# Dietary management of adults with IBD — the emerging role of dietary therapy

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Abstract | Historically, dietitians played a minor part in the management of inflammatory bowel disease (IBD), including Crohn's disease and ulcerative colitis. Patients were commonly referred for consequences of uncontrolled disease, such as malnutrition and bowel obstruction risk. Today, dietitians are fundamental members of the multidisciplinary IBD team, from educating on the role of diet at diagnosis and throughout the lifespan of a patient with IBD to guiding primary induction therapy. This aspect is reflected in published guidelines for IBD management, which previously placed diet as only a minor factor, but now have diet-specific publications. This Review describes a four-step approach in a dietitian's assessment and management of diet in patients with IBD: (1) identifying and correcting nutritional gaps and dietary imbalances; (2) considering diet to treat active disease with the use of exclusive enteral nutrition (EEN) or emerging diets that could replace EEN; (3) using therapeutic diets to control existing complications of IBD, such as reduced fibre to prevent bowel obstruction in stricturing disease or a fermentable oligosaccharides, disaccharides, monosaccharides and polyols diet to manage co-existing functional gut symptoms; and (4) considering the role of diet in preventing IBD development in high-risk populations.

Almost every patient diagnosed with inflammatory bowel disease (IBD) will consider what to eat. Diet is one of the first things manipulated by patients with IBD, and many patients and health practitioners believe that diet can change the course of the disease[1]. If not appropriately directed by their treating doctor, many patients avoid foods that they associate with symptoms[2] or turn to the internet or complementary and alternative medicine (CAM)[3,4]. Now, there is a need for accessible expert dietary opinion and management to help steer patients through valuable, valueless and potentially harmful information.

The role of dietitians in the care of patients with IBD has evolved from an almost non-existent role in the mid-20th century to a role heavily centred around inpatient care, and now to a leading role in guiding the provision of therapeutic diets, as in the example of exclusive enteral nutrition (EEN)[5]. Indeed, authoritative guidelines, such as those from the British Society of Gastroenterology and the National Institute of Health and Care Excellence quality standards, recommend access to a gastroenterology dietitian as part of an IBD service[6], although many services fall short of these standards as shown in an audit of the quality of care for Australian patients with IBD[7] and the IBD UK 2019–2020 IBD Benchmarking Tool[8]. Research into diet and dietary therapies has substantially increased in the past decade. Literature describing the role of dietitians in the management of patients with IBD has largely focused on access to a dietitian for implementation of EEN or nutrition screening and management[9–11], but few reports describe the full scope of a dietitian's function. The exception is a review that defined four steps of IBD dietary management: nutritional care, managing disease activity, managing disease complications and addressing prevention[12]. This Review focuses on advances in each of these steps since 2015 and translates these data into a practical clinical guide for IBD dietary management. It identifies a need for dietary intervention and referral to a dietitian, then provides instruction on the optimal implementation of dietary treatment (FIG. 1). We propose that nutritional management of patients with IBD should assess all four steps of dietary care at diagnosis, should assess changes in IBD inflammatory status, escalation of symptoms and changes in diet, and should ideally be managed by a dietitian well-versed in IBD, given the complexities of the condition, in relation to these four steps. For the purposes of this Review, the discussion focuses on adults with IBD, unless specified otherwise.

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https://doi.org/10.1038/s41575-022-00619-5

**Key points**

- Specialized dietitian intervention is a key component of inflammatory bowel disease (IBD) management and all patients with symptoms or who have changed their diet should be referred to a dietitian.
- Nutrition assessment needs to include body composition assessments that are associated with clinical outcomes.
- Exclusive enteral nutrition (EEN) and the Crohn's Disease Exclusion Diet could be used to induce IBD remission, with potential for emerging, more-targeted diets to treat disease.
- Dietary therapy is used to managed complications of IBD, including bowel obstruction risk and co-existing functional gut symptoms.
- Preoperative nutritional support, with oral nutritional supplements or EEN, improves surgical outcomes and should be optimized if possible.
- Disordered eating is an emerging issue in IBD and needs clinical consideration and further examination.

