Relationship between fructose and lactose intakes and irritable bowel syndrome symptoms in a sample of 50-year old Cantabrians

by

Robin Spencer

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Abstract

**Background:** One therapeutic strategy to alleviate irritable bowel syndrome [IBS] symptoms may be to reduce the intake of dietary fructose and lactose. The majority of patients with IBS believe that diet contributes to their symptoms. They may limit their intake of certain food groups or specific foods that are vital in the diet to provide essential nutrients in attempt to self-manage their symptoms. The purpose of this pilot study was to examine the relationship between fructose and lactose consumption and IBS symptoms in 50-year old adults residing in Canterbury.

**Methods:** The Canterbury Health Ageing and Life Course [CHALICE] study is a longitudinal study consisting of 50-year old (n = 300) Cantabrians. Participants attended a 4 – 6 hour assessment and underwent multiple interviews and procedures. Data used in this thesis include the Birmingham IBS symptom questionnaire and a four-day estimated food and beverage diary [FBD]. Participants who reported any IBS symptoms were categorised into the IBS symptom group and those who reported no symptoms were categorised into the no symptoms group. Using the Birmingham IBS symptom questionnaire, individual participant scores for constipation, diarrhoea, pain score, and total symptom score were calculated. FBD data were converted to nutrients using the food and nutrient analysis programme; Kai-culator.

**Results:** Two hundred and twenty seven (75.7%) participants completed the Birmingham IBS symptom questionnaire and a four-day estimated FBD and were included in the analyses. The IBS dimensions constipation, diarrhoea, and total IBS score were not associated with fructose or lactose intake. A lower prevalence of IBS
pain symptoms was associated with higher mean daily intakes of fructose (P = 0.055) and lactose (P = 0.041).

**Conclusions:** The findings suggest that participants with IBS symptoms may have reduced their intake of fructose and lactose. People with IBS could benefit from guidance from a Dietitian to achieve a well balanced diet while excluding foods they have identified that contribute to their particular IBS symptoms.
Preface

The CHALICE study is a prospective longitudinal study of 50-year old males and females living within the Canterbury District Health Board [CDHB] catchment area. Study planning began in 2009 and participant recruitment and baseline data collection commenced in August 2010. The CHALICE study aims to investigate physical, psychological and cognitive health amongst a cohort of 1000 participants every five years from baseline.

This thesis uses CHALICE data from the first 300 participants interviewed, of which 227 participants completed and returned a Birmingham IBS symptom questionnaire and a four-day estimated FBD. The relationship between specific sugars, as measured by a FBD; and IBS symptoms is examined.

As part of this thesis, the candidate:

• Observed participant interviews (all seven modules).
• Was responsible for checking returned FBDs for any omissions or foods requiring clarification, and provided study interviewers with specific questions to ask the study participants to gain additional detail.
• Entered FBDs into the nutrient analysis programme.
• Checked FBD data entered using the old Diet Cruncher nutrient analysis program and updated data using the new Kai-Culator nutrient analysis program.
• Updated the existing assumptions list designed for the old nutrient analysis program.
• Completed all statistical analyses presented in this thesis.
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<td>CDHB</td>
<td>Canterbury District Health Board</td>
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<tr>
<td>CHALICE</td>
<td>Canterbury Health Ageing and Life Course</td>
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<tr>
<td>ELSI_{SF}</td>
<td>Economic living standard index short form</td>
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<td>FBDs</td>
<td>Functional bowel disorders</td>
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<td>FODMAPs</td>
<td>Fermentable Oligo-, Di- and Mono-saccharides And Polyols</td>
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<td>FBD</td>
<td>Food and beverage diary</td>
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<td>FFQ</td>
<td>Food frequency questionnaire</td>
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<td>FM</td>
<td>Fructose malabsorption</td>
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<td>GI</td>
<td>Gastro intestinal</td>
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<td>Irritable bowel syndrome</td>
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<td>Lactose malabsorption</td>
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<td>NNS</td>
<td>National nutrition survey</td>
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<td>NZ</td>
<td>New Zealand</td>
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<td>NZANS</td>
<td>New Zealand Adult Nutrition Survey</td>
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<td>SD</td>
<td>Standard deviation</td>
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<td>USA</td>
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1 Introduction

Irritable bowel syndrome is a chronic functional gastrointestinal tract disorder in the absence of any detectable structural abnormalities or biomarkers of organic disease. IBS is a syndrome and, as such, the diagnosis is symptom-based. These symptoms are recurrent abdominal pain, altered bowel habits, bloating, distension, flatulence, relief of pain with defecation and incomplete defecation (1).

The estimated worldwide prevalence of IBS varies from 8 - 23% depending on the population studied and the diagnostic criteria used (2). A cross-sectional birth cohort conducted in Dunedin, New Zealand [NZ] using the Manning criteria estimated an IBS prevalence of 18% (3).

Irritable bowel syndrome is the most common gut disorder in the general population and imposes a substantial financial burden on society. Annual direct costs associated with IBS include medical consultations, drug prescriptions, and diagnostic tests which have been estimated to cost 15-30 billion dollars per year for all IBS patients in the United States of America [USA] (4,5). New Zealand has an ageing population that is anticipated to substantially increase health care costs in the future (6). The incidence rate of IBS increases with age and the most common age group to present to a physician for the first time for IBS is usually 30 - 50 years old (7,8). This could further substantiate the financial burden in NZ’s ageing population.

Patients who have IBS have a substantially reduced quality of life. On average, IBS patients miss 13.4 days of work or school per year, have a higher chance of losing a job and work fewer hours than matched controls (9). Additionally, IBS patients report
that they would be willing to sacrifice 25% of their remaining life to relieve their IBS symptoms (10).

There are multiple possible aetiologies for IBS and no consistently effective therapies. Most IBS patients believe that diet plays a role in their symptoms (11). It would, therefore, be expected that IBS patients are selective with their dietary choices. However, studies comparing the diet of IBS patients and controls have found mixed results (9,12–14). The reduction of Fermentable Oligo-, Di- and Mono-saccharides And Polyols [FODMAPs] in the diet has been proposed as an effective way to manage IBS symptoms (15). In particular, lactose and fructose malabsorption [FM] may contribute to IBS symptoms through fermentation leading to gas and distention in the large intestine (5,15). Many studies have shown that when fructose and/ or lactose is limited or excluded from the diet and patients with IBS are compliant, IBS symptoms significantly improve with the exception of one study which found controls had greater improvement than IBS patients (12,16–22).

The aim of this research was to examine the relationship between fructose and lactose consumption and IBS symptoms in 50-year old adults residing in Canterbury.
2 Literature Review

2.1 Irritable bowel syndrome:
Irritable bowel syndrome is a functional disorder of the gastrointestinal tract. The main symptoms of IBS include recurrent abdominal pain, altered bowel habits, bloating, distension, flatulence, relief of pain with defecation and incomplete defecation (1).

2.1.1 Diagnosis
Traditionally, an exclusion approach has been used by clinicians to diagnose IBS as there are no detectable structural abnormalities or biomarkers for diagnosis (1, 2). Over the past two decades a range of tools have been developed to allow clinicians to diagnose patients presenting with IBS symptoms based on clinical criteria (23). These include the Rome, Manning and Kruis criteria and the Birmingham IBS symptom questionnaire (24–27). In 2008 the Birmingham IBS symptom questionnaire was developed and validated by Roalfe et al (27). The need for an IBS symptom measure incorporating a symptom frequency scale was determined due to the fluctuating nature of IBS. The Birmingham IBS symptom questionnaire was shown to be valid and reliable during a cross-sectional pilot study and is recommended to be utilised in future IBS studies (27).

2.1.2 Pathogenesis
There are multiple possible aetiologies for IBS and the exact aetiology is not known. Possible aetiologies include carbohydrate malabsorption, bacterial overgrowth, enteric nervous system disturbances, previous gastrointestinal infection and disturbed colonic motility (2,28). The management of IBS can, therefore, be difficult and aims at the relief of IBS symptoms rather than treatment of the cause of the symptoms (5,28).
Carbohydrate malabsorption has received a great amount of attention due to the similar symptoms that IBS and carbohydrate malabsorption produce. In 2005, Gibson and Shepherd proposed the FODMAP hypothesis (15). FODMAPs are highly fermentable and poorly absorbed short-chain carbohydrates and polyols. FODMAPs encompass many food components including the sugars fructose and lactose. When FODMAPs are poorly absorbed in the small intestine they exert an osmotic effect increasing water delivery to the large intestine where they are rapidly fermented by luminal bacteria producing gas, luminal distension and pain (5). This hypothesis has led to the development of the “low-FODMAP diet” which has an increasing evidence base as an effective new treatment option for IBS.

![Figure 2.1: The theoretical basis for the relationship between FODMAPs and the genesis of functional gut symptoms (from Barrett & Gibson (29))](image)

Another proposed aetiological factor in IBS is the role of visceral hypersensitivity (5). King et al found healthy controls did not develop symptoms even at the most rapid rates of luminal gas production whereas IBS patients experienced symptoms (30). This suggests IBS patients are more sensitive to the luminal effects of dietary components such as FODMAPs, which are rapidly fermented in the proximal colon. Therefore,
modifying the diet to exclude dietary components causing symptoms in people with IBS could be an effective way of improving symptoms.

2.1.3 IBS Prevalence and Trends

The prevalence of IBS is relatively similar across the world. It is difficult to compare different countries due to the use of different diagnostic criteria. In a NZ birth cohort, 64% of participants experienced at least one IBS symptom in the previous year and 18% were diagnosed with IBS by fulfilling at least two of the Manning criteria for IBS (3). Australia has an IBS prevalence of 6.9% using Rome criteria and 13.6% using Manning criteria. This prevalence is similar to many other countries and higher than some African and European countries (8). Overall the prevalence of IBS across the world is 8 - 23% (2).

2.1.4 IBS Consequences

Patients who have IBS have a substantially reduced quality of life which has been compared to the same degree of reduced quality of life as people living with chronic diseases such as congestive heart failure, hepatic cirrhosis, renal insufficiency and diabetes (5,9). The level of symptoms present in patients with IBS is highly variable between different patients, ranging from mild to severe and daily pain to intermittent pain in weekly or monthly intervals (9).

An international survey reported that patients with IBS experienced an average of 73 days per year of restricted activity, reduced quality of life due to dietary restrictions, and disruption of daily activities and mood disturbances (10). On average, patients with IBS miss 13.4 days of work or school per year, they have a higher chance of losing a job and they work fewer hours than matched controls (9). All of these factors may affect the
quality of life of patients with IBS and reduce their yearly income. Additionally, the international survey reported IBS patients would be willing to sacrifice 25% of their remaining life to receive a treatment which would relieve them of their IBS symptoms (10).

2.1.5 Effect on health budget

A large proportion of patients with IBS do not seek any form of health care, nevertheless, IBS patients generate a substantial work load for the primary and secondary health care providers which exceeds visits from patients with diabetes, hypertension and asthma (5). An Australian study estimated around 81% of IBS patients see a general practitioner with some patients having many consultations each year, resulting in an estimated 285 000 general practice consultations annually (31). There are direct and indirect costs associated with IBS including medical consultations, drug prescriptions, diagnostic tests, sick leave days, lower productivity at work and higher rates of hospitalisation (5). It is difficult to estimate the financial burden of IBS on society as the direct costs are more straightforward to estimate than the indirect costs and both contribute to the overall costs of IBS on the healthcare system. A USA study compared the health care use and costs between patients with IBS and non-IBS controls (32). Compared to controls over a 2-year period, IBS patients had more outpatient visits, were hospitalised more often, and had more prescriptions (P < 0.05). Total costs for IBS patients were 51% higher than controls and total costs increased as the severity of IBS increased (P < 0.05). Total healthcare costs have been estimated at $259 per patient per year in Canada, $619 in USA, £90 in the UK, and 15 - 30 billion dollars per year for all IBS patients in USA (4,5).
Dietary manipulation has the potential to reduce healthcare costs for IBS patients. Bohmer and Tuynman demonstrated diet restriction as a treatment for IBS has the potential to reduce IBS associated health costs (12). In a 5-year follow up study, following a lactose-restricted diet reduced clinic visits by 75% in patients with IBS (22).

