meeting the suggested conditional recommendation set by WHO (free sugars <5% TE) for the prevention of dental caries. Perhaps the focus of why free sugars need to be reduced needs to be reframed in the context of dietetic practice to emphasise the importance of dental caries in addition to prevention of NCDs. Reducing the incidence of dental caries is important for a number of reasons, including cost and appearance, however from a dietitian's perspective, the negative effects become increasingly important with advanced age (21, 38). As age progresses, dental caries often result in tooth loss which has been associated with lower nutritional intake, and greater risk of micronutrient deficiencies, as well as lower quality of life (107, 108). The results from this study show that intakes of free sugars are higher in younger adults which may result in greater incidence of dental caries, resulting in short term consequences, as well as impacting on nutritional health in the long term.

Furthermore, this research highlighted the high quantity of free sugars in many popular foods and therefore how challenging it is for the general public to meet strict recommendations. To meet the <5% TE from free sugars set by WHO, more action may be required at a public health and policy level. The results from this project could serve as evidence, showing more needs to be done to change the food environment and that public health dietitians have an important role in advocating for strategies to reduce the availability of nutrient poor foods. For example, food labelling would be enhanced with the inclusion of information regarding free sugars and dietitians can advocate for this with confidence, knowing that there is suitable data to generate free sugars content of foods. In a clinical setting, having readily available nutritional information regarding free sugars in different foods may assist when educating patients/clients about how to recognise which kinds of sugar-containing foods should be reduced first and foremost.

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9 Appendix

Appendix A- Total sugar intake (g/day) be age group, ethnic group and sex for the NZANS 08/09

Appendix B- Total sugars as a percentage of total energy by age group, ethnic group and sex for the NZANS 08/09

Appendix C - Sucrose intake (g/day) by age group, ethnic group and sex for the NZANS 08/09

Appendix D - Sucrose as a percentage of total energy by age group, ethnic group and sex for the NZANS 08/09

Appendix E- Added sugar (g/day) intake by age group, ethnic group and sex for the NZANS 08/09

Appendix F- Added sugar as a percentage of total energy by age group, ethnic group and sex for the NZANS 08/09

Appendix A – Total sugar intake (g/day) by age group, ethnic group and sex for the NZANS08/09

		Total sugars (g/day)[1]			
		Mean	10th[2]	Median (50th), 95% CI	90th[2]
Total population		114	61	107 (105-109.)	175
By age group (years)					
Males	15-18	132	60	126 (118, 134)	214
	19-30	137	73	126 (117, 135)	215
	31-50	128	67	122 (114, 130)	194
	51+	110	62	106 (102, 110)	164
	Total	124	66	117 (113, 122)	188
Females	15-18	117	60	109 (104, 115)	179
	19-30	121	63	112 (104, 121)	184
	31-50	104	58	99 (95, 103)	156
	51+	98	55	95 (91, 98)	143
	Total	106	58	100 (97, 102)	157
Maori					
Males	15-18	134	73	128 (109, 146)	217
	19-30	144	63	136 (111, 162)	229
	31-50	120	64	112 (101, 123)	203
	51+	96	50	92 (74, 109)	147
	Total	123	61	112 (102, 121)	202
Females	15-18	112	50	108 (88, 129)	172
	19-30	126	61	114 (105, 124)	206
	31-50	109	50	103 (98, 108)	170
	51+	88	45	81 (73, 90)	139
	Total	110	51	102 (96, 108)	176
Pacific					
Males	15-18	118	67	89 (63, 116)	210
	19-30	139	58	123 (103, 154)	221
	31-50	107	45	98 (84, 113)	181
	51+	107	47	88 (65, 112)	180
	Total	117	51	109 (97, 120)	203
Females	15-18	111	59	105 (90, 120)	169
	19-30	117	49	106 (92, 119)	189
	31-50	106	53	96 (89, 102)	169
	51+	82	36	70 (57, 83)	134
	Total	104	46	94 (90, 99)	168

