An Exploration of Food Quality Across Dietary Patterns: Towards an Understanding of Ketogenic, Low-Carbohydrate, Vegetarian, and Vegan Diet Quality

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Abstract

Background:

Understanding and measuring diet quality is a topic that has received increasing attention in recent years with the NOVA system being a catalyst for this change in 2009. Recent advances in this area suggest that, at a population level, diets are shifting toward a reliance on hyper-palatable ultra-processed foods (UPFs) across the globe. While the development of UPFs was once strictly about creating convenient, mass-producible foods; with the increasing interest in alternative dietary patterns (ADPs) there is now a milieu of specialty UPFs marketed towards individuals consuming lower-carbohydrate and plant-based diets. Common lower-carbohydrate diets include the ketogenic diet (KD) and low-carbohydrate, healthy fat (LCHF) diet, while the vegan (VEGAN) and vegetarian (VEGE) are common plant-based diets. Despite the growing interest and number of UPFs available for these once-niche groups, little is known about the translation of dietary guidelines into practice and how the availability of UPFs impacts overall diet quality (DQ) in these individuals. This research aimed to explore the DQ of adults adhering to ADPs for at least 6-months using a modified questionnaire and two novel food classification systems.

Methods:

In this pilot study, a modified online dietary habits questionnaire was developed and disseminated; results were interpreted using the NOVA (not an acronym) and HISS (Human Interference Scoring System) food classification tools. Participants were recruited via social media platforms between Friday 26th August and Sunday 18th September 2022 and responded to the questionnaire, anonymously, via Qualtrics. Data were quantitatively analysed using descriptive and parametric statistics (oneway repeated measures ANOVA, two-way repeated measures ANOVA and linear regression) in the software programme, JASP (version 0.16.3.0).

Results:

There was a total of 168 responses comprising 56 KD (m=16, f=39), 66 LCHF (m=13, f=53), 14 VEGAN (m=4, f=10), and 32 VEGE (m=5, f=27). Respondents were predominantly of European descent, female, and classified as moderate-income professionals. Analysis of DQ revealed that individuals adhering to a lower-carbohydrate diet (either KD or LCHF) tended to consume a smaller proportion (% of total serves) of their diet from UPFs and a larger proportion from unprocessed and minimally processed foods (KD 53 ±12; LCHF 51 ±13). There was a statistically significant difference in NOVA% among the four ADPs $F(6.150, 336.184) = 8.285$, $p < 0.001$, with a medium effect size ($\eta^2 = 0.063$). Food groups contributing to intake in NOVA 1 (minimally processed food category) and NOVA 4 (ultra-processed food category) were similar among lower-carbohydrate individuals and plant-based individuals respectively. There was an inverse

relationship between perceived and actual DQ, and NOVA and HISS were only similar across the fourth level of processing (UPFs). These data show that diet quality assessment tools can be applied to a range of dietary patterns.

Conclusion:

These data indicate that in free-living individuals, DQ (as assessed by the proportion of dietary intake as a number of serves, across different levels of food processing) is higher among those adhering to lower-carbohydrate diets compared to those adhering to plant-based diets. However, these individuals are not exempt from the consumption of UPFs or the belief that their diet quality is superior to what it is. Future research should explore the difference in DQ in larger samples, validate existing tools for the quantification of DQ and assess whether there are safe thresholds for the consumption of UPFs in the context of different dietary patterns.

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Abbreviations

ADP	Alternative dietary pattern
AMDR	Acceptable Macronutrient Distribution Range
ANOVA	Analysis of variance
DQ	Diet quality
DietQ	Actual diet quality
EI	Energy intake
FCC	Food contact chemical
FFQ	Food frequency questionnaire

HISS	Human Interference Scoring System
HSR	Health Star Rating
KD	Ketogenic diet
LC	Lower carbohydrate
LCHF	Low carbohydrate, healthy fat
MPF	Moderately processed food
PB	Plant based
PQual	Perceived diet quality
RCT	Randomised controlled trial
UPF	Ultra-processed food

VEGAN Vegan VEGE Vegetarian

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed: Kayla Anne Lenferna De La Motte ________________________

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Ethics approval

Ethics approval was granted for this project (application 22/202) by AUT Ethics Committee on 5th September 2022 (Appendix A).

1. Introduction

Diet quality (DQ) is an area of nutrition research gaining significant traction globally among academics, policymakers, and lay individuals. There is a growing awareness among these populations that DQ is an important consideration for overall health and that a reductionist view of nutrition may no longer be fit for purpose in the current food environment (Cannon & Leitzmann, 2022; Monteiro et al., 2019). To date, there have been two dominant schools of thought regarding DQ. One suggests that DQ can be measured by understanding the composition of the diet; while the other suggests that this may be too simplistic (ignoring the food-matrix interactions) and that to fully understand DQ, the degree of processing a food has undergone must be examined and quantified (Drewnowski, 2005; Monteiro et al., 2019). To date, food composition has largely been the main area of focus in nutrition research and has served as a proxy for understanding food and diet quality, which has in turn advised nutrition policies at a country and global level. This has resulted in the development of food scoring indices that account for the macro and micronutrient content of foods (Dickie et al., 2018; Drewnowski, 2005, 2009; Drewnowski et al., 2019; Drewnowski & Fulgoni, 2020; Drewnowski et al., 2020; Ferreiro et al., 2021). Among these food scoring indices are the Health Star Rating (New Zealand and Australia) (Ministry of Primary Industries, 2021), the Nutrient Reference Framework (United States) (Drewnowski & Fulgoni, 2020), and the Nutri-Score (Europe) (Ferreiro, et al., 2021) which all use mathematical formulations to penalise processed products for the inclusion of certain nutrients (e.g. fat and salt) and reward them for the inclusion of others (e.g. fibre). As a result, many food manufacturers modify products to meet the requirements of the food quality system in their jurisdiction which can result in the inclusion of several additives and non-nutritive components to foods. The implications for health and overall DQ of these additives remains unknown. Moreover, research examining the Nutri-Score and levels of processing (using the NOVA food classification system) found that ultra-processed foods (UPFs) were found in even the highest scoring categories, suggesting that these systems, designed to inform consumers to make healthy food choices, may be misleading consumers to buy unhealthy, UPF formulations (Romero Ferreiro, Lora Pablos, et al., 2021).

In recent years increasing attention has been paid to food classification systems that categorise foods based on the level of processing they have undergone (Davidou et al., 2020a; Monteiro et al., 2019). Several tools have been developed, one of the most popular novel food classification systems is the NOVA (not an acronym) food classification system which categorises foods into four distinct groups (unprocessed or minimally processed, culinary, processed and ultra-processed). The NOVA system (developed in Brazil) has heavily influenced the Brazilian dietary guidelines, has been used as a tool to quantify DQ in several studies, and appears to be easily understood by lay consumers (Ares et al., 2016; Food and Agriculture Organization of the United Nations, n.d.; Monteiro et al., 2019; Nazmi et al., 2019). Other countries, like New

Zealand, have since followed suit and included clauses in their healthy eating guidelines to include advice around limiting UPFs; however, there is still a strong emphasis on increasing or limiting particular food groups (e.g. increasing whole grains and limiting saturated fat intake) (New Zealand Ministry of Health, 2020). Emerging evidence suggests that focusing attention narrowly on calories, macronutrients, and micronutrients does not account for the impact that additional chemicals and additives in foods. It is worth noting that foods are eaten in the context of a diet, not in isolation, and are impacted by the effects of processing techniques (which have evolved considerably in the last 100 years) (Cannon & Leitzmann, 2022; Lustig, 2020; Marti, 2019). This new lens through which to understand DQ moves from a reductionist to holistic approach and understanding of DQ but is not beyond criticism (Cannon & Leitzmann, 2022; Sadler et al., 2022). Considering the critiques posed, a novel food processing classification system was developed by the AUT Human Potential Centre (AUT HPC) in 2021. The HISS (Human Interference Scoring System) seeks to address shortfalls of the NOVA system, namely its inability to appropriately classify meals that are comprised of multiple food components and capture the continuum across which food processing exists, given that food processing has evolved considerably with new technologies available that would not have been used even as recently as 100 years ago (Braesco et al., 2022; Knorr & Watzke, 2019; Sadler et al., 2022). These systems will be discussed in further detail in the literature review.

To date, research examining DQ focuses predominantly on understanding how closely population habits align with the standard dietary pattern or healthy eating guidelines. Population guidelines for healthy eating typically align with the advice of the World Health Organisation (WHO) and are comprised of a series of eating statements (New Zealand Ministry of Health, 2020). These eating statements support a diet that is typically comprised of the following Acceptable Macronutrient Distribution Ratios: 15-25% protein, 45-65% carbohydrate and 20-35% fat (National Health and Medical Research Council & Ministry of Health, 2006). Given that at a population level, diets have shifted dramatically towards a reliance on UPFs (with some countries estimating intake beyond 50% of total energy), it is worth exploring and determining whether the same can be said for alternative dietary patterns (ADPs) (Monteiro et al., 2019; Vandevijvere et al., 2019). Despite their growing popularity, there is limited research examining the DQ of lower carbohydrate (LC) and plant-based (PB) diets, either through DQ scoring systems or the NOVA food classification system (Gallagher et al., 2021; Gehring et al., 2020; Knightbridge-Eager, 2020). This can be attributed to two main factors. First, data regarding the translation of standard diets is available on a large scale through population health surveys. In addition, the majority of UPFs available in supermarkets are designed for and can be eaten in the context of individuals eating a standard diet (i.e. marketing tactics typically rely on terms like ‘high fibre’, ‘reduced salt’, or ‘low fat’) which is in line with the healthy eating guidelines of many countries. Despite this, there is a growing number of individuals adhering to ADPs that intentionally exclude certain foods groups for a variety of reasons, amongst them being health and ethical concerns. Among these ADPs are the ketogenic (KD), low carbohydrate high fat (LCHF), vegan (VEGAN), and vegetarian (VEGE) diets (Kamiński et al., 2020). In fact, the VEGAN, VEGE, LCHF and KD approaches were among the top five searched diets on Google between 2009 and 2014 (Kamiński et al., 2020). A common driving factor for the adoption of LC or PB diets is improved health (Bakaloudi et al., 2021; Knightbridge-Eager, 2020; Volek et al., 2021). With the growing interest in these dietary patterns, there is a growing number of UPFs being developed and marketed towards those adhering to them. One area of particular concern in the increasing availability of specialty confectionary and convenience items marketed toward those adhering to LC and PB diets. Among these hyper-palatable convenient items are food formulations like biscuits, protein bars and fast foods which may be perceived as healthy by consumers as a result of the health halo that is often associated with these diets and as a result any products which may be aligned with them. While there is a well-established body of knowledge that illustrates the increasing availability and consumption of mainstream UPFs, a limited body of research suggests that the increasing availability of such products negatively impacts DQ in PB individuals (Gallagher et al., 2021; Gehring et al., 2020; Monteiro et al., 2019). Whether the same can be said for those on LC diets is not yet known. Another concern among academics and practitioners when considering DQ of PB diets specifically is PB meat products which often contain large amounts of refined carbohydrates and additional additives to mimic the taste and texture of meat or cheese (Tso & Forde, 2021; Wickramasinghe et al., 2021). Given their relatively recent introduction to the market, the long-term health consequences of these products, and particularly the effects of regular consumption on health remains unknown (Romão et al., 2022; Toh et al., 2022). Ultraprocessed specialty foods (UPSFs) will often contain terms targeting these individuals to believe in the perceived 'healthiness' of the product like 'low sugar' or 'plant-based' which does not inherently mean the product will have a favourable impact on health but leads the consumer to believe it will. Given the growing number of UPSFs, and the limited knowledge of how these foods impact DQ, it stands to reason that it is worth exploring how frequently they are consumed in those adhering to these diets and how their consumption affects DQ in practice.

The seemingly ever-increasing availability of UPFs (both generic and speciality) is a public health concern as the consumption of these products in large quantities negatively affects health (Monteiro et al., 2019). A growing body of research illustrates the negative impact of increased UPF intake on several health outcomes with a recent prospective longitudinal cohort study reporting that with each 10% increment increase in UPF consumption, there was a corresponding 15% increase in the risk of all-cause mortality (Chen et al., 2020; Monteiro et al., 2019; Romero Ferreiro et al., 2021). The exact mechanisms responsible for this increased risk remains unknown but is likely the result of the dysregulation of several physiological processes which will be discussed further in later sections of this dissertation (Heindel et al., 2022). While this research is based on mainstream UPFs, given the similarities between these and niche or speciality foods developed for PB and LC diets, it is likely that these outcomes are transferable, at least to some extent.

Significant resources are attributed to discovering 'the best' dietary pattern for longevity and health; however, there is no 'one size fits all' when it comes to diet and individuals will select dietary patterns that align with their personal beliefs, preferences, and goals. Moreover, it appears that studies illustrating positive outcomes across all dietary patterns have one key metric in common, a reduction in nutrient poor UPFs and a subsequent increase in whole and minimally processed foods (MPFs) (Hall et al., 2019). Therefore, it is important to understand the current DQ of those currently adhering to ADPs, including PB and LC diets, in order for appropriate advice to be generated to help these individuals optimise their DQ and prevent a decline in health that may result from excessive consumption of UPFs (Marino et al., 2021). Despite the increasing availability of specialty products for ADPs, little is known about the inclusion and reliance on these food formulation in the diets of those adhering to PB or LC diets. As a result, the impact their inclusion has on overall DQ and long-term health remains unknown with research focused predominantly on the quality of mainstream diets (Obrero, 2007; Tso & Forde, 2021; Wickramasinghe et al., 2021). This research seeks to explore the DQ of those adhering to these ADPs using two novel tools (NOVA and HISS) and understand to what extent these UPSFs are included in the diet.

1.1. Aims and Objectives

This research aimed to explore the DQ of KD, LCHF, VEGAN and VEGE diets of free-living adults (i.e. those who have not been enrolled in a specific intervention to alter their diet habits) and understand the level of agreement between two novel food quality assessment tools (NOVA and HISS). The primary objective of this research was to contribute to a growing body of knowledge by further understanding the translation of ADPs into practice and quantifying DQ (both actual and perceived) using two novel food quality quantification frameworks and a newly developed food frequency questionnaire (FFQ) (Appendix B.1-questionnaire). The DQ of ADPs is often examined based on their efficacy in the treatment or prevention of specific conditions or based on their micronutrient sufficiency (Bakaloudi et al., 2021; Volek et al., 2021), while these are important considerations, it can be argued that overall DQ may be the underlying factor contributing to both the efficacy of a particular dietary pattern in treating and preventing disease and whether key micronutrient thresholds are met for optimal functioning and health. In this pilot, a secondary objective was understanding the applicability of the two systems (NOVA and HISS) and their ability to detect diet quality across a broad range of dietary patterns.

1.2. Research Questions

The primary research question this work sought to explore was: ‘how does food quality differ across different dietary patterns?’. Four additional sub-questions were examined through this research:

1. What is the difference in intake across the four NOVA categories among the four diet groups (KD, LCHF, VEGAN, VEGE)?
2. What is the difference in intake across the four HISS categories among the four diet groups (KD, LCHF, VEGAN, VEGE)?
3. What is the relationship between the HISS and NOVA classification tools?
4. What is the relationship between perceived and actual diet quality, and does this differ based on diet pattern, age, ethnicity, education level, occupation, or income status?

2. Literature Review

2.1. A New Era for Nutritional Sciences

The food environment has evolved radically and rapidly in the last century with a surge of new technologies allowing for the mass production of UPFs with exceedingly long shelf lives (Monteiro et al., 2019). It is important to consider that not all food processing is created equally. Our forefathers successfully used several processing techniques for decades including fermenting, drying, and pickling that did not result in the same deleterious consequences we see today (Cannon & Leitzmann, 2022; Chen et al., 2020). Rather, these pre-industrial food processing techniques (particularly fermentation and pickling) are now touted by health professionals as a key to maintaining a healthy gut microbiome. It is well understood that to adequately feed (and more importantly nourish) an ever-expanding global population, food processing plays a pivotal role in ensuring accessibility to clean, nutritious food and the prevention of diseases related to malnutrition (Cannon & Leitzmann, 2022; Knorr & Watzke, 2019). MPFs, including items like frozen and canned vegetables are often staples in households (particularly during winter months) due not only to their nutritional quality but also their cost (Donovan et al., 2022). When considering food processing and exploring its impacts on health, it is important as academics and health professionals that we do not demonise healthy, nutritious foods that may be processed to some degree and cause confusion among the public. Instead, focusing on the impact that new technologies and resulting UPFs have on health and developing ways to accurately identify these products and quantify their harm. Recent studies suggest that high-heat processing techniques (like extrusion and dehydrogenation) appear to be more harmful than low-heat techniques and that more focus should be placed on quantifying the type of processing and its resulting impact on the food matrix (Knorr & Watzke, 2019). This complex issue cannot be solved by health and nutrition professionals alone, indeed there is a need for collaboration across sectors and an argument that including food technologists as central stakeholders in this discussion to reformulate foods is a key to moving forward in a meaningful way (Davidou, Christodoulou, Fardet, & Frank, 2020b; Knorr & Watzke, 2019; Monteiro et al., 2019).

Global trend data (pooled from 80 countries) illustrates sales per capita for UPF and drink products are continuing to soar with the dominant contributor being baked goods (Vandevijvere et al., 2019). In fact, Australasia had the highest per capita sale of UPFs in 2016 with 113.3kg purchased per person (Vandevijvere et al., 2019). Globally, it is becoming increasingly evident that at a population level, diets have continued to shift from a predominantly whole-food-based approach to one which relies heavily on UPF formulations (Machado et al., 2019; Marino et al., 2021; Marrón-Ponce et al., 2018; Moubarac et al., 2017; Vandevijvere et al., 2019). These food formulations, which bear little resemblance to real food, now dominate the food supply chain and in turn make up the majority of 'food' sold in supermarkets worldwide. A recent study of New Zealand supermarkets found that 83% of the goods sold could be classified as ultra-processed (Luiten et al., 2016). Moreover, many educational nutrient profiling tools developed to alert consumers to less healthy packaged products appear to be failing with many UPFs being classified with high health star ratings or NutriScores (Dickie et al., 2018; Romero Ferreiro, Lora Pablos, et al., 2021). A second critique of these systems is that they do not educate consumers about the potential health consequences of additives and non-nutritive components like food contact chemicals. The potential impacts of these additives and non-nutritive components are discussed later in detail.