New Zealand has an ageing population that is anticipated to substantially increase health care costs in the future (6). In 2006, 33% of IBS patients in Australia were aged 45 – 64 years (31). The most common age group of IBS patients to present to a physician for the first time is usually 30 - 50 years old (8). A USA study found the incidence rate of IBS increased with age (P = 0.006), and participants over the age of 55 had the highest incidence of IBS (7).

Due to the large patient burden of IBS, the financial burden on the health care system, the high prevalence of IBS among older adults, and the ageing population in NZ, it is essential that effective treatment options for IBS are established.

2.2 Fructose

2.2.1 Chemical Structure

Fructose is a six-carbon monosaccharide that is present in food in three different forms: as a free monosaccharide, in the disaccharide sucrose (joined to glucose), and as polymerized forms oligosaccharides and polysaccharides (33).

2.2.2 Fructose Absorption

Fructose is either absorbed in the small intestine via a low capacity transporter or by a more rapid co-transporter with glucose. Therefore, fructose is absorbed more efficiently
when it is consumed in equal amounts to glucose and absorbed slower when consumed as free fructose (29).

2.2.3 The Role of Fructose in IBS

The term FM refers to the incomplete absorption of fructose in the small intestine (29). If fructose is malabsorbed, it acts as a FODMAP, moving through the small intestine exerting an osmotic effect, which leads to increased delivery of water to the proximal colon. When free fructose arrives in the colon, it is fermented by the faecal microbiota leading to gas formation causing luminal distension, pain, and discomfort (5).

2.2.4 Dietary Sources of Fructose

As fructose is absorbed efficiently when consumed in equal amounts to glucose, foods high in free fructose content are more important for people with IBS and FM to avoid than foods containing equal amounts of fructose and glucose (or greater amounts of glucose than fructose) such as plain corn syrup, bananas, and strawberries (34).

The increasing consumption of high-fructose corn syrup in the western diet may not affect symptoms in patients with IBS and FM as it has near equal amounts of fructose and glucose. This was shown by Skoog et al when breath hydrogen (diagnosing FM) was more abnormal in patients with IBS after the consumption of free fructose compared to the consumption of high-fructose corn syrup (P < 0.01) (35).

Fructose is naturally found in honey, table sugar, fruit juices and fruits. Excess fructose compared to glucose is found in some fruits such as apples and pears (29,34). The major dietary sources of fructose among NZ adults in 2008 were fruit, non-alcoholic beverages, vegetables, and sugar and sweets (36).
2.2.5 Fructose consumption data

New Zealand adult dietary intake data indicates that daily fructose consumption has remained stable between 18 - 26g/day over the past decade for adult males and females (36,37). In contrast, USA data reports a larger mean daily fructose intake which increased from 37g/day to 49g/day over two decades (38,39).

Park et al observed that women with IBS who had more severe IBS symptoms had a reduced fructose intake compared to those with less-severe symptoms (13). This suggests IBS patients may self-manage their symptoms by reducing their fructose intake. However in contrast, Jarrett et al found no difference in fructose intake between women with IBS-like symptoms and women without symptoms (14). For further information on these studies see Appendix A, table 9.1.

2.2.6 Effect of dietary fructose on IBS

The prevalence of FM among IBS patients appears to be similar to the healthy population. In 2000, Goldstein et al reported that 44% of IBS participants had FM (diagnosed by breath testing), with the same prevalence found among the non-IBS group (17). A similar rate (52%) of FM was reported among Danish patients with IBS (40).

Shepherd et al tested the effect of free fructose on IBS patients with FM by providing participants with a low-FODMAP diet then reintroducing free fructose with an increasing dose three times per day for two weeks (41). Symptoms recurred in 70% of participants and the overall intensity of symptoms increased as the fructose dose increased (P < 0.01). This suggests dietary fructose may provoke bloating, abdominal
pain and flatulence in patients with IBS and FM and exclusion of fructose from the diet may reduce symptoms in these patients. Several studies have examined this concept by altering participants’ dietary fructose intake. Choi et al reported suspected IBS patients with fructose intolerance that were compliant with a fructose-restricted diet for one year showed significant improvement in their bowel symptoms (P < 0.02). In contrast, patients who were non-compliant with the fructose-restricted diet experienced little symptom improvement (16).

In 2000, Goldstein et al reported 56% of IBS patients experienced substantial symptom improvement following a one month dietary restriction of fructose, lactose and sorbitol (P < 0.001) (17). Frederick et al reported sustainable effects of dietary restriction (42). Patients with IBS symptoms were given dietary counseling concerning fructose and lactose exclusion from their diet and were also instructed to avoid polyols. At both 6-month and 3-year follow-up, patients complying with the diet reported at least 75% symptom improvement. Shepherd et al also gave detailed dietary advice to patients with IBS and FM (18). Dietary restriction of fructose and fructans resulted in 74% of patients reporting improvement of symptoms. This effect was significantly greater in patients who adhered to the diet compared to non-adherent patients (P < 0.01).

Although these studies support the concept that dietary fructose exclusion improves symptoms in IBS patients with FM, it is uncertain if the effect shown was specifically due to fructose exclusion or if fructans, lactose or polyols played a role. Further research is needed to discriminate between these effects. Additionally, some of these
studies had small sample sizes and all were international studies, therefore, the results may not be transferrable to the NZ adult population.

One study found different results. Corlew-Roath and Di Palma aimed to determine the impact of diagnosing FM or lactose malabsorption [LM] on patients with IBS (19). Eight or more months after diagnosis 47% of patients with IBS complying with dietary changes had resolved symptoms compared to 77% of patients without IBS. However, patients were not given dietary advice following diagnosis and the proportion of patients with IBS and FM compared to without IBS was much lower compared to other studies (17,40). For further information on these studies see Appendix A, table 9.2.
2.3 Lactose

2.3.1 Lactose Chemical Structure and Absorption

Lactose is a disaccharide made up of one glucose molecule and one galactose molecule (29). When milk or milk products are consumed, lactose is hydrolysed in the small intestine into the monosaccharide’s glucose and galactose, which are then absorbed. The hydrolysis of lactose requires the enzyme lactase, attached to the brush boarder in the small intestine with its highest expression in the mid-jejunum (43).

2.3.2 Dietary Sources

Lactose is a unique carbohydrate that is only present in mammalian milk. Lactose is present in foods containing milk and milk products such as milk, yoghurt, sour cream and ice cream. Milk and milk products with only small or trace amounts of lactose include hard cheeses, butter, margarine and cream cheese (29). The major dietary sources of lactose among NZ adults in 2008 were milk, dairy products, non-alcoholic beverages, and bread (36).

People often assume that a dairy-free diet is required for the treatment of LM. It is important to educate people with LM about the availability and importance of options such as lactose-free milk and yoghurt or small intakes of low-lactose products such as hard cheeses to avoid the risk of poor calcium intake and the complications that follow.

2.3.3 Lactose consumption data

New Zealand adult dietary intake data indicates that daily lactose consumption has remained stable between 12-16g/day over the past decade for adult males and females.
(36,37). This is similar to the mean intake of 12g/day found in Swedish women in 1987-90 (44). Data from USA also report a similar mean daily lactose intake of 9-15g/day which slightly increased over one decade (45).

Patients with IBS often believe that lactose is the main cause of their symptoms. This is a concern as lactose-containing foods are an important dietary source of key nutrients such as calcium, protein, vitamin B2 and phosphorus (5,9).

There are few studies that have compared the dietary adequacy of patients with IBS to controls. Ostgaard et al compared IBS patients who were guided with dietary advice, IBS patients who had not received dietary advice, and controls (9). There were no differences in the intake of calories, carbohydrates, proteins, fat or sugar between the groups. Unguided IBS patients consumed significantly less milk and milk products than controls and significantly less calcium compared to guided IBS patients (P = 0.03) and controls (P = 0.02). In a 1994 study, women with IBS-like symptoms consumed significantly less lactose than women without symptoms (P = 0.03) (14). In contrast, Bomer and Tuynman found no difference in lactose intake between patients with IBS compared to controls, and no difference between IBS with or without LM (12). For further information on these studies see Appendix A, table 9.3.

2.3.4 The Role of Lactose in IBS

Lactose malabsorption is due to the incomplete hydrolysis of lactose in the small intestine, resulting in unabsorbed lactose moving through to the large intestine (46). Like fructose and the other FODMAPs, the presence of unabsorbed lactose in the large
intestine leads to an increased osmotic effect in the small intestine and rapid fermentation of lactose by bacteria in the large intestine causing gas, luminal distension, pain, and discomfort (29). During infancy, levels of lactase are high in concentration due to the high content of lactose in breast milk. Post-weaning, the activity of lactase reduces in the majority of the population resulting in LM (46). Rapid transit time or a damaged brush boarder of the small intestine can also result in LM (46).

2.3.5 Dietary lactose and IBS

Studies have consistently reported the prevalence of LM as 23 - 27% (diagnosed by breath testing) among patients with IBS (20,22,47,48). Vesa et al reported the same rate of LM (24%) between subjects with IBS and healthy controls without IBS (48).

Farup et al assessed LM and the effect of lactose on abdominal symptoms by giving participants 25 g of lactose and measuring breath hydrogen, breath methane and symptoms. Participants with IBS and LM had significantly higher symptoms after ingesting lactose compared to those without LM (P < 0.001) (49). A higher prevalence of symptoms was also found among those with IBS compared to healthy participants without IBS, despite the same prevalence of LM. This suggests that dietary lactose may provoke symptoms in patients with IBS and LM as well as IBS patients who are lactose digesters.

Several studies have examined the effect of excluding lactose from the diet. Parker et al reported 39% of IBS patients with LM experienced fewer symptoms after following a low-lactose diet (20). A similar result was found by Vernia et al, where patients with IBS symptoms who tested positive for LM were instructed to follow a lactose-free diet.
Compliance with the diet resulted in 44% of patients experiencing prolonged remission of symptoms and 41% experiencing partial improvement of symptoms. In contrast, no patients without LM had complete remission of symptoms after following the diet.

Bohmer and Tuynman evaluated the long-term effectiveness of following a lactose-restricted diet (12). Patients with IBS and LM consuming the lactose-restricted diet reported a significant decrease in symptoms three-weeks (P < 0.001) and six-weeks (P < 0.001) after commencing the diet. This was in contrast with the non-LM group who reported no change in symptoms after following the diet for three and six weeks. In 2001 Bohmer and Tuynman did a five-year follow-up on these patients and found reported symptoms were still significantly lower than before the study (P < 0.001) with 88% reporting no complaints (22).

Thus, there is moderate evidence that following a diet low or free in lactose reduces short and long-term symptoms in IBS patients with LM. However, these were all international studies, therefore, the results may not be transferrable to the NZ adult population. For further information on these studies see Appendix A, table 9.4.
2.4 Summary
The research presented suggests that people with IBS may be more sensitive to the intestinal luminal effects of food digestion than controls and diet restriction of fructose and lactose may help reduce symptoms. However, further research is needed to discriminate the effects of dietary fructose exclusion. The current literature available comprises predominantly experimental studies manipulating the diet. To complement this literature, future research that needs to be addressed includes: What are the benefits of fructose and lactose restriction in patients with IBS who do not have FM or LM?

It is important for accurate and effective diet restriction treatment to be researched and understood to help relieve the symptoms affecting the quality of life of a large ageing population of people with IBS. The primary aim of this research was to examine the relationship between fructose and lactose consumption and irritable bowel syndrome symptoms in 50-year old Cantabrians.
3 Objective Statement

Overall there is some evidence that dietary restriction of fructose in those with IBS and FM and dietary restriction of lactose in those with IBS and LM can result in the partial or complete relief of IBS symptoms.

The majority (90%) of IBS patients believe that diet plays a role in the cause of their IBS symptoms and, although controversial, there are some data suggesting that patients with IBS may limit their daily intake of fructose and lactose to self-manage their symptoms (9,11,13,14). However, there is no NZ research describing the association between fructose and lactose consumption and IBS symptoms, therefore, it is unknown if New Zealander’s limit their intake of fructose and lactose to self-manage their symptoms. Additionally, it is clinically important to examine specific dietary components contributing to IBS symptoms in attempt to reduce the unpleasant symptoms in patients with IBS.

Thus, the purpose of this pilot study was to examine the relationship between fructose and lactose consumption and irritable bowel syndrome symptoms in 50-year old Cantabrians. The research objectives are to:

1. Assess the fructose and lactose consumption of a sample of 50-year old Cantabrians.
2. Assess the prevalence of irritable bowel syndrome symptoms among 50-year old Cantabrians.
3. Describe the association between fructose and lactose consumption and irritable bowel syndrome symptoms in 50-year old Cantabrians.
3.1 Hypotheses
The hypotheses for this study are:

1. That 50-year olds residing in Canterbury will have a similar dietary intake of fructose and lactose compared to participants in recent nationally representative surveys.