		Total sugars (g/day)[1]			
		Mean	10th[2]	Median (50th), 95% CI	90th[2]
NZEO					
Males	15-18	133	57	128 (120, 136)	214
	19-30	136	73	124 (113-134)	215
	31-50	130	69	126 (118-134)	194
	51+	111	63	108 (103-113)	165
	Total	124	67	118 (114-122)	186
Females	15-18	119	60	111 (104-118)	182
	19-30	120	63	112 (101-124)	179
	31-50	103	60	98 (94-103)	154
	51+	99	57	96 (92- 99)	143
	Total	105	59	99 (96 -103)	155

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

Appendix B- Total sugars as a percentage of total energy by age group, ethnic group and sex for the NZANS 08/09

		Total sugars (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
Total population		21.9	14.2	21.5	29.7
By age group (years)					
Males	15-18	21.7	13.2	21.0 (19.9, 21.1)	29.7
	19-30	21.8	14.3	20.8 (19.7, 22.0)	31.1
	31-50	20.5	13.1	20.4 (19.5, 21.3)	28.0
	51+	21.0	13.0	20.8 (20.1, 21.4)	28.4
	Total	21.0	13.2	20.7 (20.2, 21.2)	28.8
Females	15-18	24.1	15.7	23.9 (23.0, 24.8)	33.1
	19-30	23.7	16.9	23.9 (22.7, 25.0)	31.8
	31-50	21.8	14.4	21.5 (20.7, 22.2)	29.7
	51+	22.7	15.2	22.2 (21.7, 22.8)	30.3
	Total	22.7	15.1	22.3 (21.9, 22.7)	30.7
Maori					
Males	15-18	21.5	13.2	20.7 (16.1, 25.3)	27.6
	19-30	21.2	12.4	20.3 (17.6, 23.1)	29.7
	31-50	19.1	12.3	17.8 (16.5, 19.2)	26.8
	51+	19.7	11.7	17.3 (16.1, 18.5)	28.0
	Total	20.1	12.4	18.8 (17.8, 19.7)	28.0
Females	15-18	23.7	13.8	23.8 (20.7, 27.0)	34.2
	19-30	23.4	14.6	23.9 (22.1, 25.7)	32.4
	31-50	23.0	13.3	23.0 (21.2, 24.8)	32.8
	51+	21.2	13.3	20.4 (18.9, 21.8)	29.5
	Total	22.8	13.7	22.8 (21.7, 23.9)	32.1
Pacific					
Males	15-18	19.9	12.8	17.5 (14.0, 21.3)	28.5
	19-30	21.7	12.6	19.8 (17.5, 22.1)	36.3
	31-50	18.0	10.7	17.9 (15.5, 20.4)	26.2
	51+	19.8	12.5	18.5 (16.1, 20.9)	29.6
	Total	19.6	11.8	18.8 (17.6, 20.1)	29.3
Females	15-18	23.9	12.4	23.6 (21.0, 26.1)	33.2
	19-30	22.5	13.1	21.7 (20.3, 23.1)	31.6
	31-50	20.8	14.2	21.1 (19.7, 22.5)	27.9
	51+	44.4	11.2	18.3 (16.2, 20.4)	27.2
	Total	21.2	13.0	21.0 (20.2, 21.9)	29.3

		Total sugars (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
NZEO					
Males	15-18	21.9	13.2	21.5 (20.4, 22.6)	30.4
	19-30	21.9	14.7	21.2 (19.6, 22.8)	31.1
	31-50	20.8	14.1	20.7 (19.9, 21.5)	28.0
	51+	21.1	13.3	20.9 (20.1, 21.8)	28.4
	Total	21.2	13.5	21.0 (20.5, 21.5)	28.8
Females	15-18	24.2	16.3	24.0 (22.9, 25.2)	33.1
	19-30	23.9	17.3	23.4 (22.7, 25.0)	31.7
	31-50	21.7	14.6	21.3 (20.5, 22.2)	29.3
	51+	22.9	15.5	22.4 (21.7, 23.0)	30.3
	Total	22.7	15.4	22.3 (21.8, 22.8)	30.4