In many developed countries, the proportion of total energy intake (EI) from UPF is 50% or greater (Monteiro et al., 2019). Rather than relying on unprocessed, MPFs and even processed foods, the basis of many diets is now comprised of predominantly UPFs. While it was once thought these foods only impacted developed countries, research indicates that sales per capita and consumption of these products is increasing in developing countries with nations like Mexico now reporting up to 30% of dietary energy intake in children in adolescents coming from UPFs (Marrón-Ponce et al., 2018). Research illustrates that due to the composition of UPFs, increased consumption drives free sugar intake well beyond the recommended limit across all ages in Australians (Machado et al., 2020). These findings are likely transferable to other nations and may be implicated in the underlying mechanisms responsible for the associated weight gain seen with UPF consumption. It is plausible that excessive sugar intake may be implicated in early-onset insulin resistance which results in a cascade of poor metabolic health. It is evident that increased availability and accessibility of these products plays a crucial role in burgeoning consumption globally across all age groups and that arming consumers with appropriate knowledge to make educated decisions in the dynamic food environment should be a point of focus moving forward. UPF products are typically low-cost, aggressively marketed toward children and adolescents, and available in convenient ready-to-go packages and portions (Monteiro et al., 2019; Vandevijvere et al., 2019). How these factors may be implicated in driving excessive calorie intake will be discussed further.

Considering the evolution of the food environment, academics are calling for a more holistic approach to quantifying DQ and as such understanding, the impacts these altered dietary patterns have on overall health (Davidou et al., 2020b; Monteiro et al., 2019). It can be argued that relying solely on the nutritive components of food is an obsolete approach as we move toward ever increasing availability (and potentially a need for) more processed and UPF products to feed an expanding population. This has resulted in an increased interest in food processing classification systems that categorise foods based on the level of processing they have undergone (Davidou et al., 2020b; Monteiro et al., 2019). Following the development of the NOVA system which uses a qualitative approach to sort food and food products into four distinct categories, alternative systems have been developed. Two particularly interesting and innovative systems (looking to progress the existing NOVA classification framework) are the Siga (Portuguese for 'to go forward') algorithm (Davidou et al., 2020b)and the recently developed HISS framework (Nicol, 2022). The Siga algorithm proposes a holisticoreductionist approach that begins with the broad categories of NOVA and then further distinguishes levels of processing (and as such potential for harm) based on quantitative metrics including markers of ultra-processed (MUPs) and additives that may cause harm (Davidou et al., 2020b). These are important considerations given that the food matrix and chemicals ingested because of UPF consumption are likely culprits in the ensuing metabolic dysregulation. While the physiological mechanisms are yet to be established, it is plausible that changes to the food matrix and endocrine disruption via chemical ingestion are at least partly to blame for the resulting negative impacts on health (Davidou et al., 2020b; Heindel et al., 2022; Martínez et al., 2021; Muncke et al., 2020; Pressman et al., 2017). It is however, unknown whether there is a safe level of UPF consumption.

This emergent and complex area of nutrition science aims to recognise that "the whole is more than the sum of its parts" and that to fully comprehend the effects of the consumption of UPFs we must consider the level and type of processing food products undergo and as such, the food matrix effect, alongside the impact of food contact chemicals and additives (Aguilera, 2019; Davidou et al., 2020b). For this research, two food processing classification systems were selected, NOVA and HISS. Table 1 outlines the four NOVA and HISS categories respectively with a brief definition of each category and a select number of examples of the foods contained in each (this list of examples is not exhaustive, to provide an exhaustive list of the foods contained in each NOVA and HISS category is beyond the scope of this research) (Monteiro et al., 2019; Nicol, 2022).

Table 1.

NOVA and HISS category definitions and food examples

Category	NOVA	HISS
1	*Unprocessed or minimally processed foods* Unprocessed foods refer to the edible parts of plants, animals, fungi, algae, and milk that remain unchanged after being separated from nature while minimally processed foods are those that have been subjected to industrial processing to remove inedible parts of the foods and extend their shelf life. **Examples:** fresh, frozen, dried fruits and vegetables, whole grains, beans, legumes and pulses, fresh or frozen meat (white or red), poultry and fish, nuts, dried herbs and eggs (fresh, powdered or chilled), milk (fresh, powdered, pasteurised) and fresh fruit and vegetables juices.	*Whole or minimally processed foods* Raw and whole foods that have undergone little to no processing. Processing types in this category include canning, freezing and drying foods to enhance nutrients and ensure products remain fresh and safe for consumption. This includes foods of plant or animal origin that are processed and stored without additional non-nutritive substances. **Examples:** Fresh and frozen raw fruit and vegetables; eggs; red and white meats; fresh, dried, canned beans and other legumes; raw nuts and seeds; honey; fresh, dried, smoked, frozen meat or fish; canned beans, fish, fruit, and tomatoes in spring water; broths; herbal teas.
2	*Culinary ingredients* These are substances in group 1 that have been altered by means of pressing, centrifuging, refining, extracting or mining and are usually eaten as part of meals rather than alone. Group 2 foods are typically used to season, prepare and cook group 1 foods. These foods may contain additives to prolong product duration, protect original properties or prevent proliferation of microorganisms. **Examples:** Cooking fats (oils, butter, lard), iodised salt, honey, kombucha.	*Foods mostly available for consumption in pre-industrial societies* Artisanal products typically available in pre-industrial, agricultural societies. Products included have been processed using traditional techniques with bacterial (non-alcoholic) fermentation. **Examples:** Milk; butter; cheese; milk and coconut creams; unflavoured yoghurts; artisan bread; coffee beans; rice; pasta; rolled oats; fermented alcoholic beverages such as beer, cider, and wine; spirits;

3	*Processed food* Foods that have had group two culinary ingredients added to enhance the flavour, modify or enhance the sensory qualities of the foods and improve the durability of group 1 foods. Additives to prolong product duration, protect original properties, or prevent proliferation of microorganisms are common in this group. **Examples:** Vegetables or legumes bottled or canned in brine, smoked or dried meat and fish, salted or roasted nuts and seeds, fruits preserved in syrup and freshly made breads and cheeses.	*Mostly homemade items* These are foods that have been domestically assembled or hand-prepared from a collection on group 1 and group 2 ingredients and additional cooking agents as required. As well as foods processed for preservation with additional flavouring and additives with no further cooking needed. **Examples:** Homemade breads; soups; granola and breakfast cereals; baking and biscuits, peeled or sliced fruit in syrup; canned fish in flavouring or oil; cured meat (beef jerky); dried fruit; hummus; pesto; aioli.
4	*Ultra-processed foods* These are food formulations, created with five or more ingredients, from items that would not typically be found in a domestic pantry or fridge and using processes that would not be possible in a domestic kitchen. The original component ingredients are not easily identifiable, and products will likely have several additives and preservatives included to prolong shelf-life beyond traditional processing techniques. **Examples:** ready-to-consume confectionery and convenience products including but not limited to snack bars, chips, pastries and cakes, energy bars, instant drinks, heat-and-eat meals like pizza and pies and reconstituted meat products like salami.	*Ultra-processed food items* Industrially manufactured food formulations that are mass produced and packaged ready to eat. The level of processing results in little to no intact whole foods. These food formulations typically contain bulking agents, stabilisers, preservatives, emulsifiers, sweeteners, colours and flavours to enhance the aesthetics and flavour profile of the foods and ensure they are shelf-stable for long periods. **Examples:** reconstituted meats (ham, salami, chicken and sausage); cured bacon, breads and wraps; rice cakes; breakfast cereals; biscuits; fizzy and energy drinks; ice cream; sweetened fruit yoghurt; sweetened milk drinks; juice; packaged foods (pizza, burgers etc); fries; canned, dehydrated soups; baked beans or spaghetti; muesli bars; protein supplements and bars; cakes; pies; confectionery (chocolate, candy); dressings and sauces; spreads; margarine; baby formulas; ready-to-drink alcoholic beverages; instant coffee.

2.2. Ultra-Processed Foods are Unregulated and Running Rampant

Current evidence indicates a clear positive association between UPF consumption and several markers of health and non-communicable diseases (Chen et al., 2020). A recent systematic review of epidemiological studies (twelve cohort studies and eight cross sectional) illustrated that increased UPF consumption is associated with all-cause mortality, gastrointestinal disease, mental health diseases, cardiovascular disease, respiratory disease, metabolic syndrome, overweight and obesity, several cancers and poor pregnancy outcomes (Chen et al., 2020). Increased inflammation and alterations to the gut microbiota may be implicated as underlying mechanisms in the above diseased states (Martínez et al., 2021). However, to date, only a single randomised control trial (RCT) has assessed the impact of UPF on energy intake (EI) in weight-stable adults (Hall et al., 2019). The findings illustrate that, even when energy and meal composition are matched, those eating an ultra-processed diet will consume more calories, particularly from carbohydrates and fat (Hall et al., 2019). This is the first study that indicates there may be a causative relationship between UPF consumption and metabolic health. Furthermore, it implies that food composition (i.e. the pairing of mostly hydrogenated fats alongside simple carbohydrates) are the likely culprit driving excessive EI. It is worth considering that, in the absence of weight gain, and the associated cascade of metabolic dysregulation, few studies have examined whether the negative implications associated with increased UPF consumption continue to present in otherwise healthy individuals. It is worth considering if these deleterious consequences ensue when EI is matched with energy expenditure and furthermore, whether relative health of the individual contributes to a threshold at which UPFs can be consumed. For instance, it is worth exploring if, in more metabolically healthy individuals who are insulin sensitive, could the potentially negative impacts of UPFs be offset to some degree. While the current medical model regards the aforementioned diseases as distinct pathological processes, an emerging theory of metabolic health suggests that an underlying dysregulation of several hormonal and metabolic processes is the cause of these 'lifestyle' diseases and that in fact, by addressing metabolic health first and foremost many of these diseases can be avoided or cured (Phillips, 2022).

While the mechanisms at play are not yet known, due in part to the relatively recent introduction of these food formulations, it is believed to be multifaceted (Hall et al., 2019; Heindel et al., 2022). The plausible mechanisms likely implicated in the negative health outcomes associated with UPF consumption are outlined below.

2.2.1. Food and diet composition: The 'bliss point'

When considering the composition of UPFs, these foods are formulated to be highly palatable and often include a combination of fat, sugar, and salt which drives overconsumption and is said to be linked to food addiction (Chen et al., 2020; Machado et al., 2020). In marketing and food technology this is known as the 'bliss point' and is thought to trigger dopaminergic pathways which in turn override endogenous satiety mechanisms and drive pathological eating habits (Vandevijvere et al., 2019). It appears that it is not these nutrients in isolation that are cause for concern, but rather it is their collective inclusion in products that results in metabolic dysregulation and pathological eating habits. To date, there has been no research examining whether UPF consumption alters satiety signalling (particularly GIP and GLP-1). Future research should aim to explore whether (and to what degree) UPFs disturb satiety signalling. The fibre content of UPFs is typically low, it is likely (given fibre's role not only in satiety but in overall health) that a diet based on UPFs could be lower in fibre which could be implicated in overeating and increase the risk of cardiovascular disease (Chen et al., 2020). While this is plausible, a recent RCT found that fibre intake on an ultra-processed diet was no different to that on a whole-food-based diet (Hall et al., 2019). Further research is required to elicit whether fibre intake is implicated in the poor health outcomes associated with diets high in UPFs. Due to manufacturers' desires to enhance shelf life and promote long term stability, the fats found in these foods are hydrolysed industrial trans fats, known to be harmful to health and promote inflammation (Pipoyan et al., 2021). It can be argued that replacing sugar with non-nutritive artificial sweeteners reduces overall calories and curbs consumption, but this evidence appears mixed (Christofides, 2021). Moreover, the potential implications of non-nutritive artificial sweeteners for gut health remain poorly understood. It can be argued that not following typical nutritional advice (adhering to a whole-food-based diet 80% of the time and enjoying some 'discretionary items' like UPFs 20% of the time) may be more important than the food composition itself. It could be that the overall displacement of whole food in favour of energy dense nutrient poor food formulations are to blame for the diseased states associated with high rates of UPF consumption or the food composition of UPFs may be responsible for driving passive over consumption. High quality research to ascertain the impact that food composition and overall DQ has on metabolism and gut health is required to ascertain whether this aspect of UPFs is in part or wholly responsible for their impact on health outcomes.

2.2.2. Processing and the food matrix effect

Food processing exists along a continuum and ranges from basic pre-industrial processes to complex industrial processes. The latter are associated with the degradation of the food matrix which may have negative consequences, particularly in relation to energy intake (Forde & Bolhuis, 2022; Gebauer, Novotny, Bornhorst, & Baer, 2016). There is a mounting interest in the impact that the form, texture and food matrix of foods has on health with a growing body of research illustrating that food processing (and its impact on the food matrix) alters the bioaccessibility (the fraction released during digestion) and bioavailability (the fraction actually absorbed) of nutrients and in turn the metabolisable energy (Aguilera, 2019; Forde & Bolhuis, 2022; Gebauer et al., 2016). The food matrix can be defined as "the complex assembly of nutrients and non-nutrients interacting physically and chemically, that influences the release, mass transfer, accessibility, digestibility, and stability of many food compounds" (Aguilera, 2019). Food processing degrades the natural cellular integrity of food structures and produces acellular nutrients. Consumption of these types of foods can result in higher glycaemic responses, increased post-prandial responses and lower satiety due to altered signalling or a lack of protein and fibre (Forde & Aguilera).

When a food is processed, it is structurally altered. The cell wall becomes disrupted and as a result, the particles reduce in size and absorption is increased (Forde & Bolhuis, 2022). The energy required for mastication to break foods down is also reduced when food form is altered to be softer (e.g. grinding almonds to almond butter or steak to a burger patty) (Forde & Bolhuis, 2022; Gebauer et al., 2016). Therefore, changes in both chemical and mechanical digestion explain why the metabolisable energy from, for example, ground almonds and almond butter is greater than that of whole raw almonds (Gebauer et al., 2016). Essentially, less is required from the body to access the same amount of energy. Not only is the amount of accessible energy available increased, there is evidence that when food form and texture are altered eating rate increases and as a result more calories are consumed (Forde & Bolhuis, 2022). A recent RCT illustrated that meal eating rate (measured in kcal/min consumed) was significantly greater in those eating an ultra-processed diet when compared with those eating a whole-food-based diet (Hall et al., 2019). To date, the research examining the impact of the food matrix affect is largely limited to single food items like almonds versus almond butter (Gebauer et al., 2016). It is plausible, given the fact that UPFs are energy dense, have been shown to be eaten more quickly and are likely to have greater quantities of metabolisable energy that the food matrix affect is at least partly implicated in the increase in energy consumption observed in relation to UPFs. The food structure may be responsible for driving passive over consumption which results in weight gain and metabolic dysregulation.

2.2.3. Additives and food contact chemicals

It is worth noting that when considering UPFs, factors beyond the food formulations themselves are worth exploring, this includes but is not limited to the impact of additives and increased exposure to harmful chemical substances (often referred to as obesogens) which might cause endocrinological disturbances through both processing and packaging (Heindel et al., 2022; Muncke et al., 2020; Pressman et al., 2017). Food additive safety is usually considered on an additive-by-additive basis, and it appears that cumulative food additives promote carcinogenicity and genotoxicity, adversely affecting the expression of genes and increasing the risk of cancer (Chen et al., 2020). It is important however to consider the source of the additives (natural or manufactured) (Davidou et al., 2020b). Prolonged intake of an UP diet is associated with biochemical alterations including oxidative stress, inflammation, and intestinal dysbiosis as well as impaired immunological health (Martínez Leo et al., 2021). Whether the underlying cause can be attributed to food composition (macro and micronutrients), food structure (matrix) or additives and contact chemicals remains unknown (Chen et al., 2020). A recent review of the available literature of obesogens, highlighted the causal links between chemical exposure and obesity (Heindel et al., 2022). Within the food environment there are three distinct classes of obesogens; bisphenols, phthalates and parabens that are known to disrupt metabolism via epigenetic mechanisms (Buckley et al., 2019; Heindel et al., 2022). Research illustrates that chemicals in food packaging migrate to the foods we eat when they are in direct contact with one another, these are known as food contact chemicals (FCCs) and many have been linked to adverse health consequences (Muncke et al., 2020). Buckley and colleagues examined the relationship between UPF consumption and exposure FCCs, namely to phthalates and bisphenols and found that with each 10% increase in energy attributed to UPF there was a corresponding 8% increase in urinary monocarboxyoctyl phthalate (indicating exposure to phthalates) (2019). They also found that eating foods outside the home (like hamburgers and French fries) was associated with greater exposure to multiple chemicals (Buckley et al., 2019). Considering packaged foods are often enclosed in plastic, it seems sensible to reduce the amount of plastic exposure by reducing the number of packaged foods in the diet (whether they are speciality foods or not) and eating homemade and hand prepared foods where possible. While the use of chemicals like BPAs and phthalates are regulated in the food supply chain, there are several points of concern that warrant scepticism among consumers. Toxicity thresholds are determined based on singular chemical components, this means that analyses do not take into account the cumulative impact of several different chemicals and their exposure (Pressman et al., 2017). Moreover, these thresholds are determined based on the chemical component but do not consider the by-products created during heating, cooling, and storing for long periods of time which may also be toxic (Pressman et al., 2017). While there are approximately 12 000 chemicals used in the food supply chain, we only understand the toxicological impacts of a subsection of these, due in part to an inability to detect and test a large portion of the FCCs (Muncke et al., 2020; Pressman et al., 2017). Finally, these toxic thresholds do not account for the effects which may exist at lower doses, particularly to the endocrine system (Heindel et al., 2022; Muncke et al., 2020; Pressman et al., 2017). It is evident that the negative impacts of UPFs are far reaching, beyond the nutrients themselves and that to fully understand the metabolic implications of these food formulations we must further investigate the impact of food composition, structure, processing, and FCCs in a holistic manner.