2. That the prevalence of IBS symptoms of 50-year olds in Canterbury is similar to the prevalence of participants in New Zealand populations.

3. That a high pain, constipation, diarrhoea, and IBS symptom score is associated with a low intake of dietary fructose.

4. That a high pain, constipation, diarrhoea, and IBS symptom score is associated with a low intake of dietary lactose.
4 Methods

4.1 Study Design
The CHALICE study is a prospective longitudinal study, comprising a random selection of 50-year old adults who live within the CDHB catchment area in NZ. The data used in this thesis are baseline data collected from the first 300 CHALICE study participants who had been recruited to CHALICE and had all data of interest available by 20 June, 2013. Assessment data were collected with a 4 - 6 hour face-to-face interview, self-completed questionnaires, lifestyle diaries, and diagnostic tests. For each participant, longitudinal follow-up will be performed every five years. Additionally, participants complete a brief questionnaire annually. Ethical approval was obtained from the Upper South A Regional Ethics Committee (Appendix B).

4.2 Study Procedures
Standardised CHALICE protocols relevant to this thesis are described in this section. The broader CHALICE methods are described in more detail by Schluter et al (50).

4.2.1 Sample selection
The NZ Electoral Roll Centre provides the CHALICE study with an up to date list (health research extract) of people who are currently 50-years old and are registered within the following territorial authorities that align with the CDHB catchment area: Kaikoura District, Hurunui District, Waimakariri District, Christchurch City, Selwyn District, and Ashburton District. A new health research extract of 50-year olds is requested annually, beginning June 2010 to achieve the full CHALICE sample of 1000 participants. Each annual extract is randomly ordered and 300 people are recruited, in a ratio of 4:1 non-Maori to Maori.
4.2.2 Participant Contact

CHALICE interviewers sent a letter to all potential participants inviting them to take part in the study, using addresses obtained from the electoral roll. If participants did not respond to the letter the interviewers telephoned them up to four times using telephone numbers from the White Pages and the internet. A second letter was sent to participants six weeks later if they did not respond. CHALICE interviewers visited participants at their home as a final contact attempt if participants had not responded. If they were unable to contact the participant through the letters, telephone calls and home visit or if there was no home telephone number available participants were classified as not having the opportunity to accept or decline participation and categorised as end of line.

4.2.3 Participant Interviews

The participants were then randomly assigned to an interviewer. Participants attended a 4 - 6 hour assessment and underwent multiple interviews and procedures as part of the wider CHALICE study. For the majority of participants the assessment was completed on one day but in a minority of cases it was completed over two or more days. The following modules were completed on the interview day(s):

- Module 1 – physical assessment and blood tests
- Module 2 – personal health history questionnaire
- Module 3 – well-being questionnaire
- Module 4 – heart health – Electrocardiography
- Module 5 – psychological health and personality questionnaire
- Module 6 – cognitive health assessment
- Module 7 – lifestyle questionnaire: four-day estimated FBD.

Four questionnaires - including the Birmingham IBS symptom questionnaire.
The components of the two modules (module 2 and 7) and The Birmingham IBS symptom questionnaire used in this thesis are described in greater detail below.

4.2.3.1 Module 2: Demographics Section
Module 2 is the personal health history questionnaire, consisting of questions related to demographics, chronic conditions, health service utilisation, and risk and protective factors. This thesis includes data only from the demographics section of this module. The demographics section included questions on gender, date of birth, ethnicity, education, income and standard of living. When calculating economic living standard index short form [ELSI_{SF}], home ownership, social participation, economising, self-rated standard of living, satisfaction with standard of living, and adequacy of income are taken into account (51). See Appendix C for the demographics section, which includes details on the questions used to calculate the ELSI_{SF} score.

4.2.3.2 Module 7: Lifestyle questionnaire
Module 7 contains a home food inventory, How you eat and what you eat questionnaire, and a four-day estimated FBD. For the purposes of this thesis, only data from the four-day FBD was used.

The FBD (Appendix D) was completed by participants in their own time after their initial assessments and returned to CHALICE by post. Participants were shown how to complete the FBD and shown examples by a trained CHALICE interviewer; written instructions for completion were also included with the diary. When the diaries were returned, study nutritionists checked the FBD for any missing information. If further
information was required, interviewers contacted the participants by telephone or email to ask them relevant questions or for further clarification.

The FBD was pretested in a group interview with a convenience sample of eight men aged 50 years and older. A group of men was used because they were less likely to know about food preparation and might therefore provide more feedback and suggestions on how to collect this information. The group discussed the FBD layout and the content of the diary instructions. Their feedback was incorporated into a revised FBD and the associated instructions for completion. Participants were asked to complete the FBD on one weekend day and three week days.

4.2.3.3 Birmingham IBS symptom questionnaire

The Birmingham IBS symptom questionnaire (Appendix E) was one of the four questionnaires that participants completed in the week prior to attending the 4 - 6 hour assessment day. The Birmingham IBS symptom questionnaire incorporates a symptom frequency scale measuring IBS symptoms over the past four week period (27). A symptom frequency scale is an important component due to the fluctuating nature of IBS. The questionnaire has been shown to be a valid and reliable tool for measure IBS symptoms (27). The questionnaire comprises 11 IBS symptom questions and each question has a standard 6-point response scale ranging from 1 = “all of the time” to 6 = “none of the time”.

4.2.4 Raw Data Handling

Each participant was allocated a study number upon entry to the study. This study number was used on all questionnaires and data collected relevant to that participant. Only study interviewers were aware of the names of participants. Others involved in
participant feedback, data entry or checking of FBDs used the study number to identify participants. Raw data were kept in locked cabinets within the University of Otago CHALICE office.

4.2.5 Sample Size Calculation

As this is a pilot study and CHALICE data collection is an on-going process, a cut-off point of 300 participants was decided upon as this was the estimated number of participants who would have been interviewed and their data entered and cleaned by August 2013. No formal sample size calculations were undertaken due to the exploratory nature of the data analysis.

4.3 Data Analysis

4.3.1 Data Entry

All raw data except FBD data were entered into a study wide custom built database Progeny 7 (Progeny Software, LLC www.progenygenetics.com). The accuracy of data entry was confirmed by the study database manager by checking the data entered against the questionnaire answers, and screening for data anomalies. FBDs were entered into the food and nutrient analysis programme; Kai-culator (version v1.08d) the dietary assessment software developed in the Department of Human Nutrition, University of Otago. The food composition database includes current and previous versions of FOODfiles from Plant and Food Research Ltd and selected recipes calculated for the 2008/09 New Zealand Adult Nutrition Survey [NZANS] (52,53). Trained nutritionists entered all FBDs using a standard operating protocol. The protocol was checked by the study nutritionists and other expert nutritionists (including a thesis supervisor), and was added to as required throughout the data entry process. Meetings among the students
undertaking data entry were held regularly to help minimise error in data entry. A second nutritionist checked all FBD data, once entered, and any errors were corrected.

4.4 Variable Coding
The IBS symptom data and ELSI\textsubscript{SF} data were dichotomised (low and high) for statistical analysis as shown in Appendix F.

4.4.1 Standard of Living Coding
The ELSI\textsubscript{SF} score is calculated as a continuous score ranging from 0 to 31. It is usually broken into seven categories representing standards of living. Those with scores from 0 to 24 (hardship and comfortable categories) were categorised as having a low standard of living. Participants with scores from 25 to 31 (good and very good categories) were categorised as having a high standard of living. Refer to Appendix F for the distribution of participants’ ELSI\textsubscript{SF} scores and the frequencies of high and low categories.

4.4.2 Food and Beverage Diary Coding
FBD data were converted to nutrients in Kai-culator. The following nutrients were used in this thesis: Fructose (g), Lactose (g), Total Energy (Kcal), and total Sugars (g).

4.4.3 Irritable Bowel Syndrome Coding
Raw data from the Birmingham IBS symptom questionnaire was used to calculate individual participant scores for constipation-predominant IBS (IBS-C), diarrhoea-predominant IBS (IBS-D), pain score, and total symptom score. These four dimensions of IBS were calculated by calculating the total score of specific questions within the Birmingham IBS symptom questionnaire (Appendix E):

\begin{align*}
\text{IBS-D:} & \quad \text{Total of scored questions for b), c), i), j) and k).} \\
\text{IBS-C:} & \quad \text{Total of scored questions for d), e) and f).} \\
\text{Pain score:} & \quad \text{Total of scored questions for a), g) and h).} \\
\text{Total symptom score:} & \quad \text{Total of all scored questions for a) - k).}
\end{align*}

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To divide the participants into two groups for IBS, participants who reported any IBS symptoms during the last four weeks were categorised into the IBS symptom group and those who reported no symptoms were categorised into the no symptoms group. Refer to Appendix F for the frequencies of the high and low categories.

### 4.5 Statistical Methods

All statistical analyses were performed using R Studio version 0.97.551 (R Studio, inc, 2009-2012). Means, standard deviations, and frequencies were calculated to describe each variable. The criterion for statistical significance was set at $P < 0.05$. The Shapiro-Wilk test was used to test for normality. Mean daily fructose and lactose intakes had a uni-modal right skew as shown in Appendix G.

As IBS is a condition that only some people have, many participants reported experiencing no IBS symptoms. Therefore, binary logistic regression was used to predict relationships between the mean daily intake of fructose and lactose (independent variables) and each of four IBS dimensions (dependent variables). Gender, ethnicity, and ELSI$_{SF}$ were covariates, giving four independent variables for each model.

Linear regression was used to predict relationships between the mean daily intake of fructose and lactose and each of four IBS domains exclusively in the participants who experienced any IBS symptoms at all.
5 Results

5.1 Participant Response Rate

Figure 5.1 outlines the CHALICE recruitment process to achieve the first 300 participants, with numbers of all participants and Maori shown at each step. An invitation letter was sent to 672 people. As of June 20th 2013, 300 of these people completed all seven modules on the interview day. Two hundred and twenty seven (75.7%) of the 300 participants completed and returned the Birmingham IBS symptom questionnaire and completed at least three days of the FBD and were included in this thesis.
Figure 5.1: Recruitment to date (adapted from Schluter et al (50))
5.2 Sample Characteristics
Table 5.1 shows demographic characteristics of the 227 CHALICE participants whose data were included in the analysis. Fifty three percent were female, 15.9% identified as NZ Maori and the majority of participants (63%) were in the higher ELSI$_{SF}$ categories.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category Description</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>107 (47)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>120 (53)</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maori</td>
<td></td>
<td>36 (16)</td>
</tr>
<tr>
<td>Non-Maori</td>
<td></td>
<td>191 (84)</td>
</tr>
<tr>
<td><strong>ELSI$_{SF}$</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardship / Comfortable</td>
<td></td>
<td>83 (37)</td>
</tr>
<tr>
<td>Good / Very good</td>
<td></td>
<td>144 (63)</td>
</tr>
<tr>
<td><strong>Irritable Bowel Syndrome</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IBS Symptoms</td>
<td></td>
<td>172 (76)</td>
</tr>
<tr>
<td>No Symptoms</td>
<td></td>
<td>55 (24)</td>
</tr>
</tbody>
</table>

*Participants who identified as both NZ European and NZ Maori were counted as Maori and all other participants were counted as Non-Maori.