## Step 1: nutritional care

It is well-documented that IBD carries an increased risk of malnutrition and subsequently poor clinical outcomes, such as fatigue, poor health-related quality of life, infection, poor wound healing, increased mortality and increased cost of health care[13,14]. Historically, most attention was given to undernutrition, particularly in patients with active Crohn's disease with reduced oral intake generally associated with feeling unwell, and impaired nutrient absorption seen in ileal disease[15]. However, overnutrition has emerged as a factor in predicting poor clinical outcomes, particularly in countries with increasing rates of obesity[16], with patients with IBD also showing increasing rates of overweight and obesity in line with global trends[17]. Indeed, 15–40% of adults with IBD had obesity and 20–40% overweight in a report from the USA and Northern Europe[18]. There are two parts to nutritional care: nutritional assessment, including evaluation of body composition, and dietary assessment to uncover opportunities for dietary change.

### *Nutritional assessment*

To develop strategies for intervening in patients with all types of malnutrition (both undernutrition and overnutrition), it first has to be recognized. Screening tools, such as the Malnutrition Universal Screening Tool, are commonly used to indicate protein energy malnutrition[19], but perform poorly in IBD, with sensitivities as low as 63.6%[20,21]. Furthermore, such screening tools are used for identifying undernutrition only. However, nutritional excess does not necessarily preclude deficiencies, nor does undernutrition disqualify excesses in other measures. More sensitive methods for detecting nutritional abnormalities are needed.

***Identifying nutritional deficiencies.*** Protein energy malnutrition has traditionally been assessed by BMI, clinically significant unintentional weight loss and visual assessment of muscle or fat loss. When these techniques are combined in tools such as Subjective Global Assessment[22] or in the International Classification of Diseases, 10th Revision, criteria[23], protein energy malnutrition has been predicted to be present in 25% of outpatients with IBD and in 75% of inpatients with IBD[24–28]. However, such methods can falsely reassure the clinician when compared with the results of more sophisticated body composition techniques. Myopenia, defined as a depletion of lean muscle mass that is associated with an increased risk of morbidity or mortality[29,30], is a more useful clinical indicator of nutritional deficiencies as, unlike BMI, it is associated with poor outcomes in IBD, including major postoperative complications, risk of small bowel resection, primary non-response to anti-tumour necrosis factor (anti-TNF) agents (independent of disease severity), osteopenia and poor quality of life[29,31–35]. Myopenia is present in up to 60% of inpatients and outpatients with IBD, during both remission and active disease[28,31,32,34], and progresses over the disease course[29], as indicated by the deterioration of fat-free mass in >100 outpatients with IBD, followed over 24 months despite being managed according to international guidelines in a tertiary referral centre. The prevalence of myopenia increased from 19% to 24% despite fat mass and visceral adiposity adjusted for height markedly increasing over time. BMI also increased: 62% of patients were classified as having overweight or obesity[29]. Similar results have been seen in other studies of patients with IBD showing myopenia in those with normal BMI[32–34]. Indeed, the Global Leadership Initiative on Malnutrition (GLIM) has recognized the importance of body composition in the diagnosis of malnutrition and that muscle mass depletion can occur in populations with BMI-defined normal weight, overweight and obesity[20].

Sarcopenia is defined as muscle wasting associated with a loss of muscle function. Sarcopenia is assessed by measuring muscle strength and function and assessing muscle mass using the technique described in TABLE 1. Muscle strength is rarely assessed in studies in patients with IBD referring to sarcopenia; rather these studies are actually measuring myopenia[36,37]. Unlike myopenia, sarcopenia has the opportunity to determine altered muscle performance. This aspect is of direct relevance to the assessment of fatigue, which is one the most debilitating complaints amongst patients with IBD, reducing health-related quality of life[38]. Indeed, muscle fatigue identified using an isokinetic dynamometer was greater in 27 patients with Crohn's disease than in 22 matched healthy individuals as controls, and correlated well with a subjective physical fatigue score[39]. These functional impairments were reflected in reduced muscle mass (assessed by CT) and biochemically in a 54% lower phosphorylated Akt to total Akt ratio, indicating a reduced capacity for active muscle protein synthesis[40].

Measuring myopenia and sarcopenia can be challenging as radiological imaging is the gold standard for accurately determining muscle mass as outlined in TABLE 1, bringing limitations of accessibility (including trained staff for administration and reporting) and cost. However, many patients with IBD already undergo these tests as part of routine clinical care, although the body composition is not reported, so it is reasonable to use these opportunities to include such analysis in these scans, at least for reference if monitoring change is impractical. Fortunately, cheap and easily administered point-of-care tests, such as the use of validated bioimpedance and handgrip strength devices (TABLE 1), correlate well with imaging in the setting of IBD[28].

Furthermore, as ultrasonography is increasingly being used routinely to monitor disease status in patients with IBD[6], at least in some countries, it might become a very practical and accessible modality to assess changes in muscle mass and muscle quality, as seen in patients in the oncology and intensive care settings[41].

The effect on disease outcomes for deficiencies in haematinics (iron, vitamin $B_{12}$, folate) and other micronutrients has been reviewed elsewhere[42,43]. However, zinc and vitamin D have attracted attention due to their potential as targets for improving disease outcomes given their role in immunity, their enzymatic functions and their role in maintaining mucosal barrier function[44,45]. Patients with IBD who are deficient in zinc are more likely to be hospitalized, have complications and relapse, and have a twofold increased risk of requiring surgery[46]. Correcting this deficiency eliminates most of these risks[47]. A similar risk in relation to disease outcomes has been suggested for vitamin D deficiency, which has been associated with greater disease activity, pain, poorer quality of life, need for more medical and surgical interventions and increased health-care utilization[48]. Although cause and effect has not been established, monitoring and normalization of zinc and vitamin D levels, which are part of routine care, are simple management strategies with the potential to improve IBD health outcomes.

***Identifying nutritional excesses.*** There is increasing awareness that visceral adiposity might be just as detrimental to outcomes in patients with Crohn's disease as undernutrition, due to the association between visceral

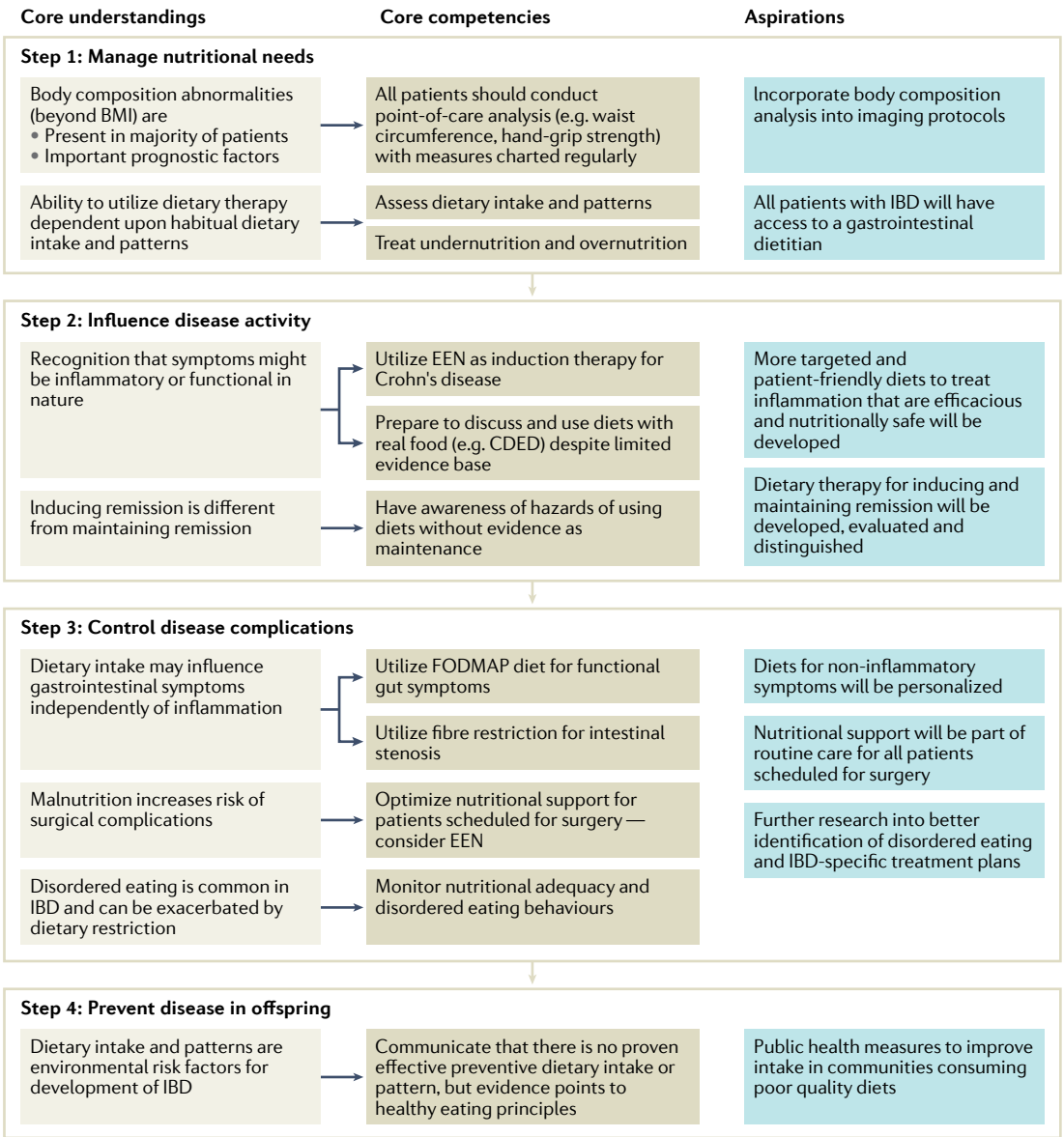


Fig. 1 | **Roles of diet therapy in management of IBD in a four-step strategy.** Four steps in the management of inflammatory bowel disease (IBD) are suggested: manage nutritional needs; influence disease activity; control disease complications; and prevent disease in offspring. CDED, Crohn's Disease Exclusion Diet; EEN, exclusive enteral nutrition; FODMAP, fermentable oligosaccharides, disaccharides, monosaccharides and polyols.

Table 1 | **Comparison of nutrition assessment techniques in populations of patients with IBD**

| Assessment technique | Measurement techniques | Level of training | Accessibility | Estimated cost | Suitability as GLIM phenotypic criterion | Marker of myopenia | Marker of sarcopenia | Marker of visceral adiposity |
|---|---|---|---|---|---|---|---|---|
| BMI | Body weight to height ratio (kg/m$^2$) | Low | Bedside or clinic rooms | Already routine | Poor, except if <18.5 kg/m$^2$ | Poor | Poor | Moderate |
| Unintentional weight loss | Weigh loss in relation to premorbid body weight (%) | Low | Bedside or clinic rooms | Already routine | Good | NA | NA | NA |
| Mid-arm circumference | Circumference of left upper arm (cm) | Low | Bedside or clinic rooms | Minimal | Not recommended | NA | NA | NA |
| Waist circumference | Measurement around abdomen at umbilicus (cm) | Low | Bedside or clinic rooms | Minimal | NA | NA | NA | Good |
| Handgrip strength | Isometric dynamometer device (kg) | Low | Bedside or clinic rooms | Moderate | Good | Good | Good with muscle mass measure | NA |
| Quadriceps muscle strength | Isokinetic dynamometer device (newton metres) | Moderate | Bedside or clinic rooms | Moderate | NA | NA | Good with muscle mass measure | NA |
| Bioimpedance | Estimate of total body water via electrical current passed between four points | Moderate | Bedside or clinic rooms | Moderate | Good | Good with validated techniques | Good with muscle strength measure | NA |
| Ultrasonography | Measure of muscle and/or fat using inbuilt software | High | Increasingly used for disease monitoring | Moderate | NA | NA | NA | Moderate |
| Dual energy X-ray absorptiometry | Measure of lean tissue mass and bone mineral content (kg) | High | Routinely conducted in patients with IBD for bone mineral density | High | Good | Reference method | Reference method | Reference method |
| CT | Abdominal CT measures visceral and subcutaneous fat and lumbar skeletal muscle (cm$^3$) | High | Routinely used to assess disease activity | Moderate[a] | Good | Reference method | Reference method | Reference method |
| MRI | Measures adipose tissue, skeletal muscle, oedema and visceral organs | High | Routinely used to assess disease activity | High[a] | Good | Reference method | Reference method | Reference method |

GLIM, Global Leadership Initiative on Malnutrition; IBD, inflammatory bowel disease; NA, not assessed. [a]Can assess myosteatosis, with specialized software.

fat and raised inflammatory cytokines, including TNF[49], and poorer responses to anti-TNF agents[50]. Visceral fat describes the high volume of adipose tissue surrounding the intra-abdominal organs, but the term visceral obesity does not yet have a consensus definition and is often reported as visceral fat area, visceral adipose tissue adjusted for height, visceral to subcutaneous adipose tissue ratio[51] or visceral adipose tissue to skeletal muscle mass ratio. This issue makes a comparison of data and IBD outcomes difficult. In a study in 134 patients with Crohn's disease, visceral fat area on CT was associated with an increased incidence (OR 2.86, 95% CI 1.32–6.21; $P = 0.008$) of postoperative complications[52], and in a study in 88 hospitalized patients with Crohn's disease, visceral obesity on CT was associated with a greater than sixfold increased likelihood of surgery over the next 22 months[34]. Further data suggest a positive association between visceral obesity in patients with ileocolonic Crohn's disease, determined through serial visceral adipose tissue measurements: subcutaneous adipose tissue ratios via dual-energy X-ray absorptiometry, and intestinal inflammation as reflected in associated higher faecal calprotectin levels and stricturing disease[16]. These data do not yet demonstrate causality due to their observational nature. However, point-of-care testing of increasing visceral adiposity can be easily measured through waist circumference, which correlates well with standard reference techniques and could be incorporated into future prospective clinical trials to evaluate its predictive capacity[53] (TABLE 1). BMI on the other hand, correlates with total fat mass adjusted for height[29,32], but performs poorly in identifying visceral obesity, which is likely to be of more clinical importance. BMI can over-identify and under-identify visceral obesity and does not correlate with any markers of body composition[34,52].

Myosteatosis or muscle attenuation is the infiltration of fat into intermuscular and intramuscular compartments and has potential as a good marker for muscle dysfunction and fatigue[54] as it correlates well with muscle strength, muscle mass, mobility and metabolism,

including insulin resistance. Evaluation of myosteatosis in IBD is limited and does not yet demonstrate causality, but there are some links between myosteatosis and IBD outcomes, including shorter intestinal resection-free period in 35 patients with Crohn's disease[55] and increased risk of readmission in 77 postoperative patients with IBD[56]. In a multivariate retrospective analysis of 71 patients with Crohn's disease, higher muscle attenuation (that is, less myosteatosis) was a protective factor for complicated Crohn's disease phenotypes[57]. There are no current point-of-care tests to indicate myosteatosis.

### *Dietary assessment*

Unlike nutritional assessment, which focuses on determining nutritional deficiencies or excesses, dietary assessment enables understanding of a patient's eating pattern and intake. This approach provides a key part of a dietitian's role in the management of patients with IBD for a few reasons: it can assist in determining underlying causes of malnutrition; it is an essential step in the implementation and evaluation of the efficacy of dietary therapy; it enables recognition of maladaptive eating behaviours (disordered eating), particularly concerning restrictive diets (discussed below); and it provides insight into psychosocial issues and the feasibility of dietary interventions in the individual.

Diet is more than a means of obtaining nutrition, but is also important for enjoyment, social interactions, and a big part of family and cultural traditions, religion and philosophy. Disturbance to diet can lead to nutritional impairment and reduced food-related quality of life[58]. Diet behaviour is particularly important in patients with IBD as restrictive diets commonly applied are known to be associated with anxiety, depression and stress in this population[59]. Dietary assessment by a dietitian is accepted as the 'gold standard' to evaluate adherence to a therapeutic diet[60]. It is more accurate than smartphone app food logs[61,62] and probably better in promoting dietary change[63]. Methods of obtaining a diet history, calculations of nutritional adequacy and actions to correct deficiencies are standard dietetic practice and few new developments related specifically to patients with IBD have been reported and so are not further discussed.

**Box 1 | Optimizing nutritional assessment in patients with IBD**

- Dietitian-led nutritional assessment in all patients: nutrition screening tools have low yield given the high proportion of abnormalities in patients with IBD.
- Abandon BMI as the major assessment: weight-based techniques alone are insufficient for recognizing body composition abnormalities except for extremes (very high or low BMI) and can be misleading.
- Use point-of-care testing for body composition: handgrip strength and waist circumference perform well in indicating body composition abnormalities.
- Incorporate body composition software into imaging protocols: body composition analysis using DXA, CT and/or MRI allows the accurate calculation of muscle and fat indices and is routinely used in patients with IBD.
- Use both routine point-of-care monitoring and formal body composition assessment: the use of formal imaging body composition techniques is impractical for monitoring, but such assessment could be completed at the same time as the assessment of IBD disease burden.
- Monitor for and treat specific micronutrient deficiencies: correction of key micronutrient deficiencies (for example, iron, zinc and vitamin D) presents potential opportunities to improve IBD health outcomes.

DXA, dual energy X-ray absorptiometry; IBD, inflammatory bowel disease.

### *Translation to clinical practice*

Advances in our understanding of body composition analysis in patients with IBD demand a revolution in clinical approach and thinking. Only when body composition indices that are associated closely with prognosis are measured will clinician awareness be heightened and questions regarding, for example, adequacy of therapy be enabled. Optimization of nutritional assessment should consider the recommendations described in BOX 1.

## Step 2: diets to treat active disease

The notion that dietary manipulation can induce remission of gut inflammation is not new. However, specific dietary components that drive inflammation in patients with IBD have not been convincingly identified. Furthermore, most literature does not distinguish between the role of diet in IBD prevention and established disease, which can differ, as in the example of coeliac disease, for which dietary restriction in high-risk populations has not been shown to provide an advantage in its prevention[64]. This confusion is reflected in some IBD dietary guidelines for controlling established disease that based many of their recommendations on epidemiological data[65], which are more relevant for disease development. The search for dietary strategies and therapeutic diets have been based on limited evidence driven by clues in epidemiology, cell systems in vitro and animal models. The last-mentioned and largely empirical approach has met with the most success, at least in Crohn's disease, as exemplified by EEN and the Crohn's Disease Exclusion Diet (CDED) in inducing remission. However, maintaining remission remains a challenge.

### *Exclusive enteral nutrition*

EEN describes the replacement of all food with a nutritional supplement, usually for 6–8 weeks. EEN was introduced about 50 years ago, and the initial concept was to concomitantly improve nitrogen balance while resting the bowel without total parenteral nutrition[66].

*Evidence for efficacy.* The bulk of the evidence indicating efficacy of EEN in Crohn's disease was derived from studies in paediatric patients, which showed that EEN has comparable effects to corticosteroids on clinical disease activity[67], but superior effects on mucosal healing (OR 5.24). Furthermore, EEN has additional benefits of correcting nutritional deficiency and promotion of growth[68,69]. EEN is now first-line therapy in paediatric patients with Crohn's disease, with remission rates of up to 80% observed[70]. Lower rates of efficacy (45%) have been observed in adults, although few randomized controlled trials (RCTs) have been performed; the lower rates in adults is thought to be mainly driven by poorer levels of adherence[71,72]. Most evidence relates to symptom-based indices or C-reactive protein (CRP)[73], with no studies examining effects on mucosal healing. Suggestions that newly diagnosed disease and disease with ileal distribution could respond better to EEN[72,74,75] have not been supported by studies demonstrating

efficacy in those with long-standing disease as well as in those with ileocolonic and isolated colonic disease[71,76–78]. The value of enteral nutrition as maintenance therapy for Crohn's disease is supported by some evidence, mainly where the enteral formula is the major contributor to nutritional intake, but it remains an unattractive option to patients given the restrictions of this dietary approach in social settings[79].

There is growing evidence to support the use of EEN in patients preoperatively, with data demonstrating a reduction in postoperative complications (discussed later)[80]. EEN is also effective in the management of complications of Crohn's disease such as strictures, abscesses and fistulae[81–83], although treatment duration might be longer. Formula choice does not seem to influence efficacy, although most formulas used are polymeric, and lactose and gluten-free, and lack fibre (82%)[84].

Evidence for the value of EEN in patients with ulcerative colitis is limited to a small study in 62 paediatric patients that showed improvements in disease activity and modification of growth factor production[85], and a 7-day open-label trial in 62 adults with acute severe ulcerative colitis in which EEN as an adjunct to standard medical therapy was associated with a lower rate of corticosteroid failure, greater reduction in CRP and faecal calprotectin levels, shorter hospital stay and higher albumin levels than standard therapy alone[86]. EEN is