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The low FODMAP diet in clinical practice: where are we and what are the long-term considerations?

Miranda C. E. Lomer[1,2]

[1]*Department of Nutrition and Dietetics, Guy's and St Thomas' NHS Foundation Trust, Westminster Bridge Road, London SE1 7EH, UK*

[2]*Department of Nutritional Sciences, King's College London, Stamford Street, London, UK*

A diet low in fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP) improves functional bowel symptoms and is a second-line dietary management strategy for the treatment of irritable bowel syndrome (IBS). The diet is complex and involves three stages: restriction, reintroduction and personalisation and clinical effectiveness is achieved with dietitian-led education; however, this is not always available. The aim of this review is to provide an update on the evidence for using the low FODMAP diet, with a focus on the impact of FODMAP restriction and reintroduction considering long-term management of IBS in a clinical setting. Randomised controlled trials have assessed symptom response, quality of life, dietary intake and changes to the gut microbiota during FODMAP restriction. Systematic reviews and meta-analyses consistently report that FODMAP restriction has a better symptom response compared with control diets and a network analysis reports the low FODMAP diet is superior to other dietary treatments for IBS. Research focused on FODMAP reintroduction and personalisation is limited and of lower quality, however common dietary triggers include wheat, onion, garlic, pulses and milk. Dietitian-led delivery of the low FODMAP diet is not always available and alternative education delivery methods, e.g. webinars, apps and leaflets, are available but remove the personalised approach and may be less acceptable to patients and may introduce safety concerns in terms of nutritional adequacy. Predicting response to the low FODMAP diet using symptom severity or a biomarker is of great interest. More evidence on less restrictive approaches and non-dietitian-led education delivery methods are needed.

Low FODMAP diet: Irritable bowel syndrome: Diet: Clinical practice

Irritable bowel syndrome (IBS) is a disorder of the gut–brain interaction[1] more commonly known as a functional bowel disorder and is characterised by recurrent abdominal pain associated with a change in bowel habits[2]. Disordered bowel habits include diarrhoea and/or constipation and are often associated with other symptoms such as abdominal bloating, flatulence and borborygmi[2]. Subtypes include diarrhoea-predominant IBS with loose stools at least 25 % of the time, constipation-predominant IBS with hard/lumpy stools

Abbreviations: BDA, British Dietetic Association; FODMAP, fermentable oligosaccharides, disaccharides, monosaccharides and polyols; IBS, irritable bowel syndrome; NICE, National Institute for Health and Care Excellence; QoL, quality of life.

Corresponding author: Miranda C. E. Lomer, Email miranda.lomer@kcl.ac.uk

at least 25 % of the time, mixed type IBS where both loose and hard/lumpy stools occur at least 25 % of the time for each and unclassified IBS where both loose and hard/lumpy stools occur less than 25 % of the time[2].

The aetiopathogenesis of IBS is complex involving psychological and biological factors which include changes in visceral sensitivity, gut motility, stress, the gut-brain axis, immune activation, gut microbiota and having a genetic predisposition[1].

IBS is extremely debilitating and negatively impacts health-related quality of life (QoL) with individual quotes such as '*I can't leave the house in fear of not finding a toilet*' and '*I avoid eating when I go out to prevent needing to run to the loo*'. It occurs in 4–12 % of the population depending on diagnostic criteria and country, more often in people under 50 years of age and approximately 70 % of people affected are women[3]. A positive diagnosis for IBS is made using a targeted approach with detailed medical history of symptoms, examination and some simple blood (e.g. full blood count, coeliac antibodies, inflammatory markers) and stool tests (e.g. faecal calprotectin) to rule out organic causes of symptoms[4,5]. Direct UK costs are £90–£316/patient/year, while annual projections are £45·6–£200 million[6]. Ideally, IBS should be managed in primary care, however it accounts for up to 50 % of secondary care referrals to gastroenterology[6,7].