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

Appendix C- Sucrose intake (g/day) by age group, ethnic group and sex for the NZANS08/09

		Sucrose (g/day)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
Total population		54	22	48 (46, 50)	89
By age group (years)					
Males	15-18	65	26	59 (55, 64)	110
	19-30	68	29	60 (55, 66)	123
	31-50	61	23	56 (53, 60)	98
	51+	50	22	45 (42, 47)	80
	Total	59	23	53 (51, 55)	97
Females	15-18	60	24	54 (50, 57)	101
	19-30	61	28	54 (50, 58)	100
	31-50	49	21	44 (42, 46)	81
	51+	43	19	40 (38, 41)	69
	Total	50	22	44 (42, 46)	82
Maori					
Males	15-18	68	30	64 (56, 73)	108
	19-30	73	26	66 (57, 74)	121
	31-50	60	22	53 (47, 59)	107
	51+	44	13	39 (31, 48)	75
	Total	61	22	54 (49, 59)	107
Females	15-18	61	18	53 (38, 67)	113
	19-30	65	25	56 (47, 65)	120
	31-50	54	21	50 (43, 57)	91
	51+	41	17	36 (30, 41)	76
	Total	55	20	47 (42, 52)	96
Pacific					
Males	15-18	54	21	46 (29, 63)	131
	19-30	71	29	68 (53, 83)	113
	31-50	53	19	48 (41, 56)	95
	51+	62	15	46 (35, 57)	110
	Total	60	21	51 (45, 57)	110
Females	15-18	58	19	51 (43, 60)	97
	19-30	60	19	52 (44, 60)	100
	31-50	53	23	48 (44, 51)	92
	51+	42	13	35 (28, 41)	67
	Total	53	18	46 (42, 49)	92

		Sucrose (g/day)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
NZEO					
Males	15-18	66	26	59 (55, 64)	110
	19-30	66	30	59 (53, 65)	123
	31-50	62	23	58 (54, 61)	98
	51+	50	22	45 (42, 48)	80
	Total	58	24	53 (51, 55)	95
Females	15-18	60	26	54 (50, 58)	98
	19-30	60	28	54 (50, 59)	95
	31-50	48	21	44 (41, 46)	79
	51+	43	20	40 (38, 42)	68
	Total	49	22	44 (42, 46)	80

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

Appendix D - Sucrose as a percentage of total energy by age group, ethnic group and sex for the NZANS08/09

		Sucrose (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
Total population		10.0	5.4	9.6 (9.4, 9.8)	15.1
By age group (years)					
Males	15-18	10.5	5.5	9.9 (9.1, 10.6)	16.4
	19-30	10.5	5.3	9.7 (9.1, 10.3)	16.5
	31-50	9.6	5.0	9.2 (8.6, 9.8)	14.1
	51+	9.3	4.7	8.9 (8.4, 9.4)	14.1
	Total	9.7	5.1	9.3 (9.0, 9.5)	14.8
Females	15-18	12.0	6.2	11.4 (10.6, 12.1)	18.0
	19-30	11.5	6.7	10.9 (10.1, 11.6)	17.2
	31-50	10.0	5.3	9.6 (9.1, 10.0)	15.0
	51+	9.7	5.4	9.3 (8.9, 9.7)	14.6
	Total	10.3	5.6	9.9 (9.7, 10.1)	15.4
Maori					
Males	15-18	10.7	5.8	10.6 (8.3, 13.0)	15.1
	19-30	10.5	5.1	10.3 (8.9, 11.7)	16.2
	31-50	9.4	4.7	9.0 (8.0, 10.0)	13.9
	51+	9.0	3.4	8.1 (6.7, 9.5)	13.6
	Total	9.8	4.7	9.3 (8.7, 10.0)	14.8
Females	15-18	12.5	6.1	11.4 (9.0, 13.7)	21.4
	19-30	11.5	6.3	11.8 (10.5, 13.0)	17.2
	31-50	10.9	5.3	11.2 (10.1, 12.2)	16.2
	51+	9.5	5.2	9.2 (8.3, 10.1)	14.8
	Total	11.0	5.4	10.5 (9.9, 11.1)	17.1
Pacific					
Males	15-18	8.8	4.7	7.9 (6.1, 9.8)	15.7
	19-30	10.8	5.6	10.3 (8.5,12.1)	16.5
	31-50	8.7	4.3	8.4 (7.5, 9.4)	13.5
	51+	10.6	4.7	9.3 (7.6, 10.9)	18.5
	Total	9.7	4.7	9.0 (8.2, 9.9)	16.0
Females	15-18	12.1	5.0	11.4 (9.4, 13.5)	17.0
	19-30	11.0	5.5	10.3 (9.1, 11.5)	17.1
	31-50	10.1	5.9	9.7 (8.8, 10.6)	14.5
	51+	9.1	4.0	8.3 (6.8, 9.8)	15.8
	Total	10.3	5.1	10.0 (9.3, 10.6)	15.7