5.3 Irritable bowel syndrome symptom score
Table 5.2 shows the prevalence of participants who scored at least one in each of the four dimensions of IBS symptoms. Seventy six percent of the sample participants had experienced at least one IBS symptom in the prior four-week period.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (%) *</th>
<th>Males (%) *</th>
<th>Overall (%) *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total IBS Symptoms</strong></td>
<td>95 (79)</td>
<td>77 (72)</td>
<td>172 (76)</td>
</tr>
<tr>
<td>Pain</td>
<td>60 (50)</td>
<td>46 (43)</td>
<td>106 (47)</td>
</tr>
<tr>
<td>Constipation</td>
<td>66 (55)</td>
<td>51 (48)</td>
<td>117 (52)</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>64 (53)</td>
<td>58 (54)</td>
<td>122 (54)</td>
</tr>
</tbody>
</table>

* Data represents participants who experienced at least one symptom over the prior four-week period.
5.4 Fructose and Lactose Intake

Table 5.3: Participant estimated mean daily energy and nutrient intakes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females (n=120) Mean (SD)</th>
<th>Males (n=107) Mean (SD)</th>
<th>All (n=227) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal/day)</td>
<td>1835 (460)</td>
<td>2478 (633)</td>
<td>2141 (621)</td>
</tr>
<tr>
<td>Fructose (g/day)</td>
<td>20.6 (10.2)</td>
<td>25.5 (14.4)</td>
<td>22.9 (12.6)</td>
</tr>
<tr>
<td>IBS Symptoms</td>
<td>20.6 (10.4)</td>
<td>23.8 (10.6)</td>
<td>20.0 (10.6)</td>
</tr>
<tr>
<td>No Symptoms</td>
<td>20.6 (9.4)</td>
<td>29.9 (20.8)</td>
<td>25.7 (17.4)</td>
</tr>
<tr>
<td>Lactose (g/day)</td>
<td>14.2 (8.9)</td>
<td>15.1 (9.2)</td>
<td>14.6 (9.0)</td>
</tr>
<tr>
<td>IBS Symptoms</td>
<td>13.4 (9.3)</td>
<td>15.5 (9.3)</td>
<td>14.3 (9.3)</td>
</tr>
<tr>
<td>No Symptoms</td>
<td>17.6 (6.4)</td>
<td>14.0 (9.1)</td>
<td>15.6 (8.1)</td>
</tr>
<tr>
<td>Total Sugars (g/day)</td>
<td>98.6 (40.0)</td>
<td>125.4 (59.3)</td>
<td>111.2 (51.6)</td>
</tr>
<tr>
<td>Fructose mg/1000 kcal</td>
<td>11.1 (4.9)</td>
<td>10.3 (5.0)</td>
<td>10.7 (4.9)</td>
</tr>
<tr>
<td>Lactose mg/1000 kcal</td>
<td>7.8 (4.6)</td>
<td>6.1 (3.6)</td>
<td>7.0 (4.2)</td>
</tr>
</tbody>
</table>

5.5 Correlation coefficient Analysis

Results from these analyses are shown in tables Table 5.4 and Table 5.5 below. Higher mean daily intake of fructose was borderline significantly associated with a lower pain score (P = 0.05) and higher overall mean daily intake of lactose was significantly associated with a lower pain score (P = 0.007). The total IBS symptom score was not significantly correlated with mean daily intakes of fructose (P = 0.17) or lactose (P = 0.19). When lactose intake was adjusted for energy intake, a higher intake of lactose was significantly associated with a higher constipation score (P = 0.01).
Table 5.4: Correlation analysis for IBS symptoms vs fructose intake

<table>
<thead>
<tr>
<th></th>
<th>Fructose $r$</th>
<th>P-value</th>
<th>Fructose mg/1000 kcal</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total IBS Symptoms</td>
<td>-0.091</td>
<td>0.17</td>
<td>-0.017</td>
<td>0.79</td>
</tr>
<tr>
<td>Pain</td>
<td>-0.128</td>
<td>0.05</td>
<td>-0.031</td>
<td>0.64</td>
</tr>
<tr>
<td>Constipation</td>
<td>-0.083</td>
<td>0.21</td>
<td>0.025</td>
<td>0.71</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>-0.005</td>
<td>0.94</td>
<td>-0.034</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 5.5: Correlation analysis for IBS symptoms vs lactose intake

<table>
<thead>
<tr>
<th></th>
<th>Lactose $r$</th>
<th>P-value</th>
<th>Lactose mg/1000 kcal</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total IBS Symptoms</td>
<td>-0.086</td>
<td>0.19</td>
<td>-0.002</td>
<td>0.98</td>
</tr>
<tr>
<td>Pain</td>
<td>-0.178</td>
<td>0.007*</td>
<td>-0.077</td>
<td>0.25</td>
</tr>
<tr>
<td>Constipation</td>
<td>0.054</td>
<td>0.42</td>
<td>0.165</td>
<td>0.01*</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>-0.085</td>
<td>0.20</td>
<td>-0.10</td>
<td>0.14</td>
</tr>
</tbody>
</table>

* P-value of <0.05 is considered statistically significant

5.5.1 Fructose and Lactose intake vs Pain Scatterplots

Figure 5.2 demonstrates the relationship between fructose and lactose mean daily intakes and pain scores. Participants who experienced no pain are represented in red and were excluded from this analysis.
Figure 5.2: Fructose and lactose intake vs pain scatterplot. The blue line represents the linear regression of only participants who experienced pain (blue dots), excluding participants with no pain (red dots)
5.6 Logistic Regression Analysis

To investigate associations between fructose and lactose intake and the four dimensions of IBS symptoms, exploratory analysis was conducted using an unadjusted logistic regression (model 1). The following predictors were adjusted for in model 2: gender, ethnicity, and ELSI\textsubscript{SF}.

5.6.1 Fructose

Table 5.6 shows the results for the associations between mean daily fructose intake and the four dimensions of IBS symptoms. Total IBS score, constipation, and diarrhoea were not associated with fructose intake. A higher fructose intake was negatively associated with the pain score as shown in table 5.6. For every 10g increase in mean daily fructose intake, the probability of experiencing any pain decreased by 21\% (P = 0.043, CI 0.95, 1.00). This association became borderline significant after adjusting for covariates, however, the effect size was unchanged (P = 0.055, CI 0.95, 1.00).

When adjusting for the covariates, ELSI\textsubscript{SF} was associated with total IBS symptoms, constipation, and diarrhoea. However, when the association between ELSI\textsubscript{SF} and the total IBS score, constipation, and diarrhoea was examined independent of fructose intake, the significant associations remained significant (see table 5.7).
Table 5.6: Logistic regression analysis of fructose intake and four IBS dimensions

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Model 1</th>
<th></th>
<th></th>
<th>Model 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio (CI)</td>
<td>P-value</td>
<td>Odds Ratio (CI)</td>
<td>P-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total IBS Symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.98 (0.95 – 1.00)</td>
<td>0.073</td>
<td>0.98 (0.95 – 1.00)</td>
<td>0.114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.72 (0.38 – 1.36)</td>
<td>0.313</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.89 (0.39 – 2.17)</td>
<td>0.783</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.34 (0.16 – 0.68)</td>
<td>0.004*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.98 (0.95 – 1.00)</td>
<td>0.043*</td>
<td>0.98 (0.95 – 1.00)</td>
<td>0.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.82 (0.48 – 1.41)</td>
<td>0.476</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.65 (0.30 – 1.35)</td>
<td>0.253</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.66 (0.38 – 1.14)</td>
<td>0.135</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constipation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.99 (0.97 – 1.01)</td>
<td>0.349</td>
<td>0.99 (0.97 – 1.01)</td>
<td>0.453</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.74 (0.42 – 1.29)</td>
<td>0.291</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.76 (0.36 – 1.60)</td>
<td>0.0468</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.32 (0.18 – 0.56)</td>
<td>&lt; 0.001*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diarrhoea</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose</td>
<td>0.99 (0.97 – 1.02)</td>
<td>0.606</td>
<td>0.99 (0.97 – 1.02)</td>
<td>0.596</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1.06 (0.62 – 1.82)</td>
<td>0.840</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>1.07 (0.52 – 2.23)</td>
<td>0.859</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.52 (0.30 – 0.90)</td>
<td>0.022*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* P-value of <0.05 is considered statistically significant

Table 5.7: Logistic regression analysis of ELSI<sub>SF</sub>

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio (CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total IBS Symptoms</strong></td>
<td>0.35 (0.16 – 0.70)</td>
<td>0.004*</td>
</tr>
<tr>
<td><strong>Pain Score</strong></td>
<td>0.67 (0.39 – 1.15)</td>
<td>0.148</td>
</tr>
<tr>
<td><strong>Constipation</strong></td>
<td>0.33 (0.18 – 0.57)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td><strong>Diarrhoea</strong></td>
<td>0.52 (0.30 – 0.90)</td>
<td>0.021*</td>
</tr>
</tbody>
</table>

* P-value of <0.05 is considered statistically significant
5.6.2 Lactose

Table 5.8 shows the results for the associations between mean daily lactose intake and the four dimensions for IBS symptoms. Total IBS score, constipation, and diarrhoea were not associated with lactose intake. A higher mean daily lactose intake was negatively associated with the pain score as shown in table 5.8. For every 10g increase in mean daily lactose intake, the probability of experiencing any pain decreased by 28% (P = 0.037, CI 0.94, 1.00). This association remained significant after adjusting for covariates (P = 0.041, CI 0.94, 1.00).

As seen for fructose, when the covariates were adjusted for, ELSI\textsubscript{SF} was significant for the total IBS score, constipation, and diarrhoea. However, when the association between ELSI\textsubscript{SF} and IBS score, constipation, and diarrhoea was examined independent of mean daily lactose intake, the significant associations remained significant (see table 5.7).
Table 5.8: Logistic regression analysis of lactose intake and four IBS dimensions

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio (CI)</td>
<td>P-value</td>
</tr>
<tr>
<td><strong>Total IBS Symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>0.99 (0.95 – 1.02)</td>
<td>0.37</td>
</tr>
<tr>
<td>Gender</td>
<td>0.66 (0.35 – 1.23)</td>
<td>0.190</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.89 (0.39 – 2.16)</td>
<td>0.780</td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.34 (0.16 – 0.69)</td>
<td>0.004*</td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>0.97 (0.94 – 1.00)</td>
<td>0.037*</td>
</tr>
<tr>
<td>Gender</td>
<td>0.76 (0.44 – 1.29)</td>
<td>0.306</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.64 (0.30 – 1.32)</td>
<td>0.230</td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.68 (0.39 – 1.17)</td>
<td>0.166</td>
</tr>
<tr>
<td><strong>Constipation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>1.00 (0.97 – 1.03)</td>
<td>0.728</td>
</tr>
<tr>
<td>Gender</td>
<td>0.71 (0.41 – 1.23)</td>
<td>0.223</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>0.76 (0.36 – 1.61)</td>
<td>0.478</td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.32 (0.18 – 0.56)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td><strong>Diarrhoea</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose</td>
<td>0.99 (0.96 – 1.02)</td>
<td>0.597</td>
</tr>
<tr>
<td>Gender</td>
<td>1.03 (0.61 – 1.75)</td>
<td>0.905</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>1.07 (0.52 – 2.23)</td>
<td>0.865</td>
</tr>
<tr>
<td>ELSI&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>0.52 (0.30 – 0.91)</td>
<td>0.023*</td>
</tr>
</tbody>
</table>

* P-value of <0.05 is considered statistically significant

5.7 Linear Regression Analysis

To assess for associations between fructose and lactose mean daily intakes and IBS symptoms in only the participants who experienced any IBS symptoms at all, exploratory analysis was conducted using linear regression. No relationships were statistically significant.
6 Discussion

6.1 Summary of main findings
This study found that 50-year old Cantabrians have a similar mean daily intake of fructose and lactose compared to similar age groups from recent NZ national nutrition surveys, have a higher prevalence of IBS symptoms compared to previous NZ data, and a higher mean daily intake of fructose and lactose are associated with fewer IBS pain symptoms.

6.2 Mean daily fructose and lactose intake

6.2.1 Fructose
The mean daily fructose intake of 25.5g for males and 20.6g for females is comparable to a similar age group in the 1997 national nutrition survey [NNS] and the 2008/09 NZANS (36,37). This suggests NZ adult fructose intake has remained stable since 1997 in contrast to the USA where a mean daily fructose intake of 49g increased from 37g/day over two decades (38). The 2008/09 NZANS reported that New Zealanders obtain the majority of their fructose intake from fruit (29%), followed by non-alcoholic beverages (18%). In contrast, Americans obtain the majority of their fructose intake from non-alcoholic beverages followed by grain products and fruit (38).

6.2.2 Lactose
The mean daily lactose intake was 15.1g for males and 14.2g for females, which is comparable to a similar age group in the 1997 NNS and the 2008/09 NZANS (36,37). These results suggest that NZ adult lactose intakes have remained stable since 1997 which is comparable to Swedish (12g/day) and USA (9-15g/day) intake data (44,45).
6.2.3 Conclusion
As hypothesised, 50-year old Canterbrians have similar mean daily fructose and lactose intakes compared to similar age groups in NZ national nutrition surveys (36,37). The results are not generalisable to other NZ age groups as the mean daily intake of fructose and lactose decrease with increasing age in the 1997 NNS and 2008/9 NZANS (36,37). It should also be noted that dietary assessment methods differed between this study and NZ national nutrition surveys (24-hour recalls were used in the nutrition surveys (37,52)).

6.3 Irritable bowel syndrome symptom prevalence
Seventy six percent and 47% of the participants reported that they experienced at least one IBS symptom and one pain symptom in the prior four weeks, respectively. Within NZ, there is only one other study that has examined the prevalence of IBS symptoms. A birth cohort of 26 year olds born in Dunedin found that 64% of participants experienced at least one IBS symptom in the previous year, and 46.5% reported abdominal pain (3).

CHALICE participants may have a higher prevalence of IBS symptoms than those in the Dunedin cohort as they were 26 years old – less than the peak age of IBS presentation (30-50 years old (8)). This is supported by a USA study, which found that the incidence of IBS increased with age ($P = 0.006$), where those older than 55-years had the highest IBS incidence (7). However, these findings are not consistent (55). As CHALICE participants are 50 years old, they are also more likely to have developed diseases that are independent of IBS that cause gastrointestinal symptoms such as diverticulitis.

It may not be valid to compare the present study to the Dunedin birth cohort study, which used the Manning criteria to assess IBS symptoms over the past year whilst CHALICE
used the Birmingham questionnaire to assess the past four weeks. Therefore, the
constipation and diarrhoea dimensions of IBS cannot be compared between the studies.
The birth cohort may also be more representative, as it involved 96% of the living sample
born in Dunedin during 1972–73.

In conclusion, hypothesis two is rejected as 50-year olds residing in Canterbury have a
higher prevalence of IBS symptoms compared to previous NZ data. Reasons for this
discrepancy may be that the age groups are not comparable, different questions were
asked between studies, and different recruitment methods were used.

6.4 Irritable bowel syndrome symptoms and Fructose intake
A higher mean daily intake of fructose was associated with a lower pain score. This was
also found by another study where participants with more severe IBS symptoms had
lower fructose intakes (13). However, another study found no difference in fructose
intake between women with and without IBS-like symptoms (14). The participants from
these studies were all female and younger than the CHALICE participants although other
study procedures were similar.

The observation of reduced fructose intake in those with a higher pain score may suggest
that people self-manage their diet due to prior low-FODMAP knowledge. However,
people may simply avoid fructose-containing foods that trigger IBS symptoms. Another
interpretation may be that fructose intake is not associated with IBS symptoms. However,
there is strong evidence that a low fructose diet improves IBS symptoms (16–18,41,42).
When participants who experienced no IBS symptoms were excluded from analysis, there
was no relationship between fructose intake and IBS symptoms. This could be because
participants experiencing pain were excluding fructose from their diet or because the power if the analysis weakened when a large proportion of participants were excluded.

After adjustment, ELSI$_{SF}$ was significantly associated with constipation, diarrhoea and total IBS symptoms. To further explore these associations, fructose and lactose intake were excluded from the analysis and the associations remained significant confirming the relationship was independent of fructose and lactose intake (see table 5.7). In conclusion, as hypothesised, a high pain score is associated with lower intake of dietary fructose, however, this was not found for the constipation, diarrhoea, or total IBS symptom score. This finding is borderline statistically significant and other research is controversial, therefore, further research is needed to support this finding.

6.5 Irritable bowel syndrome symptoms and Lactose intake
A higher mean daily intake of lactose was associated with a lower pain score. A similar trend was found in a study where women with IBS-like symptoms consumed significantly less lactose than women without symptoms (14). This small study of 18 19-45 year old women analysed lactose intake with three-day diet FBDs. Another study found that IBS patients who had received no dietary advice, consumed significantly less milk, milk products, and calcium compared to controls (9). In contrast, another study found no difference in lactose intake between IBS patients and controls, however, the controls used were staff members at the clinic the study was conducted from (12).

These results suggest that IBS patients may self-manage their diet to reduce symptoms. Unlike fructose, lactose intake is more widely known to be associated with IBS symptoms. While it is possible that lactose intake is not associated with IBS symptoms, it
is more likely that participants exclude certain foods. There is moderate evidence that
limiting lactose intake improves IBS symptoms (12,20–22). When those without IBS
symptoms were excluded from analysis, there was no association between mean daily
lactose intake and IBS symptoms. In conclusion, as hypothesised it appears that a high
pain score is associated with a lower intake of dietary lactose, however, this was not
found for the constipation, diarrhoea, or total IBS symptom score.

6.6  Strengths and limitations

6.6.1  Strengths

The CHALICE study recruitment method randomly selects participants from the electoral
role providing a wide participant pool and allowing Maori to be over-sampled. Pre-
testing the FBD on a sample of 50-year old men refined the FBD, improving usability
and participant understanding. To further improve participant understanding the study
interviewer thoroughly explained how to record and accurately estimate beverages and
food. A four-day FBD allowed sufficient data to estimate usual intake without causing a
high respondent burden (56), demonstrated by the high return rate of the FBD (75.7%).
Estimated four-day FBDs correlate well with the gold standard weighed FBD, which has
a greater respondent burden and may have resulted in a reduced return rate (56).

The food and nutrient analysis programme, Kai-culator used to analyse the FBD contains
a large database of the foods available in NZ, reducing the number of items that needed to
be substituted. FBDs were entered by trained nutritionists using a standard protocol and
checked by a second nutritionist. Additionally, FBDs were checked by study nutritionists
for missing data and the interviewer re-contacted participants as needed.
As expected, many CHALICE participants reported no IBS symptoms so binary logistic regression was performed to compare fructose and lactose intake in participants who did and did not experience symptoms. Additionally, as a range of sensitivities among people who experience IBS symptoms due to visceral hypersensitivity was expected, we performed linear regression to predict relationships between fructose and lactose intake and IBS symptoms in only the participants who experienced any IBS symptoms.

### 6.6.2 Limitations

This is a cross-sectional study and causality cannot be claimed. However, causality may be able to be explored more fully at 5-year follow up and after. The results of this thesis may not be generalisable to the NZ population as the participants were all 50 years old and living in the CDHB catchment area, which may differ from other regions for a multitude of reasons.

As 76% of participants reported that they experienced any IBS symptoms at all and only 47% any pain symptoms, the power of the linear regression analysis may have been too small to generate statistical significance. A larger pool of participants may have resulted in significant differences where only trends were seen. Limitations arise when using estimated FBD as estimating the volume of food consumed is difficult and mistakes are inevitable. Additionally, when entering the FBD onto Kai-culator, assumptions occasionally need to be made which are potentially inaccurate.

The Birmingham IBS symptom questionnaire includes subjective questions, which may have resulted in inconsistencies. The questionnaire was not designed to diagnose IBS but
to measure the prevalence of IBS symptoms in those with IBS. However, the questionnaire has been validated and is reliable in cross-sectional pilot studies (27).

6.7 Future research
Further studies of this longitudinal cohort will provide a larger pool of participants, increasing the statistical power of analyses. Also, repeating the analysis once the current participants have been followed up may allow causality to be investigated. Aspects to consider when planning future studies with the CHALICE study could include:

- More comprehensive statistical analysis could be carried out to overcome possible confounding variables such as stress and anxiety.
- Improvements of the Kai-culator nutrient analysis program would allow other FODMAPs: fructans, oligosaccharides and polyols to be included in analysis.
- When adjusting for covariates, there was an association between ELSI\textsubscript{SF} and IBS symptoms, constipation, and diarrhoea. A higher ELSI\textsubscript{SF} may be associated with factors such as healthy diet or higher level of education, which may affect IBS symptoms. Exploring these hypotheses is not within the scope of this thesis.

6.8 Conclusions
In conclusion, the current study found that 50-year old Cantabrians who have higher fructose and lactose intakes are less likely to experience IBS pain symptoms, however, no relationship was observed when only analysing the participants who experienced IBS symptoms. Dietary modification or avoiding certain foods may be a strategy people with IBS use to reduce the severity of their IBS symptoms and Dietitians who counsel patients with IBS should be aware of this so they can help guide them to achieve a well balanced diet while excluding the identified foods. Further research needs to be carried out to investigate why these relationships exist and future research using a larger participant pool is needed.
7 Application to Practice

The majority of IBS patients believe that diet plays a role in their symptoms (11). There is much misleading information available to patients, which may lead to patients excluding food groups or specific foods that are vital in the diet to provide essential nutrients such as calcium (9). As this thesis has highlighted, IBS patients may exclude fructose and lactose in attempt to self-manage their IBS symptoms. One study found that when patients with IBS were given two hours of guidance on the dietary management of IBS, they had maintained the dietary changes two years later and experienced significantly less pain compared to unguided patients (9).

It is important that public health campaigns and Registered Dietitians who counsel patients with IBS are aware that these patients believe that diet plays a role in their symptoms and may exclude certain foods in attempt to self-manage their IBS symptoms. Dietitians need to help IBS patients identify dietary factors contributing to their symptoms and give clear dietary guidance so IBS patients are able to achieve a well balanced diet while excluding the identified foods.
8 References


35. Skoog SM, Bharucha AE, Zinsmeister AR. Comparison of breath testing with fructose and high fructose corn syrups in health and IBS. Neurogastroenterol Motil. 2008;20:505–11.


<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Participants</th>
<th>Study design</th>
<th>Main Outcome Measures</th>
<th>Relevant Results/Conclusions</th>
</tr>
</thead>
</table>
| Park, Jarrett, and Heitkemper., 2010 (13) | To examine quality of life and dietary constituents in three subgroups of women with IBS based on the severity of their bloating symptoms. | n = 187, of which, n = 25 B-minimal, n = 117 B-mild, and n = 45 B-moderate. | A secondary analysis of two studies. Women with IBS were categorized in 3-groups: Bloating-minimal, Bloating-mild, and Bloating-moderate. All participants completed a three-day diet record. | • Comparison of quality of life.  
• Comparison of dietary fibers and sugars. | Women with IBS who had more severe IBS symptoms had a reduced fructose intake compared to those with less-severe symptoms.  
This suggests IBS patients may self-manage their symptoms. |
| Jarrett et al., 1994 (14)       | To describe and compare dietary intakes of women with and without FBD. Secondly, to test the relationship among dietary intake, GI symptoms, and stool characteristics in women with and without FBD. | n = 55, of which, n = 18 met the criteria for having FBD, and n = 35 were the controls. | Case-control. All participants completed a symptom questionnaire and a three-day diet record. | • Comparison of dietary energy, protein, fat, carbohydrate, and fiber.  
• Post-hoc analysis was done for lactose and fructose intake. | No different in fructose intake between women with IBS-like symptoms and women without symptoms was found. |

IBS, Irritable Bowel Syndrome; FBD, Functional Bowel Disorders
Table 10: Effect of fructose intake on IBS symptoms

<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Participants</th>
<th>Study design</th>
<th>Main Outcome Measures</th>
<th>Relevant Results/Conclusions</th>
</tr>
</thead>
</table>
| Goldstein, Braverman, and Stankiewicz, 2000 (17) | To examine the importance of carbohydrate malabsorption in outpatients previously diagnosed with FBD, and to estimate the degree of clinical improvement following dietary restriction of the malabsorbed sugar(s). | n = 239, divided into n = 94 who met Rome criteria for IBS and, n = 145 who did not and were classified as having functional complaints. | Fructose and lactose malabsorption determined by hydrogen breath test after overnight fast and fructose and lactose dose given. One-month diet restriction of fructose, lactose, and sorbitol was instructed by a clinical Dietitian (no details). | • Fructose and lactose malabsorption prevalence in patients with IBS.  
• IBS symptom change after diet restriction. | Excluding fructose, lactose and sorbitol led to 56% of IBS participants experiencing substantial improvement of symptoms (p<0.0010).  
Combined sugar malabsorption is more common than isolated sugar malabsorption in patients with IBS. |
| Shepherd et al., 2008 (41)            | To determine if dietary restriction is the likely mechanism for symptomatic benefit and to define whether the efficacy resided in the restriction of free fructose specifically, or whether it reflected restriction of poorly absorbed short-chain carbohydrates in general. | n = 25 patients with IBS (Rome II criteria), with FM, and experienced symptom improvement after following a low-FODMAP diet. | Double-blinded, RCT, quadruple-arm, crossover, placebo-controlled, re-challenge trial in patients with IBS and FM. Participants were provided a low-FODMAP diet then reintroducing free fructose with an increasing dose three times per day for two weeks. | • IBS symptoms self-reported daily. | The reintroduction of fructose after a low-FODMAP caused symptoms to reoccur in 77% of participants with IBS and FM.  
Dietary restriction of fructose is likely to be responsible for symptomatic improvement. |

FBD, Functional Bowel Disorders; IBS, Irritable Bowel Syndrome; FM, Fructose Malabsorption
### Relevant Results/Conclusions

Patients who were compliant with a fructose-restricted diet showed significant improvement in their bowel symptoms ($p<0.02$). In contrast, patients who were non-compliant experienced little symptom improvement.

### Main Outcome Measures

- **Prevalence of FM.**
- **IBS symptom improvement as reported by validated bowel symptom questionnaire.**

### Study Design

Retrospective analysis. Patients received written and verbal dietary instructions by a dietician regarding a fructose exclusion or restricted diet. After one-year patient's symptoms were compared with those obtained at baseline.

### Participants

**n = 26** patients with suspected IBS (Rome II criteria), and with a positive fructose breath test.

### Aim

To examine: [1] the prevalence of fructose intolerance in patients with suspected IBS and to assess their symptom profiles and (2) the effects of fructose-restricted diet on symptom patterns and lifestyle in patients with IBS and fructose intolerance.

### Reference

Choi et al., 2008 (16)

### Additional Information

FM, Fructose Malabsorption; IBS, Irritable Bowel Syndrome

---

At 6-month and 3-year follow-up 58% of participants complying with the diet reported a 75% or greater symptom improvement.

- **IBS symptom improvement.**
- **Post-intervention diet compliance and symptom severity and quality of health measurements were assessed.**

### Participants

**n = 50**, with dietary fructose intolerance and IBS symptoms.

### Aim

To identify a group of well-defined dietary fructose intolerance patients and explore whether dietary education followed by dietary compliance could control symptoms and improve quality of life.
A positive symptoms response was experienced by 74% of patients, which was significantly greater in adherent (85%) compared to non-adherent (36%) patients ($p<0.01$).

Patients without IBS were more likely to have improved symptoms on follow up compared to IBS patients. However, no dietary modification advice was given at baseline.
Table 11: Lactose intake in IBS patients and controls

<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Participants</th>
<th>Study design</th>
<th>Main Outcome Measures</th>
<th>Relevant Results/Conclusions</th>
</tr>
</thead>
</table>
| Ostgaard et al., 2012 (9) | To investigate the diet and quality of life of IBS patients in comparison to the background population. Secondly, to study the effects of guidance on diet management, in regards to changes in food intake, quality of life and symptoms. | n = 114, of which n = 35 controls, n = 36 unguided IBS patients, and n = 43 guided IBS patients. | Guided IBS patients had received advice on dietary management two years earlier. All participants completed the MoBa FFQ to assess dietary intake of energy, water, macronutrients and micronutrients including calcium. | • Comparison of dietary energy, water, and nutrients.  
• Comparison of intake of food groups. | There were no differences in the intake of calories, carbohydrates, proteins, fat or sugar between the groups. Unguided IBS patients consumed significantly less milk and milk products than controls and significantly less calcium compared to guided IBS patients (0.03) and controls (0.02). |
| Jarrett et al., 1994 (14) | To describe and compare dietary intakes of women with and without FBD. Secondly, to test the relationship among dietary intake, GI symptoms, and stool characteristics in women with and without FBD. | n = 55, of which, n = 18 met the criteria for having FBD, and n = 35 were the controls. | Case-control. All participants completed a symptom questionnaire and a three-day diet record. | • Comparison of dietary energy, protein, fat, carbohydrate, and fiber.  
• Post-hoc analysis was done for lactose and fructose intake. | Women with FBD consumed significantly less lactose compared to women without symptoms (P = 0.03).  
There were no significant group differences in total calories, protein, fat, carbohydrate, or fiber. |

IBS, Irritable Bowel Syndrome; FFQ, Food Frequency Questionnaire; FBD, Functional Bowel Disorders; GI, Gastro Intestinal
There was no difference in lactose intake between patients with IBS compared to controls, and no difference in lactose intake between IBS patients with or without LM.

**Table 12: Effect of lactose intake on IBS symptoms**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Participants</th>
<th>Study design</th>
<th>Main Outcome Measures</th>
<th>Relevant Results/Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bohmer &amp; Tuynman., 1996 (12)</td>
<td>The prevalence of LM among IBS patients of Caucasian origin, and the effect of dietary disaccharide withdrawal on their symptoms.</td>
<td>n = 70, patients with IBS (Manning criteria).</td>
<td>All patients documented their daily intake over a one-week period.</td>
<td>Comparison of mean daily lactose intake.</td>
<td>There was no difference in lactose intake between patients with IBS compared to controls, and no difference in lactose intake between IBS patients with or without LM.</td>
</tr>
<tr>
<td>Farup, Monsbakken, and Vandvik., 2004 (49)</td>
<td>To compare the prevalence of LM, self-reported abdominal symptoms related to intake of milk, and abdominal symptoms after intake of lactose in persons with IBS with the corresponding prevalence in healthy volunteers.</td>
<td>n = 187, of which n = 82 patients with IBS, and n = 105 controls without IBS.</td>
<td>Case-control study. A medical history focusing on food-related abdominal complaints was taken at inclusion in the study. Patients were given 25 g of lactose then LM was assessed with a breath test, and symptoms were assessed with a questionnaire.</td>
<td>• Prevalence of LM in patients with and without IBS. • Prevalence of symptoms after ingesting milk and then lactose in patients with and without IBS.</td>
<td>Patients with LM experienced greater symptoms after lactose ingestion (P&lt;0.001) compared to those without LM. Patients with IBS had a higher prevalence of symptoms after lactose load than in healthy patients, despite the same prevalence of LM.</td>
</tr>
</tbody>
</table>

LM, Lactose Malabsorption; IBS, Irritable Bowel Syndrome
Relevent Results/Conclusions

Compliance completing a daily diary and following the low-lactose diet was poor. A reduction of IBS symptoms was experienced by 39% of patients to less than 50% of their symptoms at baseline, before the low-lactose diet. There appears to be little advantage of separating patients with LM from others with IBS.

Of the 110 patients who complete the diet, 43% had prolonged remission of symptoms and 41% had partial improvement. Symptoms never completely resided in patients with negative LM or patients with LM who were not compliant with the diet.

IBS, Irritable Bowel Syndrome; LM, Lactose Malabsorption
<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Participants</th>
<th>Study design</th>
<th>Main Outcome Measures</th>
<th>Relevent Results/Conclusions</th>
</tr>
</thead>
</table>
| Bohmer & Tuynman., 1996 (12) | The prevalence of LM among IBS patients of Caucasian origin, and the effect of dietary disaccharide withdrawal on their symptoms. | n = 70, patients with IBS (Manning criteria). n = 53 trialled lactose-restricted diet for 6-weeks. | Double Blinded case-control prospective analysis. All patients were treated with a lactose-restricted diet for 6-weeks. During the first 6-weeks, patient symptoms were scored daily. | • LM prevalence assessed by rise in breath hydrogen >20ppm and measuring blood glucose after 50g lactose load.  
• IBS symptoms.  
• Visits to outpatient clinic. | LM was detected in 24.3% of the IBS patients.  
Dietary lactose restriction significantly decreased symptoms in the LM group at three and 6-weeks (p<0.001). This is in contrast with the non-LM group whose score was unchanged after three and six weeks. |
| Bohmer & Tuynman., 2001 (22) | The effect of a lactose-restricted diet 3-weeks, 6-week, and 5-years after starting the diet, on symptom relief in LM patients earlier diagnosed with IBS. Secondly, the effect of the lactose-restricted diet on the outpatient visits over a 10-year period. | n = 70, patients with IBS (Manning criteria). n = 17 followed lactose-restricted diet for 5-years. | Follow-up of Bohmer & Tuynman., 1996 (12). Patients with LM who followed the lactose-restricted diet were followed up after 5-years. | • IBS symptoms.  
• Visits to outpatient clinic. | After 5-years, 87.5% of the LM still had no complaints while following the lactose-restricted diet.  
Mean patient visits to the outpatient clinic reduced from 2.4 to 0.6 per year (p<0.0001). |

LM, Lactose Malabsorption; IBS, Irritable Bowel Syndrome
9.2 Appendix B: Ethical Approval

14 June 2010

Professor Peter Joyce
Department of Psychological Medicine
Christchurch School of Medicine & Health Sciences
P O Box 4345
Christchurch

Attn: Janet Spittlehouse

Dear Professor Joyce,

URA/10/03/021 Canterbury Health, Ageing and Life Course Study

Investigators Prof P Joyce, Mr C Lacey, A/Prof V Cameron, Prof S Chambers, Dr R Gearry, Dr H Jamieson, Prof M Kennedy

This study was given ethical approval by the Upper South A Regional Ethics Committee on 14 June 2010.

Approved Documents

- Protocol version 2.1 dated 18.05.10
- Information sheet and Consent form version 2.1 dated 12.05.10
- CHALICE Yearly health questionnaire version 1.0 dated 02.06.10

This approval is valid until 31 August 2016, provided that Annual Progress Reports are submitted (see below).

Access to ACC
For the purposes of section 32 of the Accident Compensation Act 2001, the Committee is satisfied that this study is not being conducted principally for the benefit of the manufacturer or distributor of the medicine or item in respect of which the trial is being carried out. Participants injured as a result of treatment received in this trial will therefore be eligible to be considered for compensation in respect of those injuries under the ACC scheme.

Amendments and Protocol Deviations

All significant amendments to this proposal must receive prior approval from the Committee. Significant amendments include (but are not limited to) changes to:

- the researcher responsible for the conduct of the study at a study site
- the addition of an extra study site
- the design or duration of the study
- the method of recruitment
- information sheets and informed consent procedures.

Significant deviations from the approved protocol must be reported to the Committee as soon as possible.

Annual Progress Reports and Final Reports

The first Annual Progress Report for this study is due to the Committee by 30 June 2011. The Annual Report Form that should be used is available at www.ethicscommittees.health.govt.nz. Please note that if you do not provide a progress report by this date, ethical approval may be withdrawn.

A Final Report is also required at the conclusion of the study. The Final Report Form is also available at www.ethicscommittees.health.govt.nz.

Requirements for the Reporting of Serious Adverse Events (SAEs)
For the purposes of the individual reporting of SAEs occurring in this study, the Committee is satisfied that the study’s monitoring arrangements are appropriate.

SAEs occurring in this study must be individually reported to the Committee within 7-15 days only where they:

• are *unexpected* because they are not outlined in the investigator’s brochure, and
• are not defined study end-points (e.g. death or hospitalisation), and
• occur in patients located in New Zealand, and
• if the study involves blinding, result in a decision to break the study code.

There is no requirement for the individual reporting to ethics committees of SAEs that do not meet all of these criteria. However, if your study is overseen by a data monitoring committee, copies of its letters of recommendation to the Principal Investigator should be forwarded to the Committee as soon as possible.

Please see www.ethicscommittees.health.govt.nz for more information on the reporting of SAEs, and to download the SAE Report Form.

We wish you all the best with your study.

Yours sincerely

Alieke Dierckx

Administrator
Upper South A Regional Ethics Committee
Email: alieke_dierckx@moh.govt.nz
Module 2 Questionnaire
Personal Health History

Date of Assessment | Participant Study Number
Interviewer’s Name | Interviewer’s Number

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1. DEMOGRAPHICS

First, I am going to ask you some general questions about you and your household. Then we will go on to talk about your health.

1.01 You are male/female…? [Circle one]
   1 Male
   2 Female

Date of birth

1.02 Firstly, what is your date of birth? [Record]
   Enter eight digit date (e.g. 4 March 1946 = 04031946).

   ____/_____/___________
   .R Refused

Ethnicity

   [Showcard 1.03a]

   1.03a Which ethnic group or groups do you belong to? Call the number or numbers of the ones that apply to you from Card 1.03a. [record all mentioned]

   1 New Zealand European
   2 Māori
   3 Samoan
   4 Cook Island Māori
   5 Tongan
   6 Niuean
   7 Chinese
   8 Indian
   9 Other, such as Dutch, Japanese, Tokelauan
   .K Don’t know

   GO TO THE QUESTIONNAIRE FOR MAORI PARTICIPANTS

   GO TO 1.03b

   1.03b What other ethnicity or ethnicities do you belong to? [Record]

   ___________________________________________________

   .K Don’t remember

   GO TO 1.05a

1.04a Are you descended from Māori? That is did you have a Māori ancestor? [Circle one]

   1 Yes
   5 No
   .K Don’t remember
   .R Refused

   GO TO 1.05a

1.04b What are your iwi affiliations? [Record all]

   ___________________________________________________

   .K Don’t remember

   .R Refused
1.05a **Which country were you born in?** [Circle one]

1. New Zealand
2. Australia
3. England
4. Scotland
5. China (People’s Republic of)
6. South Africa
7. Samoa
8. Cook Islands
9. Other [specify the present name of the country] __________________________

.K Don’t know .R Refused

1.05b **In what year did you arrive to live in New Zealand?** [Record 4 digit year]

_________________

.K Don’t remember .R Refused

1.06 **How long have you lived in Canterbury?** [Record years and months]

Years ____________ Months ____________

.K Don’t remember .R Refused

**Marital/Relationship Status**

[Showcard 1.07a]

1.07a **Looking at Card 1.07a, which one of these statements is true about your CURRENT relationship status?**

1. I am married (or living together for 1 year or more)
2. Separated
3. Divorced
4. Widowed
5. Never married

.K Don’t know .R Refused

1.07b **Are you currently in a relationship? How long (in years) have you been in your current relationship?**

__________

1.08 **How long (in years) is/was the longest intimate relationship you’ve had in your life?**

__________

**Sexuality**

[Showcard 1.09]

1.09 **Looking at Card 1.09, which of the following best describes yourself?**

1. Heterosexual ("straight")
2. Gay
3. Lesbian
4. Bisexual
5. Transsexual
6. Can’t choose

.K Don’t know .R Refused
Education

1.10 What is your highest qualification? Please do not count incomplete qualifications or qualifications that take less than 3 months of full-time study to get. Please tell us your highest qualification, shown on Card 1.10. [Record one]

1. No qualification
2. Secondary school qualifications
3. Post secondary certificate, diploma, or trade diploma
4. University degree
5. Other [specify] __________________________________________

.K Don’t know
.R Refused

Income support and employment

1.11 Looking at Card 1.11, are you currently receiving any of these types of income support? [Circle yes or no and, if yes, circle all mentioned]

1. Yes
5. No
.K Don’t know/unsure
.R Refused

1. NZ Superannuation
2. Working for Families (Family Support, In Work Payment, Family Tax Credit)
3. Unemployment benefit
4. Domestic purposes benefit
5. Sickness benefit
6. Invalid’s benefit
7. Student allowance
8. Disability allowance
9. ACC (as income support, not reimbursement for health services)
10. Other government benefits (independent youth benefit, war pension, etc)

.K Don’t know
.R Refused

1.12 In the past 12 months, have you been out of paid work at any time for more than one month? Please do not include time out of paid work which was from your own choice, such as being a homemaker, caregiver, or full-time student.

1. Yes
5. No
.K Don’t know/unsure
.R Refused

1.13 What is your trained trade or profession? [Record]

[Showcard 1.14a]

1.14a Which of the statements on Card 1.14a best describes your current work situation. Please also say if you are self employed. [Circle one]

Self employed are to be coded as 1 (working in paid employment). Please also tick the box “self employed”.

Working in paid employment (1) includes students (full time or part time) if they have any paid employment.
1. Working in paid employment. [Tick if self employed □ ]

2. Not in paid work, and looking for a job
3. Not in paid work, and not looking for a job (for any reason, such as being retired, a homemaker, caregiver, or full-time student).

Specify _____________________________

4. Other Specify ___________________________________________________________________

.K Don’t know .R Refused

1.14b How many hours a week do you usually work? [Record hours]

_______________________________________

.K Don’t know .R Refused

1.14c What is your current occupation? (What is your job called? What kind of work do you do?) [Record]

_______________________________________

1.15 Looking at Card 1.15, in the last 4 weeks, which of these have you done, without pay? [Circle yes or no and, if yes, circle all mentioned]

1. Yes
5. No

.K Don’t know/unsure .R Refused

1. Household work, cooking, repairs, gardening, etc, for my own household
2. Looked after a child who is a member of my household
3. Looked after a member of my household who is ill or has a disability
4. Looked after a child (who does NOT live in my household)
5. Helped someone who is ill or has a disability (who does NOT live in my household)
6. Other voluntary work for or through any organisation, group or marae
7. Studied for 20 hours or more per week at school or any other place
8. Studied for less than 20 hours per week at school or any other place

.K Don’t know .R Refused

Income

1.16 Looking at Card 1.16, what is the total income that you yourself got from all sources, before tax or anything was taken out of it, in the last 12 months? [Record one]

1. Less than $5,000
2. $5,001 - $10,000
3. $10,001 - $15,000
4. $15,001 - $20,000
5. $20,001 - $25,000
6. $25,001 - $30,000
7. $30,001 - $40,000
8. $40,001 - $50,000
9. $50,001 - $60,000
10. $60,001 - $70,000
11. $70,001 - $80,000
12 $80,001 - $100,000
13 $100,001 - $120,000
14 $120,001 - $150,000
15 $150,001 or more
.K Don’t know .R Refused

Household income

[Showcard 1.16]

1.17 Still looking at Card 1.16, what is the total income that your household got from all sources, before tax or anything was taken out of it, in the last 12 months? [Record one]
1 Less than $5,000
2 $5,001 - $10,000
3 $10,001 - $15,000
4 $15,001 - $20,000
5 $20,001 - $25,000
6 $25,001 - $30,000
7 $30,001 - $40,000
8 $40,001 - $50,000
9 $50,001 - $60,000
10 $60,001 - $70,000
11 $70,001 - $80,000
12 $80,001 - $100,000
13 $100,001 - $120,000
14 $120,001 - $150,000
15 $150,001 or more
.K Don’t know .R Refused

ELSI (Economic Living Standard Index)

[Showcard 1.18]

1.18 I’m now going to ask you some questions about things you may or may not have access to in your household. Looking at card 1.18 for the answer, do you have…….

If respondent asks: “Does this include a cellphone?”: Access to a telephone in the household is the key concept, for example, if there is a cellphone and no landline then ‘Yes’, but only if cellphone is in the house whenever the respondent is home and they can make a phone call on it.

<table>
<thead>
<tr>
<th></th>
<th>1 Yes</th>
<th>2 No (don't want it)</th>
<th>3 No (due to the cost)</th>
<th>4 No (other reason)</th>
<th>Refused (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Telephone (see note above)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Washing machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Heating available in all main rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) A good pair of shoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) A best outfit for special occasions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Personal computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Home contents insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Enough room for family to stay the night</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
[Showcard 1.18]
1.19 Still looking at Card 1.18 for the answer, do you do the following activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Refused (R) Don’t know (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Give presents to family and friends on birthdays</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Visit the hairdresser at least once every 3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Have holidays away from home every year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Have a holiday overseas at least once every 3 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Have a night out at least once a fortnight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Have family or friends over for a meal at least once a month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Showcard 1.20]
1.20 Now I’m going to ask you about some things some people do to help keep costs down. Looking at Card 1.20, in the last 12 months, have you done any of these things not at all, a little, or a lot?

<table>
<thead>
<tr>
<th>Activity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Refused (R) Don’t know (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Gone without fresh fruit and vegetables to keep costs down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Continued wearing clothing that was worn out because you couldn’t afford a replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Put off buying clothes for as long as possible to help keep down costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Stayed in bed longer to save on heating costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Postponed or put off visits to the doctor to help keep down costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) NOT picked up a prescription to help keep down costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Spent less on hobbies than you would like to help keep down costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Gone without or cut back on trips to the shops or other local places to help keep down costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The next questions are about your material standard of living – the things that money can buy. Your material standard of living does NOT include your capacity to enjoy life. You should NOT take your health into account for these questions.
[Showcard 1.21]
1.21 Looking at Card 1.21, generally, how would you rate your material standard of living? Would you say that it is high, fairly high, medium, fairly low or low? [Circle one]

1 High
2 Fairly high
3 Medium
4 Fairly low
5 Low
.K Don't know .R Refused

[Showcard 1.22]
1.22 Looking at Card 1.22, generally, how satisfied are you with your material standard of living? Would you say you were very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied or very dissatisfied? [Circle one]

1 Very satisfied
2 Satisfied
3 Neither satisfied nor dissatisfied
4 Dissatisfied
5 Very dissatisfied
.K Don’t know
.R Refused

[Showcard 1.23]
1.23 Looking at Card 1.23, how well does your (and your partner’s combined) total income meet your everyday needs for such things as accommodation, food, clothing and other necessities? Would you say you have not enough money, just enough money, enough money, or more than enough money? [Circle one]

By total income we mean all the money respondent has access to for everyday necessities

1 Not enough
2 Just enough
3 Enough
4 More than enough
.K Don’t know
.R Refused

Home Ownership
[Showcard 1.24]
1.24 Who owns your home? [Circle one]

1 You own or partly own your house or flat (with or without a mortgage)
2 Family members
3 A family trust
4 A private landlord
5 A local authority or city council
6 Housing New Zealand
7 Other [specify] __________________________
.K Don’t know .R Refused

Medical Insurance
1.25 Are you covered by any health or medical insurance scheme? [Circle one]

1 Yes
5 No
.K Don’t know .R Refused
9.4 Appendix D: Module 7 – Food and Beverage Diary

CHALICE

Food and beverage diary

If you have any questions about this diary please contact the CHALICE team.
Part 2: How you eat and what you eat

1. How often do you usually have breakfast (more than a glass of milk or fruit juice)? (Please mark one box).
   a. I never have breakfast
   b. 1 to 3 days a week
   c. 4 to 6 days a week
   d. Every day

2. How often do you usually have lunch (more than a drink or snack)? (Please mark one box).
   a. I never have lunch
   b. 1 to 3 days a week
   c. 4 to 6 days a week
   d. Every day

3. For your main meal in the evening how often do you usually eat (Please mark one box on each line).
   a. At a restaurant/cafe
   b. Takeaway food
   c. Ready meals from a deli or supermarket (fresh or frozen)
   d. Food that is prepared and cooked at home

4. When you drink between meals what do you usually drink? (Please mark all boxes that apply).
   a. Sweetened drinks (e.g. cola, fruit juice, fruit drinks, cordials)
   b. Sugar free drinks (e.g. diet cola, sugar free cordials and fruit drinks)
   c. Milky drinks (e.g. milk shake, hot chocolate, milo, ovaltine, flavoured milk)
   d. Water (tap, bottled, still or sparkling)
   e. Tea or coffee
5. What type of milk do you usually have either as a drink or on cereal? (mark the one you have most often)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>I do not drink/use milk</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Full cream or farmhouse</td>
<td>2</td>
</tr>
<tr>
<td>c</td>
<td>Standard or homogenised</td>
<td>3</td>
</tr>
<tr>
<td>d</td>
<td>Semi-trim (light blue top)</td>
<td>4</td>
</tr>
<tr>
<td>e</td>
<td>Trim (green top)</td>
<td>5</td>
</tr>
<tr>
<td>f</td>
<td>Soya milk</td>
<td>6</td>
</tr>
<tr>
<td>g</td>
<td>Light soya milk</td>
<td>7</td>
</tr>
</tbody>
</table>

Other milk (please specify e.g. Rice milk, Almune, Calotrim, Junior)

6. What type of bread do you usually eat? (Please mark all boxes that apply)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>I do not eat bread</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>High fibre white bread</td>
<td>2</td>
</tr>
<tr>
<td>c</td>
<td>White bread</td>
<td>3</td>
</tr>
<tr>
<td>d</td>
<td>Brown/wholegrain</td>
<td>4</td>
</tr>
</tbody>
</table>

Other, please describe (e.g. rye, soda, gluten free) and give brand name (e.g. Vogel, Nature's Fresh Quality Bakers, Country Spilt, Freyas, Molenburg)

7. What brand of fat spread, butter or margarine do you use the most of? (Describe the type you use most often, name the brand and whether it is low fat or not. e.g. Flora canola, Mainland butter, Olivam)

8. Do you ever take any vitamin, mineral or food supplements?

Yes: [ ]

No: [ ]
Step 4: Food and drink
The next step in the food diary is to describe what you ate or drank. The more details you are able to give about the food and drink you have consumed, the better we will be able to estimate your nutrient intake. Include any extras like sugar and milk in your tea or cereal, butter or other spreads on your bread and sauces such as tomato sauce and mayonnaise. Do not forget to include drinking water.

Step 5: Brand and details
It would also help us if you can write down the brand name of any foods or drinks if you know it (e.g. Watties, Pams, Arnotts). If convenient, staple the wrapper to the back page of this book.
For breakfast cereals, as well as the brand name, please write down the name of the cereal (e.g. Coco Pops, Cornflakes, Sanitarium toasted museli: golden oats and fruit).
For sandwiches, please describe the type of bread used, how many slices of bread were used and give details of the filling.
For salad or mixed vegetables, please describe what is in it (e.g. 1 lettuce leaf, half a tomato, 8 slices of cucumber).
For pizza, please describe the topping (e.g. cheese and tomato, ham and pineapple).

Step 6: Preparation and cooking
If you know the cooking method used (e.g. roast, baked, boiled, fried) please write it down in this section.

Step 7: Quantity
In the next column, please write in the size of the portion of food or drink you had. For drinks, you can specify glass, cup, or mug or bottle/can size. Other descriptions include: packet (e.g. for crisps), number (e.g. for biscuits), slice (e.g. for cake, pizza), teaspoon (e.g. for sugar), tablespoon (e.g. for tomato sauce, peas), cupful (e.g. for cooked pasta or rice), handful (e.g. for nuts, grapes, berries), package weights (e.g. 150g Fresh and Fruity yoghurt). On the next page you will find some more information on how to describe the food and drink that you consume.

If you have kitchen scales it is helpful to weigh foods and record these amounts.
For **mixed food dishes and recipes** it may be easier to list the total ingredients, then describe the proportion of this recipe that you consumed.  

*e.g. 1/3 of recipe 1*

**Recipe example**  Creamy tuna pasta (recipe 1)

- 250g Diamond spiral pasta
- ½ cup Oxo chicken stock, pre-mixed with water
- ¼ cup Chopped parsley
- 2 cups Sliced button mushrooms
- 220g John West tuna canned in oil, liquid drained
- 1 cup Camation evaporated skim milk
- 1 tablespoon Parmesan cheese, dried
- ½ teaspoon Freshly ground black pepper

I had one third of this recipe.

If you make your food from separate ingredients then you can write the recipes down in the recipe list at the back of this diary.

Please write down all the ingredients for each recipe (including brand names, amounts and preparation or cooking details). Indicate the proportion of the recipe you consumed.

Don’t forget about any drinks that you have between meals e.g. tea, coffee, wine, beer, orange juice.
How to describe your food and drink using household measures

Below are some suggestions on how to describe certain food and drink items together with their household measures.

<table>
<thead>
<tr>
<th>Food</th>
<th>Description of food or drink and brand</th>
<th>Household measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacon</td>
<td>Shoulder or streaky; fried or grilled rashers, smoked or unsmoked</td>
<td>Number</td>
</tr>
<tr>
<td>Bread</td>
<td>Type of bread, eg. white, brown, wholemeal, granary, French stick, ciabatta, currant. Description of slice e.g. sandwich, toast</td>
<td>Number of slices</td>
</tr>
<tr>
<td>Canned drinks</td>
<td>Type, brand name. For example: 335ml can Diet Coca Cola</td>
<td>Number or full or half can</td>
</tr>
<tr>
<td>Crisps</td>
<td>Type, brand name e.g. 30g Rashuns</td>
<td>Packet weight</td>
</tr>
<tr>
<td>Fruit</td>
<td>Type and size of fruit e.g. large Granny Smith apple For tinned fruit; slices/ halves etc. in juice or syrup</td>
<td>Number of pieces or tablespoons</td>
</tr>
<tr>
<td>Jams</td>
<td>Type, brand name e.g. Pam’s strawberry jam</td>
<td>Teaspoons, heaped or flat</td>
</tr>
<tr>
<td>Milk</td>
<td>Type; full cream, trim, semi-trim</td>
<td>Pints, glasses or cups</td>
</tr>
<tr>
<td>Oil</td>
<td>Type e.g. canola oil, sunflower oil, corn oil, olive oil. Brand name e.g. Pam’s olive oil</td>
<td>Tablespoons</td>
</tr>
<tr>
<td>Prepacked foods e.g. beefburgers, pies, biscuits, confectionery</td>
<td>Full name of product including brand name. For example: Bird’s Eye fish fingers. Keep the package.</td>
<td>Number</td>
</tr>
<tr>
<td>Sandwiches</td>
<td>Describe fully if homemade or if bought; Full name, place of purchase and price, describe bread as above and note loaf size.</td>
<td>Number of slices of bread or number of rolls</td>
</tr>
<tr>
<td>Spreads on bread or toast</td>
<td>Type e.g. butter, low fat spread, rice bran oil spread, canola spread, reduced fat canola spread, Weightwatchers spread. Full description, and brand name Keep the package</td>
<td>Number of teaspoons or thinly, average or thickly spread</td>
</tr>
<tr>
<td>Sugar</td>
<td>Type e.g. caster, rich brown, white</td>
<td>Teaspoons, heaped or flat</td>
</tr>
<tr>
<td>Sweets, chocolate and snack bars</td>
<td>Name, size (weight) and price (if known) For example: king size Mars bar 99c Keep the wrapper</td>
<td>Weight of bar or number of sweets</td>
</tr>
<tr>
<td>Takeaways</td>
<td>Describe in full, give name of restaurant</td>
<td>Portion size</td>
</tr>
</tbody>
</table>
For example: One scoop chips, The High Street chip shop. Standard chicken chow mein, Kwang Chow

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Type: fresh, frozen, tinned or dried</th>
<th>Brand name</th>
<th>Tablespoons, full or heaped</th>
</tr>
</thead>
</table>

Adapted from NUGENOB study (www.nugenob.com)
### Sample record sheet

Please record all food and drink consumed during the whole day, including snacks and water.

Remember to report any additions to each food and drink, such as milk, sugar, salt, sauce or spreads.

<table>
<thead>
<tr>
<th>When</th>
<th>Where</th>
<th>Who with</th>
<th>Food or Drink</th>
<th>Brand and details</th>
<th>Preparation/Cooking</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 am</td>
<td>In bed</td>
<td>alone</td>
<td>Gourmet muffin</td>
<td>New World – double chocolate</td>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coffee</td>
<td>Nescafe Instant</td>
<td>Hot water added</td>
<td>1 heaped tsp in a mug</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sugar</td>
<td></td>
<td>1 heaped tsp in a mug</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Green tea milk</td>
<td></td>
<td>1/8th of a mug</td>
</tr>
<tr>
<td>10 am</td>
<td>Kitchen</td>
<td>Family</td>
<td>Tea</td>
<td>Twinings Peppermint</td>
<td>Hot water added</td>
<td>1 mug, no milk or sugar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Biscuits</td>
<td>Tim Tam Double Chocolate</td>
<td>None</td>
<td>2</td>
</tr>
<tr>
<td>12pm</td>
<td></td>
<td></td>
<td>Creamy tuna pasta</td>
<td>Homemade recipe 1</td>
<td>Pasta boiled in water</td>
<td>1/3 recipe</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>French bread stick</td>
<td>Bought – New World</td>
<td></td>
<td>6cm long</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Margarine</td>
<td>Pams–Canola low salt</td>
<td></td>
<td>1 level tsp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chicken breast</td>
<td>Skin and bone removed</td>
<td>Fried in olive oil</td>
<td>1 medium chicken breast</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Olive oil</td>
<td>Luppi</td>
<td>fried</td>
<td>3/4 tsp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>cherry tomatoes</td>
<td>raw</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Orange juice</td>
<td>McCoy, unsweetened</td>
<td></td>
<td>200ml</td>
</tr>
<tr>
<td>5.30pm</td>
<td>McDonalds</td>
<td>Son</td>
<td>Burger</td>
<td>McDonalds Big Mac (no pickles)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fries</td>
<td></td>
<td>Large</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Diet Coke</td>
<td></td>
<td>Large</td>
<td></td>
</tr>
<tr>
<td>6.30pm</td>
<td>Home</td>
<td>Friends</td>
<td>Beer</td>
<td>Monteiths Radler</td>
<td></td>
<td>2 bottles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Toast</td>
<td>Vogels Rice and Rye</td>
<td>Toasted</td>
<td>2 slices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Margarine</td>
<td>Pams–Canola low salt</td>
<td></td>
<td>1 level tsp</td>
</tr>
</tbody>
</table>
Please record brand names e.g. McCoy
Please use household measures to describe amounts of food such as margarine, butter and milk e.g. teaspoons (tsp), tablespoons (tbsp), cups

Day ...  

<table>
<thead>
<tr>
<th>When</th>
<th>Where</th>
<th>Who with</th>
<th>Food or Drink</th>
<th>Brand and details</th>
<th>Preparation/Cooking</th>
<th>Quantity</th>
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<td>When</td>
<td>Where</td>
<td>Who with</td>
<td>Food or Drink</td>
<td>Brand and details</td>
<td>Preparation/ Cooking</td>
<td>Quantity</td>
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</tbody>
</table>
Recipes

Please write down the ingredients of your recipes in this section.

<table>
<thead>
<tr>
<th>Recipe Number</th>
<th>Food or Drink</th>
<th>Brand and Details</th>
<th>Quantity</th>
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<tbody>
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</table>

Are there any special reasons why this week may differ from ‘normal’ in terms of household food (for example a child’s birthday party or other family celebration)?
Please circle either Yes or No:

No

Yes (please state reason)

__________________________________________

__________________________________________

Please check that you have answered all the questions in part 1, 2 and 3 and please make sure that you have filled in your diary for all four days.

Don’t forget to include any:

• Drinks e.g. tea, coffee, wine, beer, orange juice, soft drinks, water

• Snacks between meals e.g. biscuits, crisps, peanuts, slices, muffins

• Lollies or sweets

THANK YOU!
This diary contains three parts:

1. *Home Food Inventory*

2. *How you eat and what you eat*

3. *Food Diary*

Please make sure that you fill in all three parts and return the completed diary in the envelope provided.

Thank you!
# Appendix E: Birmingham IBS Symptom Questionnaire

**IBS (Irritable Bowel Syndrome)**

The following questions ask you about your abdominal and bowel symptoms. When we use the word abdomen we mean belly/tummy. Some of the questions ask about passing a stool. By this we mean going to the toilet for a reason other than to urinate (pass water).

All of these questions refer to the last 4 weeks. Please tick one box for each statement.

Please enter the date that you are completing this questionnaire: ____/____/___

<table>
<thead>
<tr>
<th>Date of Assessment</th>
<th>Participant Study Number</th>
<th>Interviewer’s Name</th>
<th>Interviewer’s Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(a) You had discomfort or pain in your abdomen?</th>
<th>1 All of the time</th>
<th>2 Most of the time</th>
<th>3 A good bit of the time</th>
<th>4 Some of the time</th>
<th>5 A little of the time</th>
<th>6 None of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) You been troubled with loose, mushy or watery bowel motions?</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(c) You been troubled with diarrhoea?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) You been troubled by hard bowel motions?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) You felt the need to strain to pass a motion (stool)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) You been troubled by constipation?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) You experience pain or discomfort in your abdomen after eating?</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(h) Abdominal pain prevented you from sleeping, or woken you during the night?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) You leaked or soiled yourself?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) You suffered from a feeling of urgency (feeling that you must immediately rush to the toilet to pass a stool)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(k) You passed mucus or slime in your stools?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.6 Appendix F: Participant Categorisation

Table 13: Participant categorisation in to ELSI$_{SF}$ and IBS symptom score variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Sub-category</th>
<th>Score Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELSI$_{SF}$</td>
<td>Good and Very good</td>
<td>High</td>
<td>25 - 31</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>Hardship and Comfortable</td>
<td>Low</td>
<td>0 - 24</td>
<td>83</td>
</tr>
<tr>
<td>IBS</td>
<td>IBS Symptoms</td>
<td>High</td>
<td>≥ 1</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>No Symptoms</td>
<td>Low</td>
<td>0</td>
<td>55</td>
</tr>
</tbody>
</table>
Appendix G: Test for fructose and lactose intake normality

Figure 9.1:
Distribution of mean daily fructose and lactose intake