Management takes a holistic approach and considers pharmacology, diet and lifestyle and psychological strategies[4,5,8]. First-line British Dietetic Association (BDA) and National Institute for Health and Care Excellence (NICE)[4] dietary advice, known as traditional dietary advice, involves guidance on healthy eating; reducing dietary fat, caffeine and alcohol where they are symptom triggers and ensuring the diet is adequate in dietary fibre while encouraging dietary diversity. In addition, checking for the presence of lactose intolerance and providing information on suitable low lactose alternatives is key. Eating lifestyle and eating patterns should be assessed and if chaotic or erratic, ideas to improve these will be discussed[4,8]. Probiotics may also be considered as there is evidence that they provide some symptom benefit[9]. A diet low in fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP) or the low FODMAP diet is a second-line management strategy and recommended in guidelines from the UK[4,5,8] and internationally[10,11]. The low FODMAP diet is a relatively new treatment option and the first study published in 2008 was a double-blind, randomised, placebo-controlled rechallenge trial of fructans and fructose in patients with IBS who had responded to a low FODMAP diet[12]. The diet is complex and involves three stages: restriction, reintroduction and personalisation and clinical effectiveness is achieved with dietitian-led education; however, this is not always available. The aim of this review is to provide an update on the evidence for using the low FODMAP diet, with a focus on the impact of FODMAP restriction and reintroduction considering long-term management of IBS in a clinical setting.

What are FODMAP and why do they induce gastrointestinal symptoms?

The oligosaccharides include fructans (e.g. wheat, onion, garlic) and galacto-oligosaccharides (e.g. beans and pulses). They are poorly digested in the human gut and are readily fermented by the colonic microbiota[13,14]. The disaccharide is lactose, which is only a FODMAP in individuals with lactose malabsorption. The monosaccharide is fructose in excess of glucose (e.g. honey, mango) and malabsorption is thought to arise from a defect in one or more of the facilitated fructose transport pathways (e.g. GLUT 2 or GLUT 5) in the small intestine[15]. The polyols are sugar alcohols and include sorbitol (e.g. stone fruit) and mannitol (e.g. some mushrooms). Polyol absorption is passive and predominantly occurs in the jejunum and varies hugely between individuals[13,14,16].

MRI has been used to visualise the gastrointestinal tract and demonstrates that FODMAP increase small intestinal water (e.g. free-fructose) and colonic gas (e.g. fructans) in healthy individuals and people with IBS[17,18]. Some FODMAP, e.g. fructans and galacto-oligosaccharides are malabsorbed in everyone, however it is only people with gut hypersensitivity, e.g. people with IBS, who develop gastrointestinal symptoms. The vagus nerve connects the enteric nervous system and the central nervous system, which is often referred to as the gut–brain axis. Recent mechanistic work looking at pain receptors in the brain show that fructans increase signalling in the pain-related areas of the brain supporting the theory that IBS is a dysfunction of the gut–brain axis[19].

Briefly, the low FODMAP diet incorporates three stages: FODMAP restriction which involves restricting foods containing FODMAP for a period of 4–8 weeks; FODMAP reintroduction which details challenging with high FODMAP foods one by one to identify which foods induce symptoms; FODMAP personalisation which involves incorporating high FODMAP foods back into the diet to tolerance while continuing to avoid those foods identified as dietary triggers during FODMAP reintroduction.

FODMAP restriction

FODMAP restriction is where foods high in FODMAP are restricted alongside advice on inclusion of suitable low FODMAP alternative foods to ensure the diet is nutritionally adequate in energy, macro- and micronutrients. It is good practice for patients to be given detailed information on the mechanisms of how FODMAP induce symptoms to enable them to understand the reasons for such a complex dietary protocol. Detailed resources on foods to include and exclude, with recipe ideas, meal plans are all part of the education package[20].

Prior to starting a low FODMAP diet, it is important to carry out a detailed assessment of past medical history, weight history, diet and symptoms to ensure a low

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FODMAP diet is appropriate. Contraindications to the low FODMAP diet include an inability to understand and apply the complexities of the diet, an already overly restricted diet, unexplained weight loss or low BMI, an eating disorder including avoidant restrictive food intake disorder or orthorexia nervosa and constipation-predominant symptoms[20–23]. For any of these contraindications, a modified approach may be required or an alternative treatment plan.