		Sucrose (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
NZEO					
Males	15-18	10.6	5.5	9.9 (9.1, 10.7)	17.0
	19-30	10.5	5.3	9.6 (8.9, 10.3)	16.4
	31-50	9.7	5.1	9.3 (8.5, 10.0)	14.2
	51+	9.3	4.9	8.9 (8.4, 9.4)	14.1
	Total	9.7	5.1	9.3 (9.0, 9.6)	14.8
Females	15-18	11.8	6.8	11.4 (10.6, 12.1)	17.2
	19-30	11.6	6.9	10.8 (10.0, 11.6)	17.2
	31-50	9.8	5.3	9.5 (8.9, 10.0)	14.9
	51+	9.8	5.5	9.3 (8.9, 9.7)	14.6
	Total	10.2	5.7	9.9 (9.6, 10.1)	15.1

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

Appendix E - Added sugar (g/day) intake by age group, ethnic group and sex for the NZANS08/09

		Added sugar (g/day)[1]			
		Mean	10th[2]	Median (50th)[2],(95% CI)	90th[2]
Total population		54	22	48 (46 -50)	89
By age group (years)					
Males	15-18	65	26	59 (55, 64)	110
	19-30	68	29	60 (55, 66)	123
	31-50	61	23	56 (53, 60)	98
	51+	50	22	45 (42, 47)	80
	Total	59	23	53 (51, 55)	97
Females	15-18	60	24	54 (50, 57)	101
	19-30	61	28	54 (50, 58)	100
	31-50	49	21	44 (42, 46)	81
	51+	43	19	40 (38, 41)	69
	Total	50	22	44 (42, 46)	82
Maori					
Males	15-18	68	30	64 (56, 73)	108
	19-30	73	26	66 (57, 74)	121
	31-50	60	22	53 (47, 59)	107
	51+	44	13	39 (31, 48)	75
	Total	61	22	54 (49, 59)	107
Females	15-18	61	18	53 (38, 67)	113
	19-30	65	25	56 (47, 65)	120
	31-50	54	21	50 (43, 57)	91
	51+	41	17	36 (30, 41)	76
	Total	55	20	47 (42, 52)	96
Pacific					
Males	15-18	54	21	46 (29, 63)	131
	19-30	71	29	68 (53, 83)	113
	31-50	53	19	48 (41, 56)	95
	51+	62	15	46 (35, 57)	110
	Total	60	21	51 (45, 57)	110
Females	15-18	58	19	51 (43, 60)	97
	19-30	60	19	52 (44, 60)	100
	31-50	53	23	48 (44, 51)	92
	51+	42	13	35 (28, 41)	67
	Total	53	18	46 (42, 49)	92

		Added sugar (g/day)[1]			
		Mean	10th[2]	Median (50th)[2],(95% CI)	90th[2]
NZEO					
Males	15-18	66	26	59 (55, 64)	110
	19-30	66	30	59 (53, 65)	123
	31-50	62	23	58 (54, 61)	98
	51+	50	22	45 (42, 48)	80
	Total	58	24	53 (51, 55)	95
Females	15-18	60	26	54 (50, 58)	98
	19-30	60	28	54 (50, 59)	95
	31-50	48	21	44 (41, 46)	79
	51+	43	20	40 (38, 42)	68
	Total	49	22	44 (42,46)	80

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles

Appendix F- Added sugars as a percentage of total energy by age group, ethnic group and sex for the NZANS08/09

		Added sugar (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
Total population		10.3	4.0	9.5 (9.3-9.8)	17.1
By age group (years)					
Males	15-18	12.0	4.8	11.0 (10.0-12.0)	19.1
	19-30	12.0	4.2	10.7 (9.7-11.8)	21.7
	31-50	10.1	4.3	9.5 (8.8-10.1)	16.0
	51+	9.2	3.3	8.6 (7.9-9.2)	15.1
	Total	10.3	4.0	9.5 (9.1-9.9)	17.2
Females	15-18	13.3	5.6	12.0 (11.0-13.0)	22.5
	19-30	12.3	5.0	11.8 (10.8-12.8)	19.9
	31-50	9.8	4.1	9.0 (8.3-9.7)	16.5
	51+	9.1	3.8	8.6 (8.1-9.0)	15.3
	Total	10.3	4.0	9.5 (9.2-9.8)	17.1
Maori					
Males	15-18	12.6	5.8	13.0 (9.9-16.1)	19.0
	19-30	12.3	4.5	11.7 (9.3-14.0)	20.7
	31-50	10.3	4.8	9.5 (8.5-10.4)	17.4
	51+	8.8	2.5	7.2 (6.1-8.2)	15.1
	Total	10.8	4.1	10.0 (8.9-11.2)	18.5
Females	15-18	14.5	6.2	14.5 (11.1-18.0)	23.7
	19-30	12.7	4.7	12.2 (10.8-13.7)	20.8
	31-50	10.7	4.9	10.7 (9.3-12.0)	18.0
	51+	8.7	2.8	8.1 (6.9-9.3)	16.3
	Total	11.2	4.1	10.6 (9.7-11.4)	19.4
Pacific					
Males	15-18	9.6	4.0	7.9 (6.0-9.9)	15.4
	19-30	13.0	4.9	11.4 (9.4-13.4)	24.5
	31-50	8.8	3.7	7.7 (6.7-8.7)	15.8
	51+	9.7	3.4	8.5 (7.1-9.9)	17.0
	Total	10.3	4.0	8.9 (7.9-9.9)	18.3
Females	15-18	13.0	4.9	11.0 (7.7-14.3)	24.4
	19-30	11.4	4.1	10.7 (9.3-12.0)	21.1
	31-50	9.5	4.9	8.9 (8.2-9.6)	14.7
	51+	7.5	2.4	6.37 (5.2-7.6)	13.7
	Total	10.0	3.7	8.97 (8.3-9.7)	16.7

		Added sugar (%TE)[1]			
		Mean	10th[2]	Median (50th)[2], 95% CI	90th[2]
NZEO					
Males	15-18	12.1	4.8	11.2 (10.0-12.3)	20.2
	19-30	11.9	4.2	10.5 (9.3-11.8)	21.7
	31-50	10.1	4.3	9.6 (8.8-10.5)	15.9
	51+	9.2	3.5	8.6 (7.9-9.3)	14.9
	Total	10.2	4.0	9.5 (9.0-9.9)	17.0
Females	15-18	13.0	5.9	11.9 (11.0-12.6)	21.7
	19-30	12.3	5.4	11.8 (10.5-13.0)	19.1
	31-50	9.7	3.8	8.9 (8.0-9.7)	16.4
	51+	9.1	3.8	8.6 (8.1-9.1)	15.3
	Total	10.2	4.0	9.4 (9.0-9.8)	16.8

1 Usual daily intake. These data were adjusted for intra-individual variation using MSM
2 Percentiles