2.3. The Evidence for Alternative Dietary Patterns

ADPs, particularly those that intentionally exclude or reduce the consumption of certain food groups, are becoming increasingly popular. As previously stated, between 2004 and 2019 indicated that VEGAN, VEGE, LCHF, and KDs were all among the top five diet searches on Google (Kamiński et al., 2020). While the motivations for adopting these diets may vary, three common reasons often cited are health concerns, ethical concerns, and planetary concerns (Kamiński et al., 2020). VEGAN and VEGE diets are often grouped under the broad heading of plant-based diets while KD and LCHF are often grouped together as lowercarbohydrate diets. A brief review of these dietary patterns and the evidence for benefit and harm is presented below.

2.3.1. Plant-based diets

The term 'plant-based' is an all-encompassing umbrella term that typically refers to dietary patterns that rely either predominantly or entirely on plant-based sources for energy. The recent publication of the EAT-Lancet diet has propelled the consumption of PB eating into mainstream media and food manufacturers have in turn recognised the opportunity to produce convenient, hyper-palatable, UPF formulations ranging from snack and confectionery items, to fast foods and PB substitutes including meat and dairy analogues for this growing sub-group of the global population (Boukid, 2021; Wickramasinghe et al., 2021; Willett et al., 2019). The EAT-Lancet diet is a PB approach that encourages the restriction or omission of meat and animal by-products as a strategy to reduce the burden of food production on the planet and promote overall health in a time where the global burden of non-communicable weight-related diseases is profound (Willett et al., 2019; Zagmutt et al., 2020). This diet is typically promoted in accordance with the healthy eating guidelines and standard AMDRs (detailed earlier) with a focus on the consumption of grains, legumes, pulses, beans, and fruits and vegetables. It is important to note that to date, the inclusion of plant-based alternatives (meat and dairy analogues) is not endorsed expressly by nutrition associations.

It is important to recognise that the level of exclusion of animal-based food sources encouraged in PB diets exists along a continuum and that concerns have been raised regarding the nutrient adequacy of vegan diets, the most restrictive PB diets (Bakaloudi et al., 2021; Craig et al., 2021; Melina et al., 2016). While a universal definition for vegan diets has yet to be established, it is well known as a diet that excludes all animal products and by-products including meat, fish, dairy, and honey in favour of eating predominantly fruits, vegetables, whole grains, cereals, legumes, nuts and seeds (Melina et al., 2016). Comparatively, vegetarians might exclude only the meat from some animals from their diet (e.g. pescatarians who continue to eat chicken and fish) or include only animal byproducts (ovo-lacto vegetarians who will only eat dairy and eggs) (Melina et al., 2016). The evidence for benefit in observational research suggests that several health benefits are associated with plant-based diets including a lower incidence of non-communicable diseases such as colon cancer, type 2 diabetes mellitus (T2DM), obesity, and nonalcoholic fatty liver disease (Bakaloudi et al., 2021). It is unknown whether these health benefits are impacted by DQ and the relative energy contribution of mainstream of speciality UPFs. Moreover, these studies often do not account for the inherent healthyuser bias of those identifying with PB eating and the confounding lifestyle factors that may be responsible for these improved health outcomes. It is still worth considering (and remains contentious) whether these diets are appropriate for certain groups of the population (children, adolescents, pregnant women, and the elderly) and whether the overall DQ in these groups may be negatively impacted by socio-demographic factors and an overreliance of the increasing variety of speciality UPFs may occur (Avnon et al., 2021; Craig et al., 2021; Melina et al., 2016).

Despite the positive outcomes reported in relation to whole-food, healthy PB diets, there are several concerns regarding their nutrient adequacy. A systematic review of the literature indicates that vegan diets do not meet the requirements for calcium, Vitamin D, Vitamin $B_{12,}$ and iron (Bakaloudi et al., 2021). Moreover, even when consuming a wellplanned nutritionist-designed vegan diet, low levels of serum Vitamin A, DHA, and Vitamin D have been reported in a cohort of Finnish children which could be of concern for long-term visual health (Hovinen et al., 2021). These concerns are exacerbated by the explosion of processed meat and dairy analogues which are often composed predominantly of soy, gluten, pea protein and refined carbohydrates, and the growing availability of VEGAN convenience food, suggesting that vegan diets are not synonymous with health (Gallagher et al., 2021; Gehring et al., 2020; Petersen et al., 2021; Romão et al., 2022; Tso & Forde, 2021; Wickramasinghe et al., 2021). In fact, recent observational work suggests that vegans who adhere to 'traditional' standards tend to eat diets comprised predominantly of ultra-processed convenience foods (Gallagher et al., 2021). Whether this is due to the result of increased consumption of PB meat and dairy substitutes or just an increased consumption of mainstream UPFs remains a topic of debate with mixed findings reported in the literature (Dawczynski et al., 2022; Gehring et al., 2020; Ohlau et al., 2022). While Gehring and colleagues (2020) found that in individuals adhering to a vegan diet, 39.5% of total energy consumed came from UPFs and predominantly plant-based meat substitutes, Ohlau and colleagues (2022) findings were starkly different with PB meat alternatives being the least consumed UPFs. Both studies were conducted in Europe, where the availability and prevalence of plant-based meat alternatives is the highest globally (Petersen et al., 2021). The contrast in findings may be attributed to the difference in sampling techniques used, Ohlau and colleagues (2022) used a convenience sample while Gehring and colleagues (2020) relied on population nutrition health survey data. It can be argued that the latter may be more accurately indicative of the behaviours due to a larger sample with potentially less confounding. This work illustrates that the translation of guidelines into practice results in varying DQ, even with dietary patterns that are believed to be healthful.

2.3.2. Lower-carbohydrate diets

Similarly, LC diets also exist along a continuum of carbohydrate restriction with the level of carbohydrate restriction varying anywhere for ≤130g / day for the LCHF diet to ≤50g / day in the KD and almost 0g / day on a carnivore diet (Feinman et al., 2015; Volek et al., 2021). The research on LC diets typically focuses on the more extreme restriction and it's ensuing therapeutic benefits (Volek et al., 2021). Both the KD and LCHF seek to maintain protein in accordance with Acceptable Macronutrient Distribution Range (AMDR) recommendations (20-25% total energy) and allow fat to make up the remaining calories (this can be anywhere between 65-90% total energy) (Volek et al., 2021). Even in well-planned diets of this nature, given the reduction of carbohydrate intake and the increase in animal-based products (which tend to be rich in both protein and fat) it is not uncommon for protein to exceed this recommendation in those adhering to lowercarbohydrate diets (Knightbridge-Eager, 2020; National Health and Medical Research Council & Ministry of Health, 2006; Zinn et al., 2022; Zinn et al., 2018). While the KD is rooted in therapeutic clinical practice and has been used safely and effectively for the past 100 years in the treatment of intractable epilepsy and diabetes, LC diets are becoming a popular dietary approach adopted by many to lose weight, improve and maintain health and even support athletic performance (Athinarayanan et al., 2019; Volek et al., 2021). Despite their widespread adoption, little is known about the DQ of free-living individuals adhering to LC diets. Google searches bring up terms like 'dirty keto' and 'clean keto' suggesting that in practice there is a variance in DQ according to personal preferences, goals and potentially health and cooking literacy of individuals adhering to the KD.

The main concerns related to the KD are regarding the impact that increased consumption of saturated fat will have on cardiovascular health and whether nutrient sufficiency can be achieved. To date, the limited body of evidence (both observational and hypothetical) suggests micronutrient thresholds can be appropriately met at varying degrees of carbohydrate restriction (Kenig et al., 2019; Zinn et al., 2022; Zinn et al., 2018). A 12week intervention in overweight individuals illustrated that even when a subset of micronutrients were consumed below the recommended level, this did not impact serum levels (Kenig et al., 2019). In comparison, a recent thesis published illustrated that based on the degree of carbohydrate restriction, certain micronutrients were not met in free living individuals adhering to LC diets (Knightbridge-Eager, 2020). These findings highlight two distinct points, first health and nutrition literacy can directly affect one's ability to meet nutrient requirements (this can be said for any diet). Moreover, aside from Kenig and colleagues (2019) work, research has not examined the DQ of free-living individuals adhering to LC diets longitudinally. This is an important consideration, given that short-term studies may not appropriately account for the variety in dietary intake that it likely to exist across several months. Second, this calls into question whether specific micronutrient thresholds need to be established in the context of different dietary patterns due in part to changes in metabolism. This is a point Volek and colleagues raise in their recent review with regards to fibre requirements on a KD (Volek et al., 2021).

While there remains contention surrounding LC diets in relation to saturated fat, dietary fibre, and sodium consumption (Knightbridge-Eager, 2020; Volek et al., 2021). These nutrients remain contentious among academics and clinicians alike with concerns related to cardiovascular disease risk and poor gut health as a result of excessive saturated fat and sodium intake and a lack of dietary fibre due to the exclusion of cereals and grains on LC diets (Astrup et al., 2021; Offringa et al., 2021; Volek et al., 2021). The findings to date related to the above nutrients remain unsettled with new evidence emerging regularly, suggesting the issue may be more complex than previously believed.

A full review of the debate surrounding each of these dietary patterns (and the nutrients of concern) is beyond the scope of this work and does not align with the central theme of conceptualising DQ through a lens of food processing rather than individual nutrients. Moreover, speculation among several academics suggests that context (specifically the diet pattern or approach as a whole) may be an important and under-considered area of exploration with regards to understanding individual nutrients (Burns-Whitmore et al., 2019; Dawczynski et al., 2022; Offringa et al., 2021; Volek et al., 2021).

Given the contention surrounding these ADPs and the increasing interest in them from a public and public health perspective, it is important to consider how they might translate from guidelines to practice and the prevalence of UPF consumption (specifically from specialty products).

3. Methods

3.1. Study design / Methodology

This exploratory research was conducted through a positivist framework and utilised quantitative methods to explore the research question and sub-questions. Two novel diet quality categorisation tools, the NOVA food categorisation system (Monteiro et al., 2019) and the recently developed HISS (Human Interference Scoring System) developed by the AUT HPC, were used to explore DQ among those adhering to four ADPs (KD, LCHF, VEGE, VEGAN) via a FFQ modified from the New Zealand 2008/09 New Zealand Adult Nutrition Survey Questionnaire (Appendix B.1-questionnaire). To date, the NOVA categorisation tool has not been validated, while the HISS categorisation tool has undergone preliminary validation with a select cohort of health and nutrition professionals (Malamatenios, 2022). Previous research examining the proportion of different levels of processed food in the diet has used data from FFQs, however, the FFQs used have not specifically been designed for the purpose of ascertaining levels of food processing (Marrón-Ponce et al., 2018; Moubarac et al., 2017). This is a common critique of this field of nutrition research and was one of the main driving factors that led to the development of a modified FFQ specifically designed to ascertain the levels of processed food. The questionnaire was based on the food categories and servings used in the New Zealand 2008/09 New Zealand Adult Nutrition Survey Questionnaire. This is a validated tool for the collection of dietary habit data at a population level; thus, was deemed an appropriate template to modify for this research. To date, only a handful of questionnaires have been designed and validated in this area (Fangupo et al., 2019; Fangupo et al., 2021). Moreover, the NOVA tool is relatively easy to apply to single food components, for example an apple, a steak, a can of beans, frozen berries, or a packet of chips, but becomes more challenging to apply when considering meals made from several components that would be categorised into different groups (for example a homemade casserole) (Braesco et al., 2022; Knorr & Watzke, 2019; Sadler et al., 2022). The HISS tool aims to combat this shortfall of the NOVA system by inherently considering that foods are often eaten in conjunction with one another as meals rather than as stand-alone items. Using both tools allowed for the exploration of the agreement between them, and therefore, whether the HISS tool should be used in place of the NOVA tool in future research.

3.2. Recruitment / Data collection

Recruitment was conducted using virtual flyers (Appendix B.2- Flyer) that were posted on social media platforms (Facebook, LinkedIn, Twitter and Instagram) by the student, the supervisor and colleagues. The Vegan Society of New Zealand and Vegetarian Society of New Zealand shared the virtual flyer with their mailing list. The flyer contained a URL and

QRcode for convenience. All data was collected anonymously via an online survey tool (Qualtrics) between Friday 26th August and Sunday 18th September 2022. All participants read the participant information sheet prior to starting the FFQ and by beginning the questionnaire consented to have their data included in the data set (Appendix B.3- Information sheet). Participants could exit the survey at any time, incomplete questionnaires were subsequently removed from the final dataset.

Due to the exploratory nature of this work, there was no required number of participants for the purposes of statistical analysis. However, a convenience sample of 80 participants (at least 20 participants from each diet pattern) was sought. All participants were over the age of 18 years and self-identified with one of the four ADPs being explored in this research. Although it is possible that participants may adhere to more than one dietary pattern, for the purposes of this study, they were instructed to select the one they identified with most (ketogenic, low carbohydrate high fat, vegetarian or vegan). Participants were included if they were 18 years or older, any sex or gender orientation and had been eating in accordance with one of the four ADPs for at least 6-months. This was important to ensure that they were not new to the dietary pattern and had established a way of eating within the confines of the dietary pattern. Participants were excluded from this research if they were using one of the ADPs to lose a significant amount of weight. A significant amount of weight was stipulated as being 20 kgs of body weight or more. These individuals were excluded as there was potential for them to significantly alter their usual diet to achieve their weight loss goals. While it can be argued that understanding the DQ of those employing these dietary patterns for the purpose of weight loss is important, this was beyond the scope of this work as this was a DQ study not a weight loss study. Individuals who had used one of the ADPs as a weight loss tool in the past and had lost a significant amount of weight at that stage were not excluded, only those actively seeking to lose weight. Those under 18 years of age were excluded from this research because this research is intended to examine the overall DQ of adults not adolescents or children. Moreover, the DQ of adolescents may be influenced by factors beyond their control and tools to assess DQ in these populations should be carefully designed to ensure individuals in this age group understand what is being asked. Adolescents often eat the food bought and prepared for them by parents or caregivers and therefore may not have control over their DQ. Furthermore, they are more susceptible to clever marketing and may choose less more heavily processed products due to this or peer pressure.

3.3. Questionnaire design

A modified FFQ, based on the structure and broad food category groups utilised in the New Zealand 2008/09 New Zealand Adult Nutrition Survey Questionnaire, was developed (New Zealand Ministry of Health, 2008). The FFQ included 82 questions and took take participants

on average between 15-20 minutes to complete. Participants were asked to consider the number of servings they had consumed, for each question, across a 7-day period (one week). This is a standard period to consider diet quality as it can account for the variance that may occur between days (especially week and weekend days) and is standard practice in the design of FFQs. The questionnaire was split into four main sections: demographics, food frequency, 24-hour dietary recall, and personal perceptions. All demographic data was collected as categorical variables. Foods were broadly grouped into the following eight subsections: vegetables and fruits, grain foods and lower carbohydrate substitutes, dairy products, and dairy substitutes, legumes, nuts and seeds, meat, poultry, fish, eggs, and substitutes, cooking fats, spreads, sauces and dressings, confectionery and snacks, and convenience and takeout.
These groupings aligned with the standard Ministry of Health (MoH) groupings and allowed for specialty foods to be explored (e.g. plant-based meat, plant-based dairy, and lower carbohydrate bread products). Portion sizes were based on the suggested serving sizes document in the Eating and Activity Guidelines for New Zealand Adults (New Zealand Ministry of Health, 2020). Specialty supplements (for example sports performance supplements or herbal tinctures) and vitamins were not included in the FFQ. The quality (and level of processing required for production) of these products may vary and their impact on DQ remains to be understood.

Once developed, the questionnaire was piloted with a group of six nutrition professionals, their feedback informed amendments to the layout and language used in the questionnaire.
For example, rather than ‘vegan’ or ‘vegetarian’ the term ‘plant-based’ was used. Furthermore, after piloting the questionnaire, it was altered to allow for a ‘Prefer not to say’ for all demographic data points (apart from the dietary pattern they are following, which is central to the research aim). This ensured participants only answered what they felt comfortable answering. Although this questionnaire was modified from an existing validated source, it has not been formally validated given the time constraints of this research project, therefore, the validity of these findings may be called into question.

3.4. Questionnaire coding and dietary analysis

Each question in the FFQ was allocated a NOVA and HISS category number depending on the level of processing the foods grouped in the question underwent. This coding was used to calculate the proportion (as a percentage) of each NOVA and HISS category as it contributed to the overall diet (Appendix B.4- coding). This was done to apply a quantification element to DQ without accounting for individual nutrients or energy. Occupation was coded using the ISCO-08 (International Standard Classification for Occupations) structure. The final portion of the questionnaire included questions querying participants about their perceived DQ and diet adherence; these were assessed using Likert scales (1-10).

3.5. Data preparation and statistical analysis

Data were exported from Qualtrics and prepared for analysis in Microsoft Excel. Records for participants whose FFQ completion rate was less than 85% were removed from the dataset. This threshold was set because a slider tool was used for participants to select the number of serves for each question, in some cases participants did not move the slider from zero and it was assumed that for the given food group no serves were consumed across the week. Once the data were cleaned, each question was coded to the relevant NOVA and HISS categories and then a total number of serves and proportion (%) was calculated for each participant for each category in NOVA and HISS (see Appendix B.4 for coding guidance). The proportion of each NOVA and HISS category was calculated by summing all serves within a given category and dividing them by the total number of serves for each participant. Then the proportion (% of total serves) of NOVA or HISS category per food grouping was calculated by summing the total number of serves per category in each of the eight subsections and dividing them by the total number of serves. Finally, the actual DQ was calculated by dividing the NOVA 4% by the NOVA 1% , the resultant variable is referred to as N4:N1% ratio. The closer the number is to zero the higher the DQ and the greater the number the poorer the quality.

For this FFQ, a single serving of takeout (regardless of the size) constituted a single point in the given NOVA or HISS category. This has been the approach taken in previous research and is acknowledged as a weakness of food quality classification systems by academics, as to accurately classify foods they may need to be broken down into their composite parts and classified accordingly (Fangupo et al., 2019; Knorr & Watzke, 2019). However, this work has progressed the categorisation of foods into NOVA and HISS groups by applying an element of quantification (total number of serves) without accounting for individual caloric needs.

Data were quantitatively analysed using descriptive and parametric statistics in the software programme, JASP (version 0.16.3.0). Two one-way repeated measures ANOVAs were carried out to ascertain the difference in DQ among the ADPs. The first repeated measures ANOVA explored the difference in the proportion of each NOVA category across the ADPs, while the second examined the difference in the proportion of each HISS category. The first one-way repeated measures ANOVA (with diet pattern inputted as the independent categorical variable and NOVA% in each of the four categories as the continuous dependent variable) was conducted to ascertain whether there was a statistically significant difference in intake across the four NOVA categories among the ADPs (KD, LCHF, VEGAN, and VEGE). Data were approximately normally distributed with a few outliers which were included. The Greenhouse-Geisser correction was used to correct the F-statistic due to a violation of the assumption of sphericity. A second one-way repeated measures ANOVA (with diet pattern inputted as the independent categorical variable and HISS% in each of the four categories as the continuous dependent variable) was conducted to ascertain whether there was a statistically significant difference in intake across the four HISS categories among the four diet groups (KD, LCHF, VEGAN, and VEGE). Data were approximately normally distributed with a few outliers which were included. The Greenhouse-Geisser correction was used to correct the F-statistic due to a violation of the assumption of sphericity.

A linear regression was carried out to ascertain whether there was a difference between perceived DQ (independent variable) and actual DQ (dependent variable). Finally, a two-way repeated measures ANOVA was executed to ascertain the level of agreement between the two novel tools (NOVA and HISS).

4. Results

The results of this exploratory pilot study indicate that diet quality assessment tools, specifically NOVA and HISS, can be applied to a range of dietary patterns.

4.1. Demographics

The characteristics of respondents are presented in Tables 2 and 3. The sample of 168 consisted of 56 KD (m=16, f=39), 66 LCHF (m=13, f=53), 14 VEGAN (m=4, f=10) and 32 VEGE (m=5, f=27). The sample contained more respondents who adhered to a LC diet (n=122) than a PB diet (n=46). There were more females in the sample (n=129) than males (n=38) and one respondent did not share their gender. Demographic data in illustrate that the respondents were predominantly of European descent (n=150), between the ages of 35‒64 years (n=116), and with an education level of at least high school (n=137). Typically, KD and LCHF respondents were older when compared with VEGE and VEGAN participants, but all other demographic data was similar. Almost half of the respondents were classified as working in professional jobs (n=76), with half of the respondents classifying their income status as ‘moderate’ (n=84).

Table 2

Participant Demographics

Demographics	KD	LCHF	VEGAN	VEGE
Age*	45-54 (±1.27)	45-54 (±1.10)	25-34 (±1.05)	35-44 (±1.59)
Gender†				
Male	16	13	4	5
Female	39	53	10	27
Ethnicity*	Other European (±2.10)	NZ European (±1.98)	NZ European (±0.65)	NZ European (±2.29)

Education level*	Masters (±1.47)	Bachelors (±1.35)	Bachelors (±1.70)	Bachelors (±0.67)
Occupation*	Professionals (±3.84)	Professionals (±3.53)	Professionals (±1.17)	Technicians (±4.01)
Income status*	Moderate (±0.76)	Moderate (±1.01)	Moderate (±0.65)	Moderate (±1.16)

*Median presented with std. deviation

†Total number of respondents presented

Table 3

Demographic Frequencies by Diet Pattern

Demographic	KD	LCHF	VEGAN variable	VEGE	TOTAL
Age (years)					
19-24	1	0	4	5	10
25-34	4	2	5	8	19
35-44	8	10	3	8	29
45-54	20	24	2	6	52
55-64	14	21	0	0	35
65-69	7	6	0	5	18
70 +	2	3	0	0	5
Total	56	66	14	32	168
Ethnicity					
NZ European	23	39	8	20	90
Other European	26	21	5	8	60
Maori	0	0	1	0	1
Asian	3	1	0	1	5
African	0	1	0	0	1
Latin American	0	1	0	1	2
Prefer not to say	4	3	0	2	9
Total	56	66	14	32	168
Education level					
Primary	0	0	1	0	1
High School	6	10	4	6	26
Bachelors	21	25	4	21	71
Masters	7	15	2	4	28
PhD or equivalent	6	4	1	1	12
Trade / vocational training	15	11	1	0	27
Prefer not to say	1	1	1	0	3
Total	56	66	14	32	168
Occupation					
Not listed	1	4	0	1	6
Managers	2	13	1	2	18

Professionals	30	30	6	10	76
Technicians & associate professionals	4	5	2	5	16
Service & sales workers	4	3	0	2	9
Craft related trades workers	1	0	1	2	4
Plant & machine operators & assemblers	1	0	0	0	1
Elementary occupations	0	0	0	1	1
Armed forces occupations	0	1	0	0	1
Not formally employed	13	10	4	9	36
Total	56	66	14	32	168
Income status					
Very low	2	3	1	2	8
Low	5	4	5	5	19
Moderate	28	30	8	18	84
High	21	23	0	3	47
Very high	0	3	0	2	5
Prefer not to say	0	3	0	2	5
Total	56	66	14	32	168

4.2. NOVA and diet quality

Tables 4 – 6 represent the NOVA analysis which explored the research question examining the difference in intake across the four NOVA categories among the four ADPs (KD, LCHF, VEGAN, VEGE).

Table 4 illustrates the mean percentage from each NOVA group for each ADP, here forth referred to as NOVA%. A one-way repeated measures ANOVA revealed a statistically significant difference in NOVA% among the four ADPs $F(6.150, 336.184) = 8.285$, $p < 0.001$, with a medium effect size ($\eta^2 = 0.063$).

Table 4

Proportion of Diet from Each NOVA Category Across the Four Dietary Patterns

Diet Pattern	N	NOVA 1 (Mean % ± SD)	NOVA 2 (Mean % ± SD)	NOVA 3 (Mean % ± SD)	NOVA 4 (Mean % ± SD)
Keto	56	53 ±12	12 ±8	21 ±10	15 ±12

Low carb	66	51 ±13	8 ±5	23 ±10	18 ±12
Vegan	14	42 ±18	3 ±3	22 ±10	32 ±51
Vegetarian	32	42 ±15	4 ±3	26 ±8	28 ±15

SD, Standard Deviation

The results of a post hoc comparison of NOVA categories, represented as a percentage, here represented as NOVA%, across the four ADPs are displayed in Table 5 with 95% CI, effect size and statistical significance. This comparison revealed no statistically significant differences in NOVA 2% or NOVA 3%. There was a statistically significant difference ($p <$ 0.001) of 11% [95% CI 0.02, 0.19] in NOVA 1% between KD and VEGE with a large effect size (d =1.01). There was a statistically significant difference (p < 0.001) in NOVA 4% of 18% [95% CI -0.29, -0.06; d = 1.62) and 14% [95% CI -0.22, -0.05; d = 1.26] between KD and VEGAN and KD and VEGE respectively. Finally, a statistically significant difference (p < 0.001) was observed in NOVA 4% between LCHF and VEGAN of 14% [95% CI -0.26, -0.03; 1.33] and LCHF and VEGE of 10% [95% CI -0.19, -0.02; 0.97].

Table 5

The Difference in NOVA% Distribution Across the Four Dietary Patterns

		Mean diff (%)	CI	Cohen's d	*p* value
KD N1%	LCHF N1%	2	(-0.05, 0.09)	0.15	1.00
	VEGAN N1%	10	(-0.01, 0.22)	0.94	0.05
	VEGE N1%	11	(0.02, 0.19)	1.01	<.001*
LCHF N1%	VEGAN N1%	9	(-0.03, 0.12)	0.79	0.21
	VEGE N1%	9	(0.01, 0.18)	0.86	0.003
VEGAN N1%	VEGE N1%	1	(-0.12, 0.13)	0.07	1.00
KD N2%	LCHF N2%	4	(-0.03, 0.11)	0.33	1.00
	VEGAN N2%	8	(-0.03, 0.20)	0.79	0.24
	VEGE N2%	8	(-0.01, 0.16)	0.71	0.05
LCHF N2%	VEGAN N2%	5	(-0.06, 0.16)	0.46	1.00
	VEGE N2%	4	(-0.04, 0.12)	0.38	1.00
VEGAN N2%	VEGE N2%	-1	(-0.12, 0.11)	-0.01	1.00
KD N3%	LCHF N3%	-2	(-0.09, 0.05)	-0.19	1.00
	VEGAN N3%	-1	(0.13, 0.10)	-0.10	1.00
	VEGE N3%	-5	(-0.13, 0.40)	-0.46	0.78
LCHF N3%	VEGAN N3%	1	(-0.10, 0.12)	0.09	1.00
	VEGE N3%	-3	(-0.11, 0.05)	-0.23	1.00
VEGAN N3%	VEGE N3%	-4	(-0.16, 0.10)	-0.36	1.00
KD N4%	LCHF N4%	-3	(-0.10, 0.04)	-0.29	1.00
	VEGAN N4%	-18	(-0.29, -0.06)	-1.62	<.001*

	VEGE N4%	-14	(-0.22, -0.05)	-1.26	<.001*
LCHF N4%	VEGAN N4%	-14	(-0.26, -0.03)	-1.33	<.001*
	VEGE N4%	-10	(-0.19, -0.02)	-0.97	<.001*
VEGAN N4%	VEGE N4%	4	(-0.08, 0.16)	0.20	1.00

*Indicates statistically significant difference in proportion of diet from NOVA category
N1%, NOVA 1 percentage of diet; N2%, NOVA 2 percentage of diet; N3%, NOVA 3 percentage of diet; N4, NOVA 4 percentage of diet.

These data indicate that, based on this sample, individuals tend to consume a similar percentage of total dietary intake of NOVA 2 (culinary ingredients) and NOVA 3 (processed food) foods, regardless of dietary pattern. Moreover, individuals who adhere to a KD tend to eat a statistically significantly greater proportion (as a % of total dietary intake) of unprocessed and MPF when compared to VEGE but not when compared to LCHF and VEGAN. Finally, individuals who adhered to a VEGE or VEGAN diet tended to consume a statistically significantly greater percentage of total dietary intake of NOVA 4 (ultraprocessed food) compared to those adhering to a KD or LCHF.

Table 6 illustrates the mean proportion of NOVA % by food category among the four ADPs. Where there is no displayed percentage for a given NOVA category's corresponding food category, this is because there were no foods allocated to the specific NOVA category in that food group.

Table 6

Difference in mean NOVA % between Dietary Patterns Based on the Food Categories

Diet patterns	**KETO**				**LOW CARB**				**VEGAN**				**VEGETARIAN**			
Food categories	Mean NOVA % per food group				Mean NOVA % per food group				Mean NOVA % per food group				Mean NOVA % per food group			
	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4
FRUIT & VEG	13		2		18		2		27		4		22		4	
GRAINS & SUBSTITUTES	1		1	3	2		2	5	8		1	9	4		3	9
DAIRY & SUBSTITUTES	7		9	1	6		8	2	0		8	3	4		7	3
LEGUMES, NUTS, SEEDS	3		2	0	6		2	0	6		5	0	6		3	0
MEAT, POULTRY, FISH, EGGS & SUBSTITUTES	24		4	4	13		4	3	0		0	6	3		2	3
COOKING FATS, SAUCES & SPREADS	1	10	3	3	0	8	5	3	0	3	4	5	1	4	5	4
CONFECTIONERY & SNACKS	2		1	3	1		1	5	1		1	6	0		3	8
CONVENIENCE & TAKEOUT			1	2			1	3			0	4			1	2

These data indicate that the main contributors to NOVA 1% for KD and LCHF were meat, poultry, fish, eggs and substitutes (24% and 13% respectively) and fruit and vegetables (13% and 18% respectively). Comparatively, for VEGAN and VEGE the highest NOVA 1% contributors were fruit and vegetables (27% and 22% respectively). When considering UPFs (NOVA 4) the main contributors for KD were meat, poultry, fish, eggs and substitutes (4%) while those adhering to LCHF consumed similar quantity of grain substitutes and confectionery and snacks (5% each). Comparatively, the highest contributors to NOVA 4% for VEGAN and VEGE were grains and substitutes (9%).

4.3. HISS and diet quality

Tables 7 – 9 represent the HISS analysis which explored the research question examining the difference in intake across the four HISS categories among the four ADPs (KD, LCHF, VEGAN, VEGE).

Table 7 illustrates the mean percentage from each HISS group for each dietary pattern, here forth referred to as HISS%. A one-way repeated measures ANOVA revealed a statistically significant difference in HISS% among the four diet patterns $F(6.912, 377.874) = 8.590$, $p < 0.001$, with a medium effect size ($\eta^2 = 0.086$).

Table 7

Proportion of Diet from Each HISS Category Across the Four Dietary Patterns

Diet Pattern	HISS 1 (Mean % ± SD)	HISS 2 (Mean % ± SD)	HISS 3 (Mean % ± SD)	HISS 4 (Mean % ± SD)
Keto	42 ±13	32 ±10	12 ±8	14 ±13
Low carb	42 ±11	28 ±10	11 ±8	18 ±12
Vegan	44 ±20	14 ±6	11 ±8	30 ±15
Vegetarian	37 ±13	21 ±8	13 ±8	30 ±15

The results of a post hoc comparison of HISS% across the four ADPs are displayed in Table 8 with 95% CI, effect size and significance. This comparison revealed no statistically significant differences in HISS 1% or HISS 3%. There was a statistically significant difference (p <0 .001) in HISS 2% of 18% and 11% between KD and VEGAN and KD and VEGE respectively, with [95% CI 0.06, 0.29; 1.60] and [95% CI 0.03, 0.20; 1.03]. There was a statistically significant difference ($p < 0.001$) in HISS 4% of 17% and 16% between KD and VEGAN and KD and VEGE respectively with [95% CI -0.28, -0.05; 1.50] and [95% CI -0.24, -0.07; 1.42]. Finally, there was a statistically significant difference of 11% ($p < 0.001$) with [CI 95% -0.20, -0.03; 1.01] between LCHF and VEGE HISS 4%.

Table 8

The Difference in HISS% Distribution Across the Four Dietary Patterns

		Mean diff (%)	CI	Cohen's d	*p* value
KD H1%	LCHF H1%	0	(-07, 0.07)	0.02	1.00
	VEGAN H1%	-2	(-0.13, 0.10)	-0.15	1.00
	VEGE H1%	5	(-0.03, 0.14)	0.48	0.93
LCHF H1%	VEGAN H1%	-2	(-0.13, 0.10)	0.18	1.00
	VEGE H1%	5	(-0.03, 0.04)	0.46	1.00
VEGAN H1%	VEGE H1%	7	(-0.05, 0.20)	0.64	1.00
KD H2%	LCHF H2%	4	(-0.03, 0.11)	0.36	1.00
	VEGAN H2%	18	(0.06, 0.29)	1.60	<.001*
	VEGE H2%	11	(0.03, 0.20)	1.03	<.001*
LCHF H2%	VEGAN H2%	14	(0.02, 0.25)	1.24	0.002
	VEGE H2%	7	(-0.01, 0.16)	0.67	0.09
VEGAN H2%	VEGE H2%	-6	(-0.19, 0.06)	-0.57	1.00
KD H3%	LCHF H3%	0	(-0.07, 0.07)	0.02	1.00
	VEGAN H3%	1	(-0.11, 0.12)	0.06	1.00
	VEGE H3%	-1	(-0.10, 0.08)	-0.10	1.00
LCHF H3%	VEGAN H3%	0	(-0.11, 0.12)	0.03	1.00
	VEGE H3%	-1	(-0.10, 0.70)	-0.13	1.00
VEGAN H3%	VEGE H3%	-2	(-0.14, 0.11)	-0.16	1.00
KD H4%	LCHF H4%	-4	(-0.12, 0.03)	-0.41	0.88
	VEGAN H4%	-17	(-0.28, -0.05)	-1.50	<.001*
	VEGE H4%	-16	(-0.24, -0.07)	-1.42	<.001*
LCHF H4%	VEGAN H4%	-12	(-0.24, -0.00)	-1.09	0.01
	VEGE H4%	-11	(-0.20, -0.03)	-1.01	<.001*
VEGAN H4%	VEGE H4%	1	(-0.12, 0.13)	0.08	1.00

*Indicates statistically significant difference in proportion of diet from NOVA category
H1%, HISS 1 percentage of diet; H2%, HISS 2 percentage of diet; H3%, HISS 3 percentage of diet; H4, HISS 4 percentage of diet.

These data indicate that, based on this sample, regardless of dietary patterns individuals tend to consume a similar percentage of total dietary intake of HISS 1 (whole or minimally processed foods) and HISS 3 (mostly homemade food items) foods. Moreover, individuals who adhere to a KD tend to eat a statistically significantly greater proportion (as % total dietary intake) of foods mostly available for consumption in pre-industrial societies (HISS 2) when compared to VEGE and VEGAN but not when compared to LCHF. Finally, individuals who adhered to a VEGE or VEGAN diet tended to consume a statistically significantly greater proportion (as % total dietary intake) of HISS 4 (ultra-processed food items) compared to those adhering to a KD while only those adhering to a VEGE diet consumed a greater proportion (as % total dietary intake) of HISS 4 when compared to LCHF.

Table 9 illustrates the mean proportion of HISS % by food category among the four ADPs. Where there is no displayed percentage for a given HISS category's corresponding food category, this is because there were no foods allocated to the specific NOVA category in that food group.

Table 9

Difference in mean HISS % between Dietary Patterns Based on the Food Categories

Diet patterns	**KETO**				**LOW CARB**				**VEGAN**				**VEGETARIAN**			
Food categories	Mean HISS % per food group				Mean HISS % per food group				Mean HISS % per food group				Mean HISS % per food group			
	H1	H2	H3	H4	H1	H2	H3	H4	H1	H2	H3	H4	H1	H2	H3	H4
FRUIT & VEG	13		2		14		2		27		4		24		4	
GRAINS & SUBSTITUTES	0	0	2	2	1	0	3	3	6	2	3	7	4	1	4	9
DAIRY & SUBSTITUTES		16		1		10		2		8		3		13		3
LEGUMES, NUTS, SEEDS	3		2	0	5		1	0	11		0	0	9		1	0
MEAT, POULTRY, FISH, EGGS & SUBSTITUTES	24	1	1	5	10	1	1	3	0	0	3	3	3	1	2	3
COOKING FATS, SAUCES & SPREADS		12	1	5		8	0	4		4	0	7		7	1	7
CONFECTIONERY & SNACKS		2	1	3		1	1	4		1	1	6		2	2	9
CONVENIENCE & TAKEOUT			1	2			1	2			0	4			1	3

These data indicate that the main contributors to HISS 1% for KD and LCHF were meat, poultry, fish, eggs and substitutes (24% and 10% respectively) and fruit and vegetables (13% and 14% respectively). Comparatively, for VEGAN and VEGE the highest HISS 1% contributors were fruit and vegetables (27% and 24% respectively) and legumes, nuts and seeds (11% and 9% respectively). When considering UPFs (HISS 4%) the main contributors for KD were meat, poultry, fish, eggs and substitutes (5%) and cooking fats, sauces, and spreads (5%). Those adhering to LCHF consumed similar quantity of cooking fats, sauces and spreads and confectionery and snacks (4% each). Comparatively, the highest contributors to HISS 4% for VEGAN and VEGE were grains and substitutes (7% and 9%) and cooking fats, sauces and spreads (9%) for VEGAN and confectionery and snacks (9%) for VEGE.

4.4. NOVA and HISS comparison

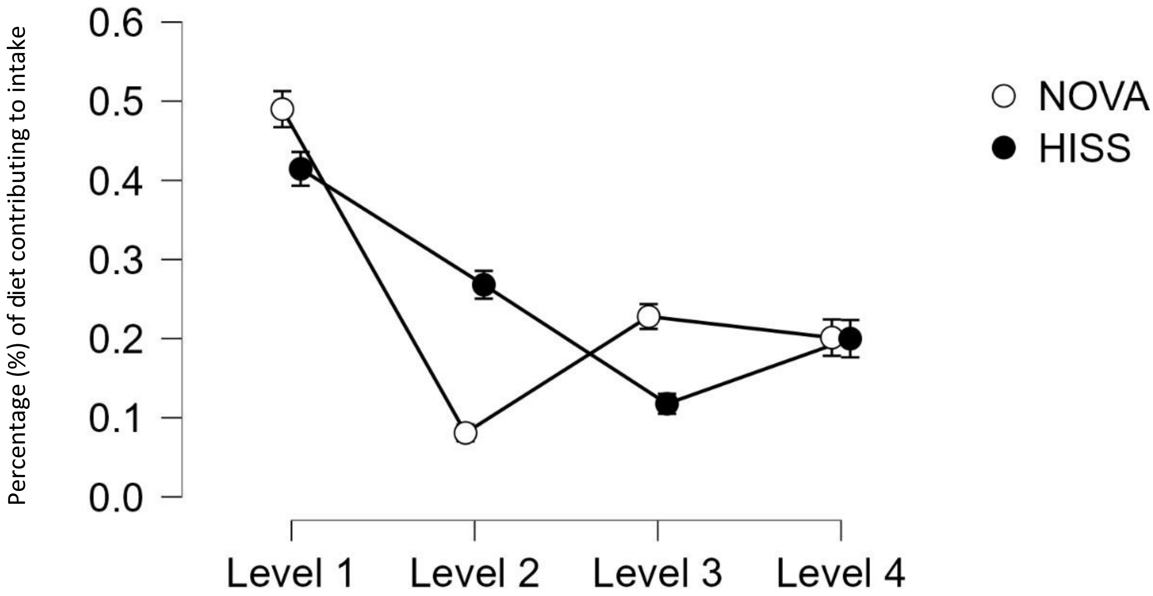
Figure 1 represents the NOVA and HISS comparison analysis which explored the research question examining the agreement between the NOVA and HISS tools.

Figure 1 shows the relationship between % intake across the four levels, and the two diet quality assessment tools (NOVA and HISS). Post hoc testing revealed the two diet tools were statistically different ($p < .001$) at Level 1, 2, and 3, but similar at level 4 ($p = 0.83$). These data indicate that both tools are equally capable of recognising UPFs.

A two-way repeated measures ANOVA was conducted to assess whether there was a statistically significant difference between the NOVA and HISS food classification systems. On average (across all 4 levels on average), there is no difference between the NOVA and HISS diet tools ($p = 0.754$). On average (across the two diet quality assessment tools) there is a difference across the four levels ($p < .001$). The tool*level interaction ($p < .001$) indicates the relationship between total proportion (%) intake and the four levels, is different between the two diet quality assessment tools.

Figure 1

Relationship between NOVA and HISS Diet Quality Assessment Tools



4.5. Actual diet quality and perceived diet quality

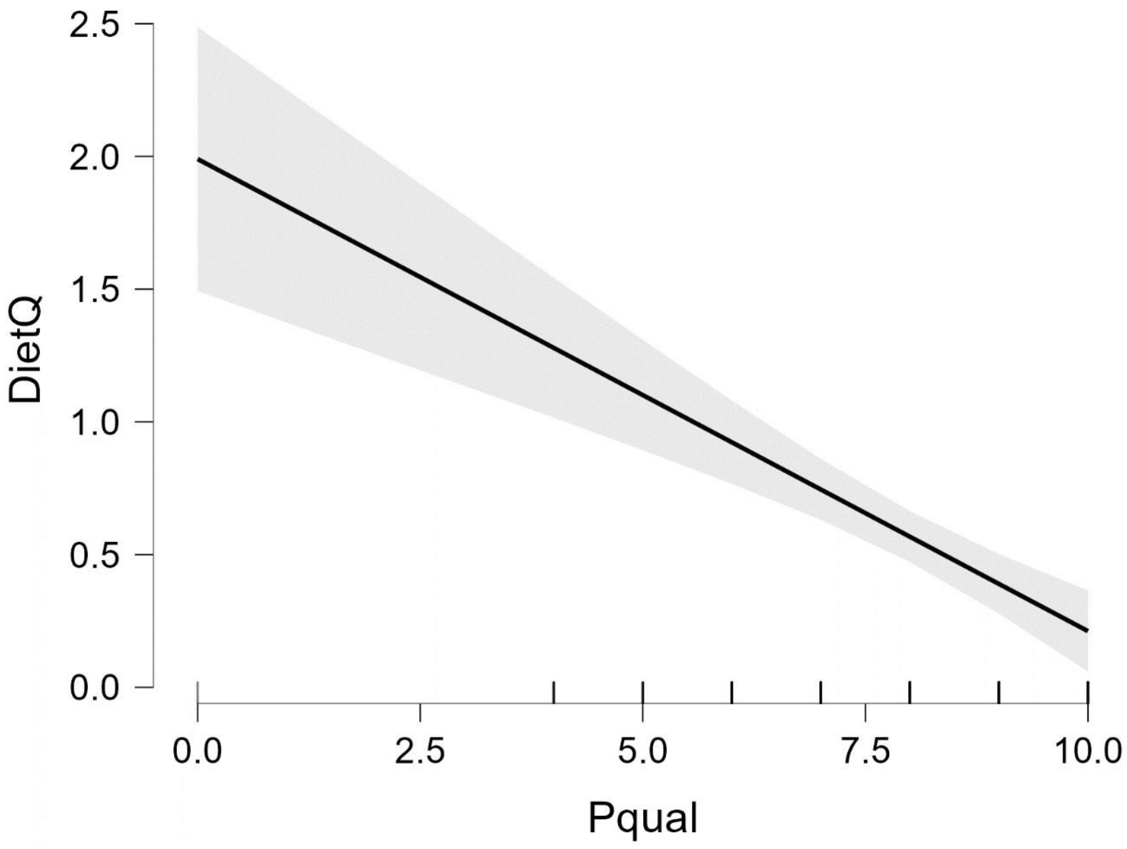
Linear regression was used to assess whether actual diet quality (N1:N4%) could be predicted by perceived diet quality (reported by respondents on a 1–10 Likert scale). The objective was two-fold, first to understand whether there was a statistically significant relationship between perceived diet quality and actual diet quality, and second, to understand whether this differed based on diet pattern, age, ethnicity, education level, occupation, or income status.

Preliminary analyses were conducted to ensure no violation of normality, linearity, multicollinearity, and homoscedasticity assumptions.

Figure 2 depicts the inverse relationship between actual diet quality and perceived diet quality discovered via linear regression. Based on the data sample, perceived diet quality can significantly predict actual diet quality using the following regression equation: Actual diet quality = 1.990 + (-0.178 * perceived quality)

Figure 2

Relationship between Diet Quality and Perceived Diet Quality



DietQ, Diet quality; PQual, Perceived quality

These data indicate that when perceived diet quality increases by one unit (on the 1−10 Likert scale) there is a corresponding 0.178 unit decrease in actual diet quality. This relationship remains statistically significant, even once gender, age, ethnicity, education level, occupation, and income status are controlled for.

5. Discussion

The availability and consumption of UPFs continue to increase globally and are associated with serious adverse health consequences including an increased risk of all-cause mortality (Chen et al., 2020; Vandevijvere et al., 2019). The research related to quantifying DQ focuses predominantly on understanding this phenomenon as a potential predictor of health at a population level and relies heavily on national nutrition survey data rather than data from specifically designed questionnaires (Monteiro et al., Fangupo et al., 2019; 2019). To date, there has been limited research examining the DQ of those consuming PB diets and there is an absence of research examining the DQ of those consuming LC diets, despite a growing interest in them and an increasing number of specialty products (Gallagher et al., 2021; Gehring et al., 2020). The work related to these ADPs focuses predominantly on nutrient sufficiency and safety and remains a contentious topic among health professionals and academics (Bakaloudi et al., 2021; Melina et al., 2016; Zinn et al., 2022; Zinn et al., 2018). It can be argued that in the context of the current food environment, where UPF products often misrepresented as 'healthy' by nutrient scoring systems and because of their affiliation with ADPs, that taking a reductionist view of DQ may have unintended consequences for overall health (Dickie et al., 2018; Romero Ferreiro, Lora Pablos, et al., 2021). Rather than pitting dietary patterns against one another (when it is recognised that individuals will select one based on personal preferences and values above scientific research) it is worth examining and understanding the impact that specialty UPFs have on DQ with regards to ADPs. Furthermore, whether there is a safe threshold for UPF consumption in the context for of these ADPs should be explored. This work was the first to explore and quantify the quality of four ADPs (KD, LCHF, VEGE, VEGAN) using a modified questionnaire and two food processing classification systems (NOVA and HISS). The findings of this research illustrated a higher intake of unprocessed and MPF among the LC diet groups compared with PB, a higher intake of UPF among PB compared with the LC diet groups, and similar intakes of culinary items and processed foods.

The two-way repeated measures ANOVA revealed that NOVA and HISS were significantly different ($p < 0.001$) at levels 1, 2 and 3. However, they are similar at level 4 (UPF). This indicates that the HISS classification tool can detect UPFs with the same certainty as NOVA. Further validity and reliability testing of the HISS tool is required to ascertain whether it is an appropriate tool for population-based assessment of DQ.

This research found an inverse relationship between actual and perceived DQ with actual diet quality reducing as perceived diet quality increased. This is consistent with previous findings. A recent study examining actual and perceived DQ in cancer survivors displayed similar findings (Xue et al., 2020). This study used the Healthy Eating Index (a reductionist index based on nutrient quantities) to assess DQ and a Likert scale (similar to the present study) to assess perceived quality. The researchers found that participants tended to over-rate their DQ. The exact mechanisms that result in this mismatch between perception and reality is yet to be determined but could be the result of confusing public health messaging related to nutrition and the clever marketing of UPFs.

5.1. Key findings

5.1.1. Demographics

There was a total of 168 respondents to the online questionnaire. The study population was predominantly European (n=150), female (n=129), between the ages of 35‒64 years and classified as professionals with a 'moderate' income level. There were proportionally more LC respondents (n=122) than PB respondents (n=46). The relatively larger number of respondents in the LC group was expected given that the social media followings of the student, supervisor and respective colleagues align with this dietary approach. Efforts were made to increase the number of plant-based respondents and the Vegan and Vegetarian Societies of New Zealand also shared the recruitment flier. It is plausible that the lower number of respondents in the plant-based group can be attributed to the fact that <1% of the global population follows a vegan diet; therefore, recruiting these individuals can prove difficult (Gallagher et al., 2021).

There are two points regarding the demographics of the study sample that require further discussion. First, the fact that the respondents were predominantly female is in line with previous research exploring the habits of those adhering to ADPs where convenience sampling is used (Gallagher et al., 2021; Knightbridge-Eager, 2020). While this research excluded those using the ADPs as a mechanism for significant weight loss (≥20kg), the larger number of female respondents was expected given this population is typically more health conscious and tend to experiment with different diets (Grzymisławska et al., 2020). Second, previous research has indicated that LC diets may be more expensive relative to mainstream diets and as a result have been viewed as 'elitist' and not appropriate for the population at large, while PB diets are frequently touted as being affordable (Donovan et al., 2022; Kidd et al., 2021; Zinn et al., 2020). Given the study sample was predominantly classified as 'moderate' income earners, this supposition could be called into question. However, it is worth noting that there may be a level of reporter bias with regards to income level as this was measured qualitatively. Further research is required to fully understand the cost and relative affordability of LC and PB diets in free-living individuals. The present study used qualitative measures of income, rather than quantitative set income brackets, this may have allowed for a certain level of reporter bias. The cost of diet should be assessed in alongside the potential benefits and whether the inclusion or exclusion of specialty UPFs impact either metric. A paper that addresses a hypothetical case study (under review) aimed to explore this topic and found that the inclusion of UPFs increased overall diet cost while simultaneously reducing nutrient adequacy (Lenferna De La Motte & Zinn, 2022).

5.1.2. Unprocessed and minimally processed food consumption

A key finding of this exploratory work illustrates that (regardless of the measurement tool of diet quality i.e. NOVA or HISS), all four groups consumed more than 40% of their diet (as a percentage of total serves) from unprocessed or MPFs (depicted as N1% or H1%). For all diet groups, unprocessed and MPFs made up the greatest proportion of their diet. This is significant and indicates that those adhering to LC and PB dietary patterns may consume more whole foods than the general population (Machado et al., 2019). Those adhering to a KD or LCHF diet consumed a greater proportion of their diet from unprocessed and MPF (53% ±12 and 51% ±13, respectively) when compared with VEGE and VEGAN (42% ±15 and 42% ±18, respectively). However, there was only a significant difference ($p < 0.001$) when comparing the KD and VEGAN groups. The findings for contribution of unprocessed and MPFs for HISS (HISS 1) were similar. This finding calls into question the supposition that LC diets contain an excess of 'nutrients to limit' and lack sufficient key nutrients to support health (Knightbridge-Eager, 2020). Instead, this suggests a higher overall quality given the fact that many animal-based foods are classified as being unprocessed or minimally processed. Moreover, research from a paper assessing hypothetical case studies (under review) suggests that by relying on unprocessed and MPFs, individuals are more likely to meet nutrient requirements (Lenferna De La Motte & Zinn, 2022). The reduced consumption of unprocessed and MPF among PB respondents could in part be explained by a reduction (or omission) of the consumption of animal-based products in favour of refined grains or plant-based meat and dairy substitutes (Gehring et al., 2020). This has been found in previous research, suggesting that when convenience is favoured over health nutritious food can be displaced by UPFs.

The results show that the food group contributing most to the consumption of unprocessed and MPF (NOVA 1) was fruits and vegetables (LCHF 18%, VEGAN 27%, VEGE 22%) and meat, poultry, and fish (KD 24%). These percentages are indicative of the total number of servings of fruit and vegetables divided by the absolute total number of servings across all levels. This is in accordance with the basic tenets of these ADPs and previous research findings. Typically, those adhering to the KD will select foods that are higher in fat and protein, while those adhering to LCHF have more freedom in their food choices given the reduced level of carbohydrate restriction and as such can include more fruits and vegetables in their diets (Knightbridge-Eager, 2020; Zinn et al., 2018). In comparison, PB diets expressly encourage the consumption of a variety of plant foods, and it is expected that this will make up a significant proportion of their diet (Willett et al., 2019; Zagmutt et al., 2020).

Interestingly, when comparing the consumption of unprocessed and MPF between those adhering to ADPs and the general population, recent research from Australia reported consumption of approximately 35% of total energy intake; whereas research from a Mexican cohort found much higher intakes of approximately 54% of total EI (Machado et al., 2019; Marrón-Ponce et al., 2018). The mixed findings from the general population could be explained by two potential factors. First, although the research was only recently published, it was based on national nutrition survey data dating back to 2012. It is plausible that in the last decade, the availability and consumption of unprocessed and MPF may have declined and become offset by UPFs, particularly in developing countries where their availability and consumption continues to increase (Vandevijvere et al., 2019). Second, neither of the studies used validated tools to assess DQ, this means there could be a level of classification error across the NOVA classification groups. This is a common critique cited in the literature (Braesco et al., 2022; Fangupo et al., 2019; Sadler et al., 2022). To accurately compare the proportion of EU from unprocessed and MPFs across different dietary patterns (and in comparison, with the standard mainstream diet), a validated tool needs to be developed and used to quantify the relative energy contribution.

5.1.3. Culinary ingredients and processed food consumption

Culinary ingredients

For all diet groups, culinary ingredients made up the smallest proportion of their diet. When examining the intake of culinary ingredient across the four ADPs the KD group consumed the most (12% ±8) and the VEGAN group the least (3% ±3). However, there was no significant difference in consumption (denoted as N2%) among the four diet groups. These findings were expected for two reasons. First, only cooking fats and oils were included in this category for the questionnaire. Given the basics tenets of a KD (low carbohydrate, high fat) it stands to reason that they will consume a greater proportion of their diet from fat-based products like cooking oils and fats (Volek et al., 2021; Zinn et al., 2018). The findings of this research are in accordance with previous research that reported lower intakes of saturated fat among those consuming PB diets (Bakaloudi et al., 2021; Melina et al., 2016). Second, typically culinary ingredients are eaten as part of a meal rather than on their own; therefore, appropriately accounting for the contribution to the diet is challenging and a commonly reported critique of the NOVA classification system (Knorr & Watzke, 2019). This is a key difference between the NOVA and HISS classification systems. Rather than grouping culinary ingredients in their own distinct category, HISS incorporates an additional level that aims to distinguish different processing techniques by intensity (Nicol, 2022).

Processed food

When considering processed foods, NOVA has one category (NOVA 3) while HISS has two (HISS 2 and HISS 3) (Monteiro et al., 2019; Nicol, 2022). For all four ADPs the relative contribution of NOVA 3 (denoted as N3%) was similar. NOVA 3 was the second largest contributor to diet intake for LCHF and KD but not VEGE and VEGAN. While intake was highest among VEGE (26% ±8) and lowest among KD (21% ±10) there was no statistically significant difference in the proportion of servings consumed from this group among the four ADPs. This outcome was expected due to the types of products included in NOVA group 3, which can be considered staples across all four diets. For example, vegetables or legumes bottled or canned in brine, salted or roasted nuts and seeds, freshly made breads and cheeses and smoked or dried meat and fish (Monteiro et al., 2019). Comparatively, when considering the proportion of pre-industrial processed foods (HISS 2) across the four diets intake was highest among KD and LCHF (32% ±10 and 28% ±10 respectively) and lowest among VEGAN and VEGE (14% ±6 and 21% ±8 respectively). This was only statistically significant when comparing KD with VEGE and VEGAN. However, when considering items mostly prepared at home (HISS 3) there was no statistically significant difference across the four ADPs.

Given that this is the first study using HISS and NOVA to quantify DQ and the limited body of research on this topic, it is challenging to compare these findings with existing literature. However, when considering NOVA, the findings can be compared to the general population and a small body of research related to PB diets. First, in the general population, processed foods are typically the third highest contributor (usually behind UPFs and MPFs and unprocessed foods) (Marrón-Ponce et al., 2018; Moubarac et al., 2017). If DQ is quantified by the relative contribution of less processed foods, then it can be inferred that LC diets are of a higher quality than the general population. For example, greater contribution of NOVA 1 and NOVA 3 products (as a proportion of total energy intake or a percentage of total serves) would indicate a higher overall quality than NOVA 4 and NOVA 1 being the highest contributors. This would be expected, given the central tenets of this dietary approach which encourages the consumption of predominantly whole, unprocessed foods (Zinn et al., 2018). In comparison, the PB respondents consumed a greater proportion of UPF compared to processed foods, previous research has suggested this could be the result of increased consumption of plant-based meat and dairy alternatives (Gehring et al., 2020). Further work is required to ascertain what the relative contribution of each NOVA or HISS groups means for overall DQ without reducing these holistic frameworks back to a scoring index.

5.1.4. Ultra-processed food consumption

This exploratory work illustrates that (regardless of the measurement tool of DQ i.e. NOVA or HISS), KD and LCHF consumed fewer servings of UPF compared with VEGE and VEGAN (depicted as N4% or H4%). For KD and LCHF, UPFs made up the second smallest proportion of their diet (behind culinary ingredients) UPFs (15% ±12 and 18% ±12 respectively). Comparatively, for VEGE and VEGAN, UPFs were the second highest contributor (28% ±12 and 32% ±12 respectively). This was significant difference ($p < 0.001$) when comparing the KD and LCHF to VEGAN and VEGE groups. When comparing this with the general population in developed countries, all four ADPs still consume less UPFs (Machado et al., 2019). Research examining the consumption of UPF illustrates that in developed countries consumption typically ranges from 42% (Australia) to 57% (America) (Machado et al., 2019; Wang et al., 2022). The fact that those adhering to ADPs consume a relatively smaller overall percentage of their diet from UPFs could be explained by the healthy user bias. It is plausible that those following ADPs are more concerned about their health (even in the absence of trying to alter body composition) and as a result are more selective when making food choices.

The results show that the food group contributing most to the consumption UPFs (NOVA 4) was ultra-processed meat, poultry, and fish (KD 4%), confectionery (LCHF 5% and VEGE 8%), grains and grain substitutes (LCHF 5% , VEGAN 9% and VEGE 9%). This is a novel finding; previous research suggests that the increase in UPF consumption among PB individuals is the result of a reliance on plant-based meat and dairy substitutes (Gehring et al., 2020). It also suggests that much like PB dietary approaches, through an over-reliance on novelty and convenience products, LC diets can also be executed with lower overall quality (Gallagher et al., 2021). While this has not been captured in the literature, a simple Google search reveals a community of individuals who align themselves with what is deemed 'dirty keto'. This dietary approach typically forgoes food quality with the sole focus placed on achieving the appropriate macronutrient ratios for a KD. As a result, individuals may consume large amount of UPFs as long as they fit within the macronutrient recommendations and ketosis is achieved. The impact of this subbranch of the KD on overall health is unknown, further research is required to understand if there are negative consequences on nutrient consumption and whether this is linked to any adverse health outcomes. While ultra-processed grain-based products and PB meat and dairy alternatives may pose a threat to the DQ of plant-based diets, those adhering to LC diets need to be mindful of processed meat products and low-carbohydrate grain substitutes, according to the findings of this research. These convenient food formulations could increase the risk of metabolic dysregulation via the ingestion of food additives and/or food contact chemicals (Buckley et al., 2019; Muncke et al., 2020; Pressman et al., 2017). Although the mechanisms are not well understood, research shows that EI increases when consuming an ultra-processed diet (Hall et al., 2019). This could be the result of the food matrix effect and/or dysregulation of satiety signalling (Aguilera, 2019; Forde & Bolhuis, 2022). While this RCT examined the impact of typical rather than alternative dietary patterns, given the similarities (processing techniques, additives, potential exposure to food contact chemicals) between generic and specialty UPF products it bears to reason that the results may be similar. Further high-quality research is required to understand the impact of UPSPs on overall health and ascertain the mechanisms of action regarding the associated negative health outcomes.

While the results of this exploratory pilot study indicate that diet quality assessment tools, specifically NOVA and HISS, can be applied to a range of dietary patterns. It is worth noting that there is a likely healthy-user bias in this sample, given that those who self-selected into participating are likely to have a high level of health literacy and are interested in eating in a way that would be deemed 'healthful'. Understanding and quantifying DQ through a holistic lens that incorporates the impact of nutrients, food processing, and non-nutritive components (like additives and food contact chemicals) is an emergent and growing field. While the emerging classification tools are imperfect, they signify a step in the right direction for nutritional sciences, toward a more holistic understanding of DQ beyond nutrients alone. This area of research is made increasingly complex when considering that even within the whole food category there are likely varying degrees of food quality. Considerations including how your food was raised or grown (and the impacts of genetic modification, feeding practices, pesticides, and antibiotics) may need to be considered in future iterations of food processing classification systems. Davidou and colleagues (2020) have begun to incorporate both holistic and reductionist thinking into a single framework, it is plausible that this framework could form the basis of further investigation into the impact that farming practices have on food quality and whether these practices should be considered as forms of 'food processing' as they may alter the structure and matrix of the foods.

6. Conclusion

This research contributes new insights to the DQ of individuals adhering to four ADPs (KD, LCHF, VEGE, VEGAN). It is among a small number of studies to explore the quality of these diets through a new paradigm that uses the level of food processing as a proxy for DQ (Gallagher et al., 2021; Gehring et al., 2020). The findings of this work suggest that those adhering to ADPs have a high diet quality. This is indicated by a higher intake of unprocessed and MPF and lower intake of UPFs. Moreover, it indicates LC diets may result in better overall DQ with lower intake of UPFs and higher intake of unprocessed and MPFs compared with PB groups. There are several key strengths and limitations of this work that are outlined below.

6.1. Limitations

First, although the questionnaire was specifically developed for the selected populations (and modified based on an existing validated questionnaire) it has not been validated or tested for reliability. However, NOVA has yet to be validated and continues to be used as a tool in research. Second, due to the nature of the research (online anonymous questionnaire) there is potential for reporter bias or misunderstanding. Typically, questionnaires of this length would be administered face-to-face with opportunities to ask questions and clarify. However, given the time and resource constraints, conducting this research in such a manner was not feasible. Furthermore, due to the sampling technique chosen (convenience) there is potential for sampling bias. The sample was heavily weighted in favour of LC diet groups, it is worth considering whether the findings would have been impacted if there was equal weighting across the ADPs. For this reason, whether these findings can be generalised to all LC and PB individuals is unknown and requires further exploration. Finally, this work did not account for energy intake and relative energy contributions from NOVA or HISS categories, nor did it account for the energy equation, instead a percentage of total servings across a week were calculated. While these limitations are worth noting, there were also several key strengths.

6.2. Strengths

First, this research resulted in the development of a specific questionnaire to assess and quantify diet quality using the NOVA and HISS frameworks. This is the first questionnaire of its kind. This presents a new lens and method that can be used to quantify DQ of those adhering to ADPs. Although this questionnaire was designed with those adhering to ADPs in mind, it could be used in the general population as it uses standard MoH food groups and serving sizes. Second, given the nature of the research (online questionnaire) a large amount of data was collected in a relatively short time frame. Furthermore, by including two novel food processing classification frameworks, this work tested the newly developed HISS framework and uncovered similarities between HISS and NOVA at level 4 (ultra-processed foods). This research is the first of its kind to quantify the diet quality of four distinct diet patterns using two novel food processing classification systems and adds new insights to this body of knowledge. Finally, this research developed an index through which to assess overall DQ (N4:N1% ratio) using the existing food processing classification systems of NOVA. This has not been done before and adds novel insights into DQ.

6.3. Future Research

Given the changing landscape of the food environment and growing interest in ADPs it is worth considering the implications of consuming specialty UPFs on DQ when adhering to a LC or PB diet. To achieve this, future research should aim to quantify the relative energy contributions of speciality UPF products and explore the impact this might have on health. It is worth considering if there is a threshold (a percentage of EI or total number of serves) of UPF consumption where the protective factors reported in accordance with ADPs are outweighed or offset by the negative impacts of the UPFs. A holistico-reductionist approach may offer new insights into the intersection between food composition (nutrients) and processing and allow for an even more holistic understanding of DQ. While there are evident, and widely reported differences between the LC and PB diets, the purpose of this research is not to pit these approaches against one another but rather to highlight that the level of processing a food has undergone is an important consideration given the rapid changes in the modern food environment and the expected changes in coming years. Moreover, that regardless of the dietary pattern, an overreliance of UPFs (which in turn displaces unprocessed and MPF) may negatively impact overall DQ and offset the benefits of an otherwise healthful dietary approach. Public health agencies should educate consumers to ensure they are choosing nutrient rich, unprocessed and MPFs as the basis of their diet and not being misled by front-of-packing labelling systems like the HSR or NutriScore (Edmunds, 2017; Romero Ferreiro, Lora Pablos, et al., 2021). This appears to be particularly important in the context of PB diets where an emergence of PB meat and dairy products may displace whole foods if consumers are not mindful of their choices. Moreover, further efforts should be placed on understanding the physiological mechanisms that cause the poor health outcomes associated with UPF consumption and whether these transfer to those consuming ADPs and the associated UPSFs. While speciality products like PB meat and dairy alternatives, processed meat products and grain substitutes are becoming increasingly popular, these should not form the basis of a healthy diet. Once these mechanisms are understood, perhaps new food processing technologies can be established that allow for the creation of alternatively processed versions of the existing offerings. In the interim, health agencies should equip consumers with adequate knowledge of the best whole food sources that align with their chosen dietary approach.

This research highlights that ADPs may have superior DQ, with LC diets faring better than PB diets. However, even supposedly healthy dietary patterns can be executed in an unhealthy manner when the relative proportion of UPFs exceeds that of unprocessed and MPFs. Advocating for a one-size-fits-all approach to nutrition is meaningless in the current food environment given that preferences, culture, religion, and socio-economic factors all play a part in an individual’s dietary choices. Instead, food quality, regardless of the chosen dietary trend, is an important consideration and whole, unprocessed foods should form the basis of any diet, whether it be vegan, vegetarian, low-carbohydrate ketogenic, or any other chosen approach.

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AUT
TE WĀNANGA ARONUI O TĀMAKI MAKAU RAU

Appendices

Appendix A: Ethics Approval

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316 E:
ethics@aut.ac.nz
www.aut.ac.nz/researchethics

5 September 2022

Caryn Zinn
Faculty of Health and Environmental Sciences

Dear Caryn

Re Ethics Application: **22/202 An exploration of food quality across different dietary patterns**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 26 August 2025.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.

6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.
8. AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Cc: kayla.lenfernadelamotte@aut.ac.nz

Appendix B: Tools

Appendix B.1: Questionnaire

Below is a word version of the questionnaire that was deployed on Qualtrics using sliding scales for total number of serves across a seven-day period.

Exploration of Diet Quality Across Different Dietary Patterns: Online Anonymous Questionnaire

Your participation in this study is completely voluntary. Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain anonymous. If you have questions about the survey or the procedures at any time, you may contact Kayla-Anne Lenferna De La Motte by email at gzb7976@ut.ac.nz. Thank you very much for your time and support. Please start with the survey now by clicking on the acceptance box below.

Section 1: Demographics

All demographic questions, except for occupation, will be multiple choice/select one option.

Q1. Please select which gender you identify with.

1. Male
2. Female
3. Other (please specify)
4. Prefer not to say

Q2. Please select which of the following age bands you fall into.

1. 19-24 years 2.
25-34 years 3.
35-44 years 4.
45-54 years 5.
55-64 years
6. 65-69 years
7. 70 years +
8. Prefer not to say

Q3. Please select which ethnicity you identify with.

1. New Zealand European
2. Other European (German/Dutch/British/French/Welsh/Irish)
3. Māori
4. Pacific (Tongan/Samoan/Niuean/Cook Island)
5. Asian (Chinese/Japanese/Indian/Pakistani/West Indian/Malaysian/Thai)
6. Middle Eastern
7. African
8. Latin American
9. Prefer not to say

Q4. What is the highest degree or level of education you have completed?

1. Primary school
2. High school
3. Bachelor's Degree

4. Master's Degree
5. Ph.D. or higher
6. Trade School or other vocational training
7. Prefer not to say

Q5. What is your occupation/job?
[FREE FIELD TO ENTER OCCUPATION]

Q6. How would you classify your income status?
1. Very low
2. Low
3. Moderate
4. High
5. Very high
6. Prefer not to say

Q7. Please select the dietary pattern you identify with **most** from the list below. Please read the descriptions of the diets carefully before answering.
1. **Ketogenic** (For the past 6 months I have consistently aimed to consume less than 50 g of carbohydrates daily i.e., extreme level of carbohydrate restriction).
2. **Low-carbohydrate** (For the past 6 months I have consistently aimed to consume less than 130 g of carbohydrates daily i.e., moderate to high level of carbohydrate restriction).
3. **Vegetarian** (For the past 6 months, I have consistently aimed to consume mainly plant foods and some animal by-products like dairy products, eggs or fish, but I do not eat any red or white meat i.e., beef, lamb, pork, or poultry).
4. **Vegan** (For the past 6 months, I have aimed to consume exclusively plant foods with no animal products).

Section 2: Food Frequency Questionnaire

All food frequency questions will give you the option to enter the number of servings you have eaten or drunk or a particular food or fluid across the past week. Please think about how you have eaten in the past seven days and make your most accurate estimate of the number of servings you have had from each of the categories.

Section 2.1: Vegetables and fruits

(1) Enter the number of servings you have eaten of **fresh or frozen starchy vegetables** in the past week. (A serving is approximately 75g or ½ cup of cooked butternut, pumpkin, potato, kumara, taro, carrot, yam, or sweet corn). **Please do not count frozen convenience foods like hash browns, frozen fries, or vegetable-based patties here.**

(2) Enter the number of servings you have eaten of **fresh or frozen non-starchy vegetables** you have eaten in the last week. Examples include leafy greens or other vegetables like capsicums, beetroot, cucumber, zucchini (courgette), mushrooms, tomatoes, broccoli, or cauliflower. (A serving is equivalent to ½ cup of cooked vegetables or 1 cup of leafy green vegetables).

(3) Enter the number of servings you have eaten of **canned, fermented, or pickled vegetables** in the past week. These can be **homemade or store-bought**. Examples include canned beetroot or sweetcorn, canned mushrooms, kimchi, sauerkraut, pickled onions, and pickles. (A serving is a ½ cup).

(4) Enter the number of servings you have eaten of **fresh or frozen fruit** in the past week. (A serving is approximately 150g or 1 medium banana/apple/pear/orange or 2 small

apricots/kiwifruits/plums or 1 cup of frozen berries or diced fruit like mango/pineapple/melon/papaya or grapes).

(5) Enter the number of servings you have eaten of **canned or dried fruit** in the past week. (A serving is approximately 150g or 1 cup of canned or dried fruit). **Please note that 'fruit cups', 'fruit roll-ups', fruit juice any other reconstituted fruit products should not be counted here.**

Section 2.2: Grain foods and lower carbohydrate substitutes

(1) Enter the number of servings of **homemade or hand-prepared** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti). **Please note that store-bought variations of these products should not be counted here but those bought from a farmers' market or artisanal store that were hand prepared on the day you bought and consumed them should.**

(2) Enter the number of servings of **homemade or hand-prepared reduced carbohydrate** bread products you have eaten in the past week like bread, rolls, wraps, rotis, or pizza bases. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti). **Please note that store-bought variations of these products should not be counted here but those bought from a farmers' market or artisanal store that were hand prepared on the day you bought and consumed them should.**

(3) Enter the number of servings of **store-bought** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti).

(4) Enter the number of servings of **store-bought reduced carbohydrate** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti).

(5) Enter the number of servings of **homemade or hand-prepared** pasta or noodles you have eaten in the past week. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include items like 2-minute noodles and store-bought variations of products should not be counted here.**

(6) Enter the number of servings of **homemade or hand-prepared lower carbohydrate** pasta or noodles you have eaten in the past week. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include items like konjac or edamame noodles and store-bought lower carbohydrate variations of pasta and noodle products should not be counted here.**

(7) Enter the number of servings you gave eaten of **store-bought** pasta or noodle products in the past week including dried pasta shells, lasagna sheets, store-bought gnocchi, udon, egg noodles or rice noodles, pre-prepared pasta found in the fridge section, and 2-minute noodles. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include filled pasta heat-and-eat meals (like ravioli).**

(8) Enter the number of servings of grains you have eaten in the last week. (A serving is a ½ cup of cooked any type of rice, couscous, quinoa, barley, buckwheat, semolina, polenta, or bulghur). **Please note this does not include packaged heat-and-eat variations that can be cooked in a few minutes in the microwave.**

(9) Enter the number of servings of **store-bought** heat-and-eat rice products (like quick-cook microwavable rice and risotto) you have eaten in the last week. (A serving is a ½ cup cooked).

(10) Enter the number of servings of **homemade or hand-prepared** breakfast cereals you have eaten in the past week. **This includes homemade cereals/mueslis made from ground nuts and seeds or fresh or roasted nuts, seeds, spices, fruit, and coconut.**

(11) Enter the number of servings of **store-bought** breakfast cereals you have eaten in the past week. (A serving is ¼ cup of muesli, 2/3 cup of breakfast flakes, 2 wheat biscuits, or ½ cup of porridge). **This includes heat-and-eat porridges and quick sachets but does not include low-carbohydrate breakfasts.**

(12) Enter the number of servings of **store-bought lower carbohydrate** breakfast cereals you have eaten in the past week. (A serving is a ¼ cup muesli or ½ cup porridge). **This includes lower carbohydrate mueslis and porridge-like products.**

(13) Enter the number of servings of **store-bought** crisp bread and crackers you have eaten in the past week. (A serving is approximately 35g or 3 crackers).

Section 2.3: Dairy, dairy products and dairy substitutes

(1) Enter the number of servings of **milk or cream** you have consumed in the past week. (A serving is 1 cup of milk and ½ cup of cream). **This includes all variations of animal milk (cow, goat, sheep) in any form (fresh, powdered, or long life) and can be full cream, trim, or reduced fat.**

(2) Enter the number of servings of **milk substitutes** you have consumed in the past week. (A serving is 1 cup). **This includes soy, oat, almond, cashew, peanut, rice, hemp, and coconut milk and can be liquid or powdered.**

(3) Enter the number of servings of **store-bought milk-based drinks** you have consumed in the past week. (A serving is 1 cup). **This includes ready-to-drink flavoured milk products or products made at home using powders bought from the store.**

(4) Enter the number of servings of milk-substitute drinks you have consumed in the past week. (A serving is 1 cup). **This includes ready-to-drink flavoured nut-based milk drinks.**

(5) Enter the number of servings of **cheese** you have consumed in the past week. (A serving is 40g or two slices). **This includes hard cheeses like Edam, Colby, and Cheddar or specialty cheeses like blue cheese, camembert, brie, or Havarti or any goat or buffalo derived cheeses and does not include sliced/grated cheese.**

(6) Enter the number of servings of **cheese substitutes** who have consumed in the past week. (A serving is 40g or two slices). **This includes plant-based cheeses.**

(7) Enter the number of servings of **plain unsweetened yogurt** (Greek) you have eaten in the past week. (A serving is a ¾ cup). **This includes whole Greek yogurt and does not include flavoured yogurt or squeeze pouches.**

(8) Enter the number of servings of **flavoured yogurt or drinkable yogurt products** you have eaten in the past week. (A serving is a ¾ cup).

(9) Enter the number of servings of **yogurt substitutes** you have eaten in the past week. (A serving is a ¾ cup). **This includes soy, coconut, or nut-based yogurt.**

Section 2.4: Legumes, nuts and seeds

(1) Enter the number of servings of **raw nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and pumpkin (pepita). They can be whole or ground. Candied or chocolate-dipped variations should not be counted here.**

(2) Enter the number of servings of **packaged or store-bought roast and or salted nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and pumpkin (pepita).**

(3) Enter the number of servings of **store-bought candied or chocolate-dipped nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This**

includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and pumpkin (pepita).

(4) Enter the number of servings of **<u>fresh or frozen beans, legumes, or chickpeas</u>** you have eaten in the past week. (A serving is 150 g or 1 cup). **This excludes green beans/string beans.**

(5) Enter the number of servings of **<u>store-bought or homemade dried or canned</u>** beans, legumes**,** or chickpeas you have eaten in the past week. (A serving is 150 g or 1 cup).

Section 2.5: Meat, poultry, fish, eggs and substitutes

(1) Enter the number of servings of **<u>fresh or frozen</u>** meat or poultry you have eaten in the last week. (A serving is a palm-sized portion which is approximately 70 g). **This includes beef, pork, lamb, veal, chicken, and venison. It does not include store-bought marinated meat, sausages, bacon, or meat patties.**

(2) Enter the number of servings of **<u>homemade or hand-prepared</u>** sausages, patties or chicken nuggets you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g).

(3) Enter the number of servings of **<u>chicken or meat substitution products</u>** you have eaten in the past week. (A serving is approximately 100 g). **This includes beyond/impossible beef burger patties, vegan hot dogs and sausages, vegan bacon, vegan mince, plantbased patties/meatballs/sausages, canned nut meat, and chicken-free chicken.**

(4) Enter the number of **<u>store-bought reconstituted</u>** meat or poultry products you have eaten in the last week. (A serving is a palm-sized portion which is approximately 70 g). **This includes sausages, patties, and chicken nuggets.**

(5) Enter the number of servings of **<u>homemade or hand-prepared cured, canned or dried</u>** meat or poultry you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g). This includes bacon, salami, deli meats, beef jerky, beef or chicken or pork rinds.

(6) Enter the number of servings of **<u>store-bought cured, canned or dried</u>** meat or poultry you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g). **This includes bacon, salami, deli meats, beef jerky, beef or chicken or pork rinds, tinned chicken, and tinned corned beef.**

(7) Enter the number of servings of **<u>fresh or frozen</u>** fish you have eaten in the past week. (A serving is 100 g). **This includes any types of seafood and does not include crumbed, battered, or canned fish, do not count those items here.**

(8) Enter the number of servings of **<u>homemade or hand-prepared</u>** crumbed or battered fish you have eaten in the past week. (A serving is 100 g).

(9) Enter the number of servings of **<u>store-bought</u>** crumbed or battered fish you have eaten in the past week. (A serving is 100 g). **This includes store-bought fish fingers, fish cakes, or nuggets.**

(10) Enter the number of servings of **<u>canned, smoked or cured</u>** fish you have eaten in the last week. (A serving is 100 g which is 1 small tin). **This includes tinned salmon, tuna, mackerel, and sardines or smoked salmon.**

(11) Enter the number of servings of **<u>fresh or powdered</u>** eggs you have eaten in the past week. (A serving is 2 large eggs or the equivalent of powdered eggs).

(12) Enter the number of servings of **<u>store-bought packaged</u>** egg whites you have eaten in the past week. (A serving is the equivalent of 2 large eggs).

(13) Enter the number of servings of **<u>egg substitute</u>** you have eaten in the last week. (A serving is the equivalent of 2 large eggs).

(14) Enter the number of servings of tofu, tempeh, or seitan you have consumed in the past week. (A serving is 170 g).

Section 2.6: Cooking fats, spreads, sauces and dressings

(1) Which of these fats do you use when cooking or preparing meals? Select all that apply.
   a. Butter, lard or drippings
   b. Coconut fat (this includes products like EVOO)
   c. Olive oil
   d. Seed oils (e.g. canola oil, sunflower oil, rapeseed oil, soybean oil, rice bran oil etc).

(2) Please insert the number of servings you have consumed in the past week. [CONDITIONAL BASED ON ANSWER TO ABOVE QUESTION – I.E. BASED ON WHICH OPTIONS THEY SELECT]

(3) Enter the number of servings of butter you have eaten in the past week. (A serving is 1 tablespoon).

(4) Enter the number of servings of **butter-substitution spreads** you have eaten in the past week. (A serving is 1 tablespoon). **This includes margarine, olivani spread, nuttlex spread, and plant-based spread.**

(5) Enter the number of servings of **homemade or hand-prepared** nut and seed-based spreads you have eaten in the past week. (A serving is 1 teaspoon). **This does not include chocolate or candied spreads like Nutella. This includes peanut, almond, and cashew butter as well as tahini.**

(6) Enter the number of servings of **store-bought** nut and seed-based spreads you have eaten in the past week. (A serving is 1 teaspoon). **This does not include chocolate or candied spreads like Nutella. This includes peanut, almond, and cashew butter as well as tahini.**

(7) Enter the number of servings of **homemade or hand-prepared** jams, spreads, pickles or preserves you have eaten in the past week. (A serving is 1 teaspoon).

(8) Enter the number of servings of **store-bought** jams, spreads, or pickles you have eaten in the past week. (A serving is 1 teaspoon). **This includes jam, marmalade, cheese spreads, yeast-based spread (e.g. Marmite), and store-made pickle or relish.**

(9) Enter the number of servings of **sugar-free or sugar-substituted store-bought** jams, spreads, or pickles you have eaten in the past week. (A serving is 1 teaspoon). **This includes jam, marmalade, cheese spreads, yeast-based spread (e.g. Marmite), and store-made pickle or relish.**

(10) Enter the number of servings of **homemade or hand-prepared** dressings and sauces you have eaten in the past week. (A serving is 1 teaspoon). **This includes salad dressings mayonnaise (and plant-based alternatives) and cook-in sauces for pasta or curries that have been made from scratch.**

(11) Enter the number of servings of **store-bought** dressings and sauces you have eaten in the past week. (A serving is 1 teaspoon). **This includes salad dressings, tomato sauce, mustard, mayonnaise (and plant-based alternatives), cook-in pasta or curry sauces, and sachets for sauces and gravies.**

Section 2.7: Confectionery and snacks

(1) Enter the number of servings of chocolate, lollies, sweets, and biscuits you have eaten in the past week. (A serving is 2 biscuits or 80g of chocolate/lollies/sweets). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**

(2) Enter the number of servings of **store-bought** muesli, snack bars, energy bars or bliss balls you have eaten in the past week. (A serving is 1 bar or 2 balls). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**

(3) Enter the number of servings of **homemade or hand-prepared** muesli or snack bars, energy bars or bliss balls you have eaten in the past week. (A serving is 1 bar or 2 balls). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**

(4) Enter the number of servings of chips, pretzels, or pre-popped popcorn, or snacks mixes (e.g. bhuja mix) you have eaten in the past week. **This includes other fried or baked plant-based snacks like cassava snaps or edamame chips.**

(5) Enter the number of servings of **homemade or hand-prepared** cake, muffins, cupcakes, or pastries you have eaten in the past week. (A serving is 1 small slice of cake, 1 small pastry, or 1 cupcake/muffin). **This includes any plant-based or low-sugar or sugarsubstituted variations of these discretionary items.**

(6) Enter the number of servings of **store-bought** cake, muffins, cupcakes, or pastries you have eaten in the past week. (A serving is 1 small slice of cake, 1 small pastry, or 1 cupcake/muffin). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**

(7) Enter the number of servings of **freshly squeezed or cold pressed** fruit juice you have consumed in the past week. (A serving is 200 ml).

(8) Enter the number of servings of **store-bought or homemade** flavoured water, kombucha, bone broth, miso, or kefir in the last week. (A serving is 200 ml).

(9) Enter the number of servings of carbonated (fizzy drinks), energy drinks, sports drinks, store-bought smoothies or cordial drinks you have consumed in the past week. (A serving is 200 ml). **This includes products like Coke, V energy drinks, and cordial mixes.**

(10) Enter the number of servings of **store-bought** fruit juices you have consumed in the past week. (A serving size is 200 ml).

Section 2.8: Convenience and takeout

(1) Enter the number of **homemade or hand-prepared takeout style meals** you have had in the past week. (1 serving = 1 meal). This includes pizzas, burgers, fries, pies and other pastry dishes like samosas. To qualify as homemade or hand prepared ALL components must be made from scratch.

(2) Enter the number of servings of takeout/fast food you have consumed in the past week. (A serving is one meal). **This includes all fast-food and takeout options like MacDonalds, Burger King and KFC.**

(3) Enter the number of frozen heat-and-eat and ready-to-cook frozen pastries you have consumed in the past week. **This includes frozen pizzas, pre-prepared and frozen meals, instant soups and pre-prepared, frozen pasta dishes, dumplings, sausage rolls, pies, and any plant-based on lower carbohydrate substitutes.**

(4) Enter the number of servings of protein powder or meal replacement you have eaten in the past week. (A serving is 30 g or 1 scoop). **This includes whey, whey-isolate, hemp, and pea protein, collagen.**

Section 3: 24-Hour Food Recall

Please think about how you have eaten in the past 24 hours and write it down below in as much detail as possible. You can use measures like cups/spoons/grams to indicate the quantity of each item you have consumed. Please include the time that you consumed each meal. If you did not eat or drink anything at any of the mealtimes, please leave the box blank.

Breakfast:
Drink: Snack:
Lunch:
Drink:
Snack:

Dinner:
Drink:
Snack:

Section 4: Self-Perceived Adherence and Diet Quality

All questions in this section will allow you to rate how you feel about certain topics related to your diet adherence and quality. This exists along a continuum. Please think about how you act most of the time.

(1) How important is eating organic/sustainable food to you? Where 0 is not important at all and 100 is extremely important.
(2) How would you rate your adherence to the diet pattern you identify with where 0 is no adherence at all and 100 is adhering all the time?
(3) How would you rate your overall diet quality where 0 is very poor and 100 is excellent?

Appendix B.2: Recruitment Flyer

Appendix B.3: Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

24th July 2022

Project Title

An exploration of food quality across different dietary patterns

An Invitation

Hello, my name is Kayla-Anne Lenferna De La Motte, I am an Honours student at the Auckland University of Technology. I would appreciate you filling out this questionnaire that will ask about your diet, the foods you usually eat, and how you perceive your diet quality. If you identify with a ketogenic, low-carbohydrate, vegetarian, or vegan diet then this questionnaire is for you.

What is the purpose of this research?

Different dietary patterns including the ketogenic, low-carbohydrate, vegetarian and vegan diets are becoming more popular and as a result, there are more specialty foods available to purchase when following these diets. This research aims to explore how these diets translate into practice, with a focus on diet quality.

The findings of this research will be used for the completion of an Honours degree in Sport and Recreation and may be used for academic publications and presentations.

How was I identified and why am I being invited to participate in this research?

If you are viewing this information sheet you will have seen a flyer for this research project. A reminder that you must be over 18 years of age to participate in this research and have been following one of the four dietary patterns for at least 6 months. You should not fill out this questionnaire if you are using one of the dietary patterns to lose a substantial amount of weight (i.e. more than 20 kgs of body weight) or are under 18 years of age.

How do I agree to participate in this research?

If you would like to complete this questionnaire, please tick the eligibility boxes at the bottom of this page. Once these have all been ticked you can click 'start questionnaire'. Completion of the questionnaire indicates your consent to be involved in this research.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You can withdraw from the study by closing the browser any time before clicking 'submit'. If you choose to withdraw from the study, your data will still be included once the anonymous survey is submitted as we will be unable to identify your data separately.

What will happen in this research?

For this research, you will fill out a 15 – 20 minute online anonymous questionnaire that will ask you about your dietary approach and the foods you usually eat.

What are the discomforts and risks?

There shouldn't be any discomfort filling out this questionnaire. If you are conscious of your diet, I would suggest you find somewhere quiet and private to fill out this questionnaire.

What are the benefits?

I would appreciate your involvement because the findings of this research will be used for the completion of an Honours degree in Sport and Recreation and may be used for academic publications and presentations. I believe reflecting on the foods we eat helps us to make more informed decisions. I firmly believe that completing this questionnaire will help you observe and reflect on your current eating habits. The findings may illustrate a link between different dietary approaches and food quality, this is something you may find interesting.

How will my privacy be protected?

Your information will be anonymous, and I will not be able to identify you in any way.

What are the costs of participating in this research?

The only cost is your time, the questionnaire should take 15 – 20 minutes to complete.

What opportunity do I have to consider this invitation?

This questionnaire will be open for 1 month while I collect data.

Will I receive feedback on the results of this research?

Yes, you will, a URL will be displayed when you complete the questionnaire, you can use this to access the results once the study has been completed. The findings will also be shared via social media by myself and my supervisor Associate Professor Dr Caryn Zinn if they are published in an academic journal. Here is the URL: https://kaylahaycock22.wixsite.com/foodfor-thought/blank-3

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Associate Professor Caryn Zinn, caryn.zinn@aut.ac.nz, +64 9 921 9999.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

You can contact the research team as follows:

Researcher Contact Details:

Kayla-Anne Lenferna De La Motte (gzb7976@aut.ac.nz) ***Project***

Supervisor Contact Details:

Associate Professor Dr Caryn Zinn (caryn.zinn@aut.ac.nz)

Approved by the Auckland University of Technology Ethics Committee on *type the date 5th September 2022*, AUTEC Reference number 22/02.

Eligibility criteria:

You must tick all three boxes to indicate you are eligible before continuing to the questionnaire.

☐ I am over 18 years of age

☐ I have been following a keto, low-carb, vegetarian or vegan diet for at least 6 months

☐ I am not using one of these diets to lose a substantial amount of weight (more than 20 kg)

Appendix B.4: Questionnaire Coding

Exploration of Diet Quality Across Different Dietary Patterns: Online Anonymous Questionnaire

Food Frequency Questionnaire: Questions and coding – NOVA and HISS

SECTION 1: Vegetables and fruits		
Question	NOVA classification	HISS classification
Enter the number of servings you have eaten of **fresh or frozen starchy vegetables** in the past week. (A serving is approximately 75g or ½ cup of cooked butternut, pumpkin, potato, kumara, taro, carrot, yam, or sweet corn). **Please do not count frozen convenience foods like hash browns, frozen fries, or vegetable-based patties here.**	NOVA 1	HISS 1
Enter the number of servings you have eaten of **fresh or frozen non-starchy vegetables** you have eaten in the last week. Examples include leafy greens or other vegetables like capsicums, beetroot, cucumber, zucchini (courgette), mushrooms, tomatoes, broccoli, or cauliflower. (A serving is equivalent to ½ cup of cooked vegetables or 1 cup of leafy green vegetables).	NOVA 1	HISS 1
Enter the number of servings you have eaten of **canned, fermented, or pickled vegetables** in the past week. These can be **homemade or store-bought**. Examples include canned beetroot or sweetcorn, canned mushrooms, kimchi, sauerkraut, pickled onions, and pickles. (A serving is a ½ cup).	NOVA 3	HISS 2
Enter the number of servings you have eaten of **fresh or frozen fruit** in the past week. (A serving is approximately 150g or 1 medium banana/apple/pear/orange or 2 small apricots/kiwifruits/plums or 1 cup of frozen berries or diced fruit like mango/pineapple/melon/papaya or grapes).	NOVA 1	HISS 1
Enter the number of servings you have eaten of **canned or dried fruit** in the past week. (A serving is approximately 150g or 1 cup of canned or dried fruit). **Please note that 'fruit cups', 'fruit roll-ups', fruit juice any other reconstituted fruit products should not be counted here.**	NOVA 3	HISS 2

SECTION 1: Grain foods and lower carbohydrate substitutes		
Question	NOVA classification	HISS classification
Enter the number of servings of **homemade or hand-prepared** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti). **Please note that store-bought variations of these products should not be counted here but those bought from a farmers' market or artisanal store that were hand prepared on the day you bought and consumed them should.**	NOVA 3	HISS 3
Enter the number of servings of **homemade or hand-prepared reduced carbohydrate** bread products you have eaten in the past week like bread, rolls, wraps, rotis, or pizza bases. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti). **Please note that store-bought variations of these products should not be counted here but those bought from a farmers' market or artisanal store that were hand prepared on the day you bought and consumed them should.**	NOVA 3	HISS 3
Enter the number of servings of **storebought** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti).	NOVA 4	HISS 4
Enter the number of servings of **storebought reduced carbohydrate** bread products you have eaten in the past week like bread, rolls, wraps, pizza bases, rotis, and naan bread. (A serving is 1 slice of bread, 1 wrap, or ½ bread roll, naan bread, or roti).	NOVA 4	HISS 4
Enter the number of servings of **homemade or hand-prepared** pasta or noodles you have eaten in the past week. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include items like 2-minute noodles and store-bought variations of products should not be counted here.**	NOVA 1	HISS 3

Enter the number of servings of **homemade or hand-prepared lower carbohydrate** pasta or noodles you have eaten in the past week. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include items like konjac or edamame noodles and store-bought lower carbohydrate variations of pasta**	NOVA 1	HISS 3
and noodle products should not be counted here.		
Enter the number of servings you gave eaten of **store-bought** pasta or noodle products in the past week including dried pasta shells, lasagna sheets, store-bought gnocchi, udon, egg noodles or rice noodles, pre-prepared pasta found in the fridge section, and 2-minute noodles. (A serving is ½ cup of cooked pasta or noodles). **Please note this does not include filled pasta heat-and-eat meals (like ravioli).**	NOVA 4	HISS 2
Enter the number of servings of grains you have eaten in the last week. (A serving is a ½ cup of cooked any type of rice, couscous, quinoa, barley, buckwheat, semolina, polenta, or bulghur). **Please note this does not include packaged heat-andeat variations that can be cooked in a few minutes in the microwave.**	NOVA 1	HISS 1
Enter the number of servings of **storebought** heat-and-eat rice products (like quick-cook microwavable rice and risotto) you have eaten in the last week. (A serving is a ½ cup cooked).	NOVA 4	HISS 4
Enter the number of servings of **homemade or hand-prepared** breakfast cereals you have eaten in the past week. **This includes homemade cereals/mueslis made from ground nuts and seeds or fresh or roasted nuts, seeds, spices, fruit, and coconut.**	NOVA 1	HISS 3
Enter the number of servings of **storebought** breakfast cereals you have eaten in the past week. (A serving is ¼ cup of muesli, 2/3 cup of breakfast flakes, 2 wheat biscuits, or ½ cup of porridge). **This includes heat-and-eat porridges and quick sachets but does not include lowcarbohydrate breakfasts.**	NOVA 4	HISS 4
Enter the number of servings of **storebought lower carbohydrate** breakfast cereals you have eaten in the past week. (A serving is a ¼ cup muesli or ½ cup porridge). **This includes lower carbohydrate mueslis and porridge-like products.**	NOVA 4	HISS 4

Enter the number of servings of **storebought** crisp bread and crackers you have eaten in the past week. (A serving is approximately 35g or 3 crackers).	NOVA 4	HISS 4

SECTION 3: Diary, dairy products, and dairy substitutes		
Question	NOVA classification	HISS classification
Enter the number of servings of **milk or cream** you have consumed in the past week. (A serving is 1 cup of milk and ½ cup of cream). **This includes all**	NOVA 1	HISS 2
variations of animal milk (cow, goat, sheep) in any form (fresh, powdered, or long life) and can be full cream, trim, or reduced fat.		
Enter the number of servings of **milk substitutes** you have consumed in the past week. (A serving is 1 cup). **This includes soy, oat, almond, cashew, peanut, rice, hemp, and coconut milk and can be liquid or powdered.**	NOVA 3	HISS 2
Enter the number of servings of **storebought milk-based drinks** you have consumed in the past week. (A serving is 1 cup). **This includes ready-to-drink flavoured milk products or products made at home using powders bought from the store.**	NOVA 4	HISS 4
Enter the number of servings of milksubstitute drinks you have consumed in the past week. (A serving is 1 cup). **This includes ready-to-drink flavoured nutbased milk drinks.**	NOVA 4	HISS 4
Enter the number of servings of **cheese** you have eaten in the past week. (A serving is 40g or two slices). **This includes hard cheeses like Edam, Colby, and Cheddar or specialty cheeses like blue cheese, camembert, brie, or Havarti or any goat or buffalo derived cheeses and does not include sliced/grated cheese.**	NOVA 3	HISS 2
Enter the number of servings of **cheese substitutes** who have consumed in the past week. (A serving is 40g or two slices). **This includes plant-based cheeses.**	NOVA 4	HISS 4
Enter the number of servings of **plain unsweetened yogurt** (Greek) you have eaten in the past week. (A serving is a ¾ cup). **This includes whole Greek yogurt and does not include flavoured yogurt or squeeze pouches.**	NOVA 1	HISS 2

Enter the number of servings of **flavoured yogurt or drinkable yogurt products** you have eaten in the past week. (A serving is a ¾ cup).	NOVA 4	HISS 4
Enter the number of servings of **yogurt substitutes** you have eaten in the past week. (A serving is a ¾ cup). **This includes soy, coconut, or nut-based yogurt.**	NOVA 4	HISS 4

SECTION 4: Legumes, nuts and seeds		
Question	NOVA classification	HISS classification
Enter the number of servings of **raw nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and**	NOVA 1	HISS 1
pumpkin (pepita). They can be whole or ground. Candied or chocolate-dipped variations should not be counted here.		
Enter the number of servings of **packaged or store-bought roast and or salted nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and pumpkin (pepita).**	NOVA 3	HISS 3
Enter the number of servings of **storebought candied or chocolate-dipped** **nuts or seeds** you have eaten in the past week. (A serving is 30 g or 1 heaped tablespoon). **This includes any type of nuts like cashews, almonds, walnuts, pistachios, peanuts, or seeds like sunflower and pumpkin (pepita).**	NOVA 4	HISS 4
Enter the number of servings of **fresh or frozen beans, legumes, or chickpeas** you have eaten in the past week. (A serving is 150 g or 1 cup). **This excludes green beans/string beans.**	NOVA 1	HISS 1
Enter the number of servings of **storebought or homemade dried or canned** beans, legumes, or chickpeas you have eaten in the past week. (A serving is 150 g or 1 cup).	NOVA 3	HISS 1

SECTION 5: Meat, poultry, fish and eggs (and plant-based substitutes)		
Question	NOVA classification	HISS classification

Enter the number of servings of **<u>fresh or frozen</u>** meat or poultry you have eaten in the last week. (A serving is a palm-sized portion which is approximately 70 g). **This includes beef, pork, lamb, veal, chicken, and venison. It does not include storebought marinated meat, sausages, bacon, or meat patties.**	NOVA 1	HISS 1
Enter the number of servings of **<u>homemade or hand-prepared</u>** sausages, patties or chicken nuggets you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g).	NOVA 3	HISS 2
Enter the number of servings of **<u>chicken or meat substitution products</u>** you have eaten in the past week. (A serving is approximately 100 g). **This includes beyond/impossible beef burger patties, vegan hot dogs and sausages, vegan bacon, vegan mince, plant-based patties/meatballs/sausages, canned nut meat, and chicken-free chicken.**	NOVA 4	HISS 4
Enter the number of **<u>store-bought reconstituted</u>** meat or poultry products you have eaten in the last week. (A serving is a palm-sized portion which is approximately	NOVA 4	HISS 4
70 g). **This includes sausages, patties, and chicken nuggets.**		
Enter the number of servings of **<u>homemade or hand-prepared cured, canned or dried</u>** meat or poultry you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g). This includes bacon, salami, deli meats, beef jerky, beef or chicken or pork rinds.	NOVA 3	HISS 3
Enter the number of servings of **<u>storebought cured, canned or dried</u>** meat or poultry you have eaten in the past week. (A serving is a palm-sized portion which is approximately 70 g). **This includes bacon, salami, deli meats, beef jerky, beef or chicken or pork rinds, tinned chicken, and tinned corned beef.**	NOVA 4	HISS 3
Enter the number of servings of **<u>fresh or frozen</u>** fish you have eaten in the past week. (A serving is 100 g). **This includes any types of seafood and does not include crumbed, battered, or canned fish, do not count those items here.**	NOVA 1	HISS 1
Enter the number of servings of **<u>homemade or hand-prepared</u>** crumbed fish you have eaten in the past week. (A serving is 100 g).	NOVA 3	HISS 2

Enter the number of servings of **storebought** crumbed or battered fish you have eaten in the past week. (A serving is 100 g). **This includes store-bought fish fingers, fish cakes, or nuggets.**	NOVA 4	HISS 4
Enter the number of servings of **canned, smoked or cured** fish you have eaten in the last week. (A serving is 100 g which is 1 small tin). **This includes tinned salmon, tuna, mackerel, and sardines or smoked salmon.**	NOVA 3	HISS 3
Enter the number of servings of **fresh or powdered** eggs you have eaten in the past week. (A serving is 2 large eggs or the equivalent of powdered eggs).	NOVA 1	HISS 1
Enter the number of servings of **storebought packaged** egg whites you have eaten in the past week. (A serving is the equivalent of 2 large eggs).	NOVA 3	HISS 4
Enter the number of servings of **egg substitute** you have eaten in the last week. (A serving is the equivalent of 2 large eggs).	NOVA 4	HISS 4
Enter the number of servings of tofu, tempeh, or seitan you have consumed in the past week. (A serving is 170 g).	NOVA 4	HISS 3

SECTION 6: Cooking fats, spreads, sauces and dressings		
Question	NOVA classification	HISS classification
Please insert the number of servings you have consumed in the past week. [CONDITIONAL BASED ON ANSWER TO ABOVE QUESTION – I.E. BASED ON WHICH OPTIONS THEY SELECT]	Butter/lard/dripping = NOVA 2 Coconut fat = NOVA 2 Olive oil = NOVA 2 Seed and vegetable oils = NOVA 2	Butter/lard/dripping = HISS 2 Coconut fat = HISS 2 Olive oil = HISS 2 Seed and vegetable oils = HISS 4
Enter the number of servings of butter you have eaten in the past week. (A serving is 1 tablespoon).	NOVA 2	HISS 2
Enter the number of servings of **buttersubstitution spreads** you have eaten in the past week. (A serving is 1 tablespoon). **This includes margarine, olivani spread, nuttlex spread, and plant-based spread.**	NOVA 4	HISS 4

Enter the number of servings of **homemade or hand-prepared** nut and seed-based spreads you have eaten in the past week. (A serving is 1 teaspoon). **This does not include chocolate or candied spreads like Nutella. This includes peanut, almond, and cashew butter as well as tahini.**	NOVA 1	HISS 3
Enter the number of servings of **storebought** nut and seed-based spreads you have eaten in the past week. (A serving is 1 teaspoon). **This does not include chocolate or candied spreads like Nutella. This includes peanut, almond, and cashew butter as well as tahini.**	NOVA 3	HISS 4
Enter the number of servings of **homemade or hand-prepared** jams, spreads, pickles or preserves you have eaten in the past week. (A serving is 1 teaspoon).	NOVA 3	HISS 2
Enter the number of servings of **storebought** jams, spreads, or pickles you have eaten in the past week. (A serving is 1 teaspoon). **This includes jam, marmalade, cheese spreads, yeastbased spread (e.g. Marmite), and storemade pickle or relish.**	NOVA 4	HISS 4
Enter the number of servings of **sugarfree or sugar-substituted store-bought** jams, spreads, or pickles you have eaten in the past week. (A serving is 1 teaspoon). **This includes jam, marmalade, cheese spreads, yeastbased spread (e.g. Marmite), and storemade pickle or relish.**	NOVA 4	HISS 4
Enter the number of servings of **homemade or hand-prepared** dressings and sauces you have eaten in the past week. (A serving is 1 teaspoon). **This includes salad dressings mayonnaise (and plant-based alternatives) and cook-in sauces for pasta or curries that have been made from scratch.**	NOVA 3	HISS 2
Enter the number of servings of **storebought** dressings and sauces you have eaten in the past week. (A serving is 1 teaspoon). **This includes salad dressings, tomato sauce, mustard, mayonnaise (and plant-based alternatives), cook-in pasta or curry sauces, and sachets for sauces and gravies.**	NOVA 4	HISS 4

SECTION 7: Confectionery and snacks		
Question	NOVA classification	HISS classification
Enter the number of servings of chocolate, lollies, sweets, and biscuits you have eaten in the past week. (A serving is 2 biscuits or 80g of chocolate/lollies/sweets). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**	NOVA 4	HISS 4
Enter the number of servings of **storebought** muesli, snack bars, energy bars or bliss balls you have eaten in the past week. (A serving is 1 bar or 2 balls). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**	NOVA 4	HISS 4
Enter the number of servings of **homemade or hand-prepared** muesli or snack bars, energy bars or bliss balls you have eaten in the past week. (A serving is 1 bar or 2 balls). **This includes any plant-based or low-sugar or sugar-substituted variations of these discretionary items.**	NOVA 3	HISS 3
Enter the number of servings of chips, pretzels, or pre-popped popcorn, or snacks mixes (e.g. bhuja mix) you have eaten in the past week. **This includes other fried or baked plant-based snacks like cassava snaps or edamame chips.**	NOVA 4	HISS 4
Enter the number of servings of **homemade or hand-prepared** cake, muffins, cupcakes, or pastries you have eaten in the past week. (A serving is 1 small slice of cake, 1 small pastry, or 1 cupcake/muffin). **This includes any plant-based or lowsugar or sugar-substituted variations of these discretionary items.**	NOVA 3	HISS 3
Enter the number of servings of **storebought** cake, muffins, cupcakes, or pastries you have eaten in the past week. (A serving is 1 small slice of cake, 1 small pastry, or 1 cupcake/muffin). **This includes any plantbased or low-sugar or sugar-substituted variations of these discretionary items.**	NOVA 4	HISS 4
Enter the number of servings of **freshly squeezed or cold pressed** fruit juice you	NOVA 3	HISS 2
have consumed in the past week. (A serving is 200 ml).		
Enter the number of servings of **storebought or homemade** flavoured water, kombucha, bone broth, miso, or kefir in the last week. (A serving is 200 ml).	NOVA 1	HISS 2

Enter the number of servings of carbonated (fizzy drinks), energy drinks, sports drinks, store-bought smoothies or cordial drinks you have consumed in the past week. (A serving is 200 ml). **This includes products like Coke, V energy drinks, and cordial mixes.**	NOVA 4	HISS 4
Enter the number of servings of **storebought** fruit juice you have consumed in the past week. (A serving is 200 ml).	NOVA 4	HISS 4

SECTION 8: Convenience and take out		
Question	NOVA classification	HISS classification
Enter the number of **homemade or handprepared takeout style meals** you have had in the past week. (1 serving = 1 meal). This includes pizzas, burgers, fries, pies and other pastry dishes like samosas. To qualify as homemade or hand prepared ALL components must be made from scratch.	NOVA 3	HISS 3
Enter the number of servings of takeout/fast food you have consumed in the past week. (A serving is one meal). **This includes all fast-food and takeout options like MacDonalds, Burger King and KFC.**	NOVA 4	HISS 4
Enter the number of frozen heat-and-eat and ready-to-cook frozen pastries you have consumed in the past week. **This includes frozen pizzas, pre-prepared and frozen meals, instant soups and pre-prepared, frozen pasta dishes, dumplings, sausage rolls, pies, and any plant-based on lower carbohydrate substitutes.**	NOVA 4	HISS 4
Enter the number of servings of protein powder or meal replacement you have eaten in the past week. (A serving is 30 g or 1 scoop). **This includes whey, wheyisolate, hemp, and pea protein, collagen.**	NOVA 4	HISS 4