Research suggests that FODMAP restriction achieves symptom control within 2–4 weeks[20,24]; however, in clinical practice reviewing patients before 4 weeks is rarely encountered due to clinical capacity and high demands on dietetic services. Thus, FODMAP restriction is often followed for 4–8 weeks. The clinical effectiveness of the restriction stage of the low FODMAP has been assessed in more than 15 randomised controlled trials. Two recent systematic reviews and meta-analyses and a systematic review and network meta-analysis support the use of the low FODMAP diet[24–26]. Van Lanen *et al.* from the Netherlands included twelve studies in their meta-analysis. All studies compared the low FODMAP diet to a control diet, nine were parallel trials and three were cross-over trials. The meta-analysis reported that FODMAP restriction for between 4 d and 3 months reduced the severity of IBS by a moderate to large extent when compared with a control diet[25]. Furthermore, the authors report improvements in IBS quality of life (IBS-QoL)[27] following FODMAP restriction in six studies when compared with a control diet[25,28]. Wang *et al.* from China included ten studies in their systematic review and meta-analyses also found that FODMAP restriction had greater global improvement of symptoms compared to a control diet in seven studies but for IBS-QoL there was no difference in five studies. They also assessed anxiety and depression using the hospital anxiety and depression scale[29] which was reported in only two studies but there were no differences found between the low FODMAP diet and a control diet[26]. A systematic review and network meta-analysis from the UK and Australia assessed the efficacy of the low FODMAP diet in relation to the efficacy of other dietary treatments[24]. The authors report on a network meta-analysis of thirteen randomised controlled trials, and with a probability of 99 %, they showed that a low FODMAP diet was more efficacious than any other comparator diet, including first-line BDA/NICE guidelines for global IBS symptoms, abdominal pain and bloating[24].

Universal FODMAP restriction should not be a long-term strategy due to negative impacts on nutrient intake and microbial diversity with continuing avoidance of high FODMAP foods[20,30]. Some FODMAP are prebiotics and have a positive effect on the gastrointestinal microbiota, so a reduction in their intake during FODMAP restriction has the potential to negatively impact the gastrointestinal microbiota[31]. A systematic review on the colonic microbiome following FODMAP restriction reports that from nine studies there is a consistent reduction in the abundance of *Bifidobacteria*[31]. There were no other consistent negative impacts on microbial diversity or faecal SCFA.

A reduction in FODMAP intake can potentially impair nutrient intake, e.g. some sources of fructans are fortified with folic acid, B vitamins and iron (wheat starch, bread, breakfast cereals) and sources of lactose provide calcium in a readily bioavailable form (milk and milk products)[32]. Furthermore, many high FODMAP foods provide dietary fibre from a diverse range of fruit, vegetables and grains. Dietitian-led education provides patients with personalised advice on suitable alternatives to high FODMAP foods during FODMAP restriction and research indicates that macronutrient and dietary fibre intakes are largely unaffected[33]. However, FODMAP restriction does reduce diet quality and many nutrients do not meet dietary recommendations[33]. Thus, to ensure the low FODMAP diet is safe as well as effective, FODMAP reintroduction to tolerance and personalisation of the diet is key to management.

FODMAP reintroduction and personalisation

Most of the research on the clinical effectiveness of the low FODMAP diet has been carried out during FODMAP restriction; however, FODMAP reintroduction and FODMAP personalisation are important stages of the diet. FODMAP reintroduction is where dietary triggers can be identified using high FODMAP food challenges. FODMAP personalisation is where the diet becomes more personalised for long-term application to encourage dietary diversity to meet nutrient recommendations and restore any negative impacts to the gut microbiome resulting from FODMAP restriction. Having a better understanding of dietary triggers enables patients to take control of symptom management, giving them autonomy and an increased feeling of self-management in clinical decision making for the long term.

FODMAP reintroduction uses high FODMAP food challenges with increasing amounts of a specific food over a 3 d period[20]. In clinical practice, usually one food from each FODMAP group is challenged with to test for tolerance to that FODMAP, e.g. for lactose, milk may be used for the food challenge with day 1 containing approximately 4 g lactose (i.e. 125 ml), and amounts on day 2 and day 3 being double (250 ml) and triple (375 ml) the amount for day 1, respectively. An exclusion to this rule is for advice on fructans, and challenging with several foods is suggested (e.g. wheat, rye, onion, garlic) due to their differing degrees of polymerisation which leads to differences in colonic bacterial fermentation and gas production[34]. Different protocols for FODMAP reintroduction are available in different countries with constant amounts of challenge foods across the 3 challenge days[30] or 4 d to challenge[35] and differing durations for washout in between challenges depending on whether symptoms occur during the challenge[20,30,35,36]. Several studies have used double-blinded powdered FODMAP challenges to identify which FODMAP are symptom triggers[12,37,38]; however, the food matrix and combining FODMAP-containing

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foods in meals may be important in determining tolerance thresholds in the clinical setting.

Where education on FODMAP restriction, reintroduction and personalisation is provided, long-term symptom response has been observed in 57–67 % of patients[39,40] and up to 83 % reported >50-point reduction in IBS symptom severity scale[35,41]. In addition, other studies assessing symptoms for FODMAP restriction and reintroduction according to local protocol show symptom reduction between 55 and 89 %[42–44] lower symptom scores, e.g. using the gastrointestinal symptom rating scale[45] or symptom response[45–51] (Table 1). Improvements in QoL using short form 36 health survey questionnaire[52] or IBS-QoL[27] have also been reported[40,47,49]. Furthermore, nutritional adequacy of the diet and FODMAP intake returns to levels observed in baseline habitual diets and food-related QoL improves compared with baseline[35,40]. In addition, diet acceptability, food-related QoL, healthcare utilisation and work absenteeism do not negatively impact patients after FODMAP personalisation compared with patients who returned to a habitual diet[39].

In the long term, the negative impact on luminal *Bifidobacteria* levels seen after FODMAP restriction[31] are restored following FODMAP personalisation[40] supporting the importance of the reintroduction and personalisation stages of the low FODMAP diet.

There are a small number of studies that have researched which foods are identified as dietary triggers during FODMAP reintroduction. A prospective study 6–18 months after low FODMAP education showed that IBS patients who had followed the three-stage low FODMAP diet protocol had lower intakes of onion, garlic and wheat pasta and higher intakes of gluten-free bread, lactose-free/plant-based alternatives to milk and milk products and low FODMAP vegetables when compared with IBS patients who had reportedly returned to their habitual diet after FODMAP restriction[39]. Another study reports on limited concordance between perceived dietary triggers before and after the low FODMAP diet[35]. The authors report that lactose is the only FODMAP with moderate agreement suggesting that it is important to carry out FODMAP challenges to confirm which foods really are dietary triggers. In a very small study of eight patients with IBS who completed FODMAP reintroduction, common foods identified as triggers were wheat and rye bread, pasta, sweetheart cabbage, onion, garlic, leek, broccoli, green peas, cauliflower, kidney beans, chickpeas, sweet potatoes, avocado, mushrooms, apples and apple juice[48]. Dietary triggers have also been reported for 2053 users of a low FODMAP diet mobile application with the top dietary triggers and foods challenged being wheat bread, onion, garlic, milk and wheat pasta. For any given food challenge, less than half of users reported the food as a dietary trigger[53]. This is an important finding and indicates that more than half the time, FODMAP challenges do not induce symptoms. Therefore, foods that are tolerated can be reintroduced back into the diet for long-term self-management reducing safety concerns regarding the negative impact of FODMAP restriction on the gut microbiota and nutritional adequacy.

Application to clinical practice

Patients with IBS referred for dietary advice to manage functional bowel symptoms can be triaged to ascertain their suitability for education on the low FODMAP diet[20]. The triage process includes a detailed clinical, symptom and dietary assessment to ensure that a low FODMAP diet is an appropriate treatment option considering past medical history, current symptom profile and any dietary issues related to eating lifestyle, diet diversity and dietary restrictions. The optimal delivery of low FODMAP education is dietitian-led[54]. First, this enables patients to receive personalised and detailed advice on suitable low FODMAP alternative foods to replace high FODMAP foods during FODMAP restriction which assists with dietary diversity and nutritional adequacy and ensures dietary fibre intake is adequate for optimal stool frequency and consistency. Secondly, patients are provided with structured information on FODMAP reintroduction and personalisation which is rarely considered without the support of a dietitian[43,55]. Thirdly, patients are supported with personalised high-quality information improving their confidence in the material which helps to apply the diet in a real-world situation. However, the success of dietitian-led education for the low FODMAP diet has led to an overwhelming increase in dietetic referrals, causing a bottleneck in the clinical pathway due to limited supply in the dietetic workforce resulting in longer waiting lists for treatment[43,55]. To overcome this challenge, different delivery methods from dietitian-led group education, other healthcare professional delivery, mobile applications or leaflets have all been considered[23,55–57].

Dietitian-led group education on the low FODMAP diet is clinically effective, increases clinical capacity and reduces costs in the clinical pathway[56,58]. It is not suitable for every patient and careful triage will identify which patients will benefit from this approach and who will need a one-to-one approach, e.g. patients with complex dietary needs, current or previous eating disorders, language barriers or atypical symptoms. Although group education may reduce the personalised approach to some extent, it provides patients with peer support and evidence supports the use of groups up to twelve patients[56].

Some general practitioners and gastroenterologists have limited dietetic access for IBS referrals and thus provide patients with basic written information, e.g. food lists, or suggest they search the internet for information without guidance on reputable websites[55]. Although patients trust their general practitioner and gastroenterologists, they can be concerned about the validity and simplicity of information they receive, furthermore such information may not align with healthy eating guidelines[55]. Patients also find that non-dietitian led advice does not enable them to deal with social

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Table 1. Studies in patients with IBS measuring long-term outcomes following low FODMAP restriction, reintroduction and personalisation according to local protocol

Reference	*N* and participants	Study design and duration	Long-term findings
de Roest, 2013 [42] New Zealand	90 secondary care patients with IBS	Prospective observational 15·7 months (4–24)	72·1 % of patients were satisfied with their symptom improvement Symptom improvement using GSRS was reported at long-term follow-up compared with baseline: abdominal pain, bloating, diarrhoea, nausea, flatulence, loose stools, urgency, incomplete evacuation (all $P < 0·001$), constipation ($P = 0·003$), hard stools ($P = 0·001$) 75·6 % of patients adhered to the low FODMAP diet restriction and reintroduction protocol
Maagaard, 2016 [50] Denmark	131 secondary care patients with IBS	Prospective observational Follow-up 16 months (2–80)	At follow-up 57 % of patients had partial response, 29 % had full response and greatest improvement was for bloating and abdominal pain no baseline or significance data available Quality of life improved – no baseline or significance data available Normal stool pattern improved from 15 % at baseline to 56 % at follow-up ($P < 0·0001$)
Harvie, 2017 [47] New Zealand	50 primary and secondary care patients with IBS	Randomised trial Group 1 low FODMAP diet advice at baseline ($n = 23$) Group 2 habitual diet at baseline ($n = 27$) then low FODMAP diet advice at 3 months 6 months	IBS-SSS reduced from baseline to 6 months: group 1 272–160, group 2 254–124, no significance levels available for baseline and follow-up data Significant improvements were reported for IBS-D in both groups ($P < 0·01$) and IBS-M for group 2 ($P = 0·03$) IBS-QoL improved from baseline to 6 months: group 1 66–77, group 2 73–80, no significance levels available for baseline and follow-up data
O'Keeffe, 2018 [39] UK	103 primary and secondary care patients with IBS	Prospective observational 6–18 months	Adequate relief using global symptom question in 59 (57 %) at long-term follow up 84 (82 %) continued adapted low FODMAP diet 19 (18 %) habitual diet Individual symptoms significantly reduced compared with baseline: abdominal pain ($P < 0·001$), bloating ($P < 0·001$), flatulence ($P < 0·001$), incomplete evacuation ($P = 0·007$), lethargy ($P = 0·001$). Belching, borborygmi, urgency, nausea, acid regurgitation, heartburn reported less frequently at baseline and no significant differences at long-term follow-up At long-term follow-up adapted low FODMAP diet group had lower intakes of onion, garlic and wheat pasta and higher intakes of gluten-free bread, lactose-free/plant-based alternatives to milk and milk products and low FODMAP vegetables when compared with habitual diet group More patients in adapted low FODMAP diet group compared with habitual diet group reported diet more expensive than before 72 (86 %) *v*. 8 (42 %; $P < 0·001$), increased difficulty eating out 66 (79 %) *v*. 11 (58 %; $P = 0·030$), eating at friends/family 61 (72 %) *v*. 9 (48 %: $P = 0·009$) and travelling 63 (76 %) *v*. 9 (48 %: $P = 0·014$)

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Table 1. (*Cont.*)

Reference	*N* and participants	Study design and duration	Long-term findings
Bellini, 2020 [35] Italy	41 secondary care patients with IBS	Prospective observational 6–24 months	34/41 >50pt reduction in IBS-SSS compared to baseline at long-term appointment Improvements at long-term FU for watery stools, defecatory urgency, incomplete evacuation $P < 0{\cdot}05$ No difference compared to baseline for energy, macronutrients and selected micronutrients QoL physical health and mental health indices improved $P < 0{\cdot}05$ HADS – anxiety and depression improved $P < 0{\cdot}05$ Acceptability – spent more time shopping and cooking compared with habitual diet and diet more expensive, more difficult during travel and eating out, less tasty and less enjoyable Food-related QoL – better, meals were more pleasant in daily life, seeing problems with food less and compared to habitual diet Perception of trigger foods generally inconsistent with perceived triggers at baseline, moderate for lactose, fair for fructans and poor for polyols, fructose and galacto-oligosaccharides
Gravina, 2020 [46] Italy	100 secondary care patients with IBS	Prospective observational 6 months	Used neurological bowel dysfunction score to assess symptoms 12·8 (moderate/severe score) at baseline to 6·4 (lower score) at 6 months ($P < 0{\cdot}05$) Adherence used a Morisky scale [75](adherence to the diet scores 3–4) and at 6 months adherence was reported as 3·621
Tuck, 2020 [43] Canada	80 secondary care patients with IBS	Prospective observational 10 months (1–60)	52/80 (55 %) reported ≥50 % improvement in symptoms Patients who saw a dietitian had improved knowledge, but patients who did not see a dietitian used speciality food shops more, found the diet more expensive and found travel made it more difficult to follow Patients who saw a dietitian were more likely to appropriately follow the 3 stages of the diet
Weynants, 2020 [44] Belgium	90 secondary care patients with IBS	Prospective observational 25 months (12–42)	80 % of participants continued to restrict the intake of some specific high FODMAP foods in the long term and 89 % were satisfied with their symptoms
Ankersen, 2021 [48] Denmark	12 secondary care patients with IBS	Randomised cross-over trial of low FODMAP diet *v*. probiotic 12 months	8/12 (75 %) completed FODMAP reintroduction and 5/12 (42 %) reported a clinical response IBS-QoL did not change between responders and non-responders Most common trigger foods wheat and rye bread, pasta, pointed cabbage, onion, garlic, leek, broccoli, green peas, cauliflower, kidney beans, chickpeas, sweet potatoes, avocado, mushrooms, apples and apple juice
Goyal, 2021 [49] India	101 patients with IBS-D	Randomised trial of low FODMAP diet ($n = 52$; 4 weeks FODMAP restriction then reintroduction until 16 weeks) *v*. traditional diet advice ($n = 49$)	Low FODMAP diet – energy, carbohydrate, fat and fibre decreased 4 weeks but restored by 16 weeks Symptom response higher in low FODMAP diet at 4 weeks 32/51 *v*. traditional diet advice 20/49 ($P = 0{\cdot}0448$) and 16 weeks 27/51 *v*. 20/49 ($P = 0{\cdot}0274$)
Seamark, 2021 [51] UK	177 primary care patients with IBS	Prospective observational Median 13 months (IQR 12–16)	All symptoms improved from baseline to long-term follow-up, with the most common symptoms reducing in frequency: abdominal pain (62 %), bloating (50 %), increased wind (48 %) and urgency to open bowels (49 %) ($P < 0{\cdot}001$). Satisfactory relief of symptoms improved from 10 % at baseline to 55 % at long-term follow-up ($P < 0{\cdot}001$) Dietitian-led education resulted in reduced appointments for gastroenterology (from 37 to 12 %; $P = 0{\cdot}002$) and general practitioners (from 96 to 34 %; $P < 0{\cdot}001$) and less medication use and investigations for gut symptoms

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Staudacher, 2022 [40] UK	18 secondary care patients with IBS	Prospective observational 10 months after randomised controlled trial of low FODMAP diet. All participants received low FODMAP diet, at baseline ($n = 8$) and 4 weeks later ($n = 10$)	Adequate relief at baseline 5/18 (28 %) increased to 12/18 (67 %; $P = 0{\cdot}039$) IBS-SSS at baseline (median (IQR)) was 227 (99) decreased long-term 154 (89; $P < 0{\cdot}001$) *Bifidobacteria* abundance at baseline (median 11·13 log10 rRNA genes/g, IQR 0·04) was similar long term (11·33 rRNA genes/g, 0·42; $P = 0{\cdot}054$, $q = 0{\cdot}108$) Energy ($P = 0{\cdot}043$), protein ($P = 0{\cdot}011$), fat ($P = 0{\cdot}048$), carbohydrate ($P = 0{\cdot}039$) and iron ($P = 0{\cdot}005$) intakes lower in long term compared with baseline, fibre and calcium similar, FODMAP intake similar to baseline except for sorbitol was lower ($P = 0{\cdot}028$) SF-36 pain improved Overall IBS-QoL and interference with activity and health worry improved compared to baseline

IBS, irritable bowel syndrome; IBS-D, diarrhoea-predominant IBS; GSRS, gastrointestinal symptom rating scale[45]; IBS-SSS, IBS symptom severity scale[41]; IBS-QoL, IBS quality of life[27]; QoL, quality of life; HADS, hospital anxiety and depression scale[29]; SF-36, short-form 36 health survey questionnaire[52]; FODMAP, fermentable oligosaccharides, disaccharides, monosaccharides and polyols.

situations around preparing and eating meals and eating out with family and friends[55].

The use of mobile apps in healthcare is rapidly growing[59] and there are apps dedicated to the low FODMAP diet to support users. Some apps provide detailed information on portion sizes of suitable and unsuitable foods, recipe ideas and meal planning while others enable users to monitor symptoms during the different stages of the diet and identify dietary triggers[53,60].

Patient webinars on first-line dietary advice for IBS were developed by a group of dietitians in primary care to provide non-dietitian led education as part of the clinical pathway[61]. Patients found the webinars an acceptable alternative to dietetic appointments, and this reduced dietetic referrals for IBS by 44 %. Almost a third of patients who took part in the webinar survey said they were keen to watch a webinar on the low FODMAP diet, so the group developed this and it has been viewed by thousands of people[61].

A feasibility study assessed whether leaflets or an app could be used to educate patients on the low FODMAP diet rather than dietitian-led education. The leaflets were comprehensive booklets providing information on the mechanisms of FODMAP and where they occur in the diet along with detailed lists of suitable and unsuitable foods, meal plans including information on avoidance of constipation, low FODMAP plant-based protein, low FODMAP recipes, lists of suitable food products and detailed information on FODMAP reintroduction and personalisation[57]. The app described the three stages of the low FODMAP diet with videos to support users on using the apps functions, i.e. providing users information to search for suitable and unsuitable foods using the integral camera function to scan food barcodes for suitability as well as providing lists of suitable and unsuitable foods[53]. Acceptability of the different delivery methods was measured; the leaflets were considered inferior to the app or dietitian-led education and did not provide enough information for participants to self-manage without further support. There were improvements in symptom severity for all types of education methods although the study was not powered to detect this.

A service evaluation in primary care showed that dietitian-led education on the low FODMAP led to significant symptom improvement which was maintained at least 11 months after the initial treatment[51]. In addition, after dietitian-led education, there were significant reductions in general practitioner and gastroenterologist appointments related to symptoms when compared with the previous 12 months suggesting that low FODMAP education may improve self-management and reduce the burden of clinical follow-up. Furthermore, patients reported less medication use and investigations for gut symptoms.

Since the Covid-19 pandemic, there has been a rapid shift in delivery of care from face-to-face to virtual telephone and video clinics[62,63] which generally are acceptable to patients and clinicians. Virtual clinics provide a more sustainable option for healthcare and increases patient choice; however, digitalisation of services can be costly when considering information governance and the correct digital infrastructure, information technology, hardware and software that need to be integrated into clinical pathways. Many patients find virtual clinics more acceptable than face-to-face clinics citing convenience and less environmental impact[62]. Furthermore, changes in healthcare delivery are likely to generate long-term cost savings for healthcare providers and improve sustainability.

A low FODMAP diet is considered as a 'top-down' approach to management and a modified approach or 'bottom-up' may be considered more appropriate for some people[22]. Indeed, a randomised trial comparing a low FODMAP diet, a gluten-free diet and a BDA/NICE first-line advice diet in ninety-nine patients with non-constipated IBS reported similar improvements in symptom severity across the three diets; however, the BDA/NICE first-line advice was reported as being cheaper and more convenient than the other two diets[63]. The low FODMAP diet certainly had a greater number of patients reporting improved symptom severity compared with the other two groups, but the authors report that the study was underpowered to detect this. It would be of interest to establish whether a modified approach to the low FODMAP diet, i.e. a less restrictive

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version would be as clinically effective and more acceptable to patients to follow.

Eating disorders such as avoidant restrictive food intake disorder or orthorexia nervosa are not uncommon in IBS[64] and when patients with IBS are suspected of having an eating disorder, they are more often likely to restrict their diet rather than have body dysmorphia[23]. These patients need a comprehensive assessment to determine whether FODMAP restriction would be appropriate as their diet may already be limited and nutritionally inadequate. Furthermore, a strategy to lessen the dietary restrictions is often considered appropriate in the clinical setting and further supports using an FODMAP light approach to management[23,65,66].

Due to the complexity of the low FODMAP diet and knowing that approximately a third of people with IBS will be non-responders, it is pertinent to identify whether a certain symptom profile or a biomarker can predict response. One study has assessed symptom severity for predicting response to a low FODMAP diet and reported that high symptom severity scores using the IBS symptom severity scale at baseline led to a greater response to a low FODMAP diet[67]. However, other studies using metagenomics have assessed whether there are biomarkers that can predict response. One study in adults with IBS suggests that having a certain faecal bacterial profile might predict non-response to a low FODMAP diet but not to BDA/NICE first-line advice[68]. Another study in children with IBS reported that those who responded to a low FODMAP diet had microbiomes with greater saccharolytic metabolic capacity at baseline, i.e. those able to ferment complex carbohydrates such as inulin which is an FODMAP[69]. Both studies report on the abundance of bacterial taxa but have opposing results with reference to prediction of response to a low FODMAP diet, indicating a need for further investigation in a more heterogeneous population. A further study identified a greater clinical response to the low FODMAP diet in patients with IBS who had a distinct pathogenic-like gut microbiota at baseline compared to those who had a more health-like gut microbiota[70]. Finally, faecal volatile organic compound profiles have been used as a measure of microbial functionality and volatile organic compound profiles at baseline that contained fifteen specific features were able to predict response in IBS patients with a high degree of accuracy, specificity and sensitivity for the low FODMAP diet[71]. These preliminary research studies in small sample sizes are of great interest, external validation in heterogeneous populations is needed to develop biomarkers that can be used cheaply and quickly in the clinical setting.

Dietary exclusion leading to symptom response followed by food rechallenge to confirm symptom induction is the gold standard for identification of food intolerance and is the principle behind the low FODMAP diet[72]. Hydrogen and/or methane breath tests can be used to identify lactose malabsorption and whether there is a need to restrict lactose, but breath testing is not useful for other FODMAP due to a lack of reproducibility[20,73]. Confocal laser endomicroscopy has been considered as a measure of direct food intolerance as it can visualise changes in the gut mucosa in response to food antigens; however, it is an invasive and expensive procedure and research suggests it is not sensitive or specific enough for widespread use[74].

In conclusion, a low FODMAP diet improves functional bowel symptoms and is a second-line dietary management strategy for patients with IBS. The restriction stage of the low FODMAP diet is superior to other dietary treatments for IBS and achieves symptom response, improves QoL but negatively impacts the abundance of gut *Bifidobacteria* and diet quality; however, FODMAP reintroduction and personalisation are important stages of the low FODMAP diet, maintaining symptom response and restoring nutrient adequacy and the gut microbiota. Dietitian-led delivery of the low FODMAP diet is optimal but not always available and alternative education delivery methods, e.g. webinars, apps and leaflets, are available and should include FODMAP reintroduction and personalisation to mitigate any safety issues. It should be noted that these delivery methods remove the personalised approach and may be less acceptable to patients. Predicting response to the low FODMAP diet using symptom severity or a biomarker is of great interest. More evidence on less restrictive approaches and non-dietitian-led education delivery methods is needed.

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Conflict of Interest

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Authorship

M. C. E. L. developed, wrote and edited the final manuscript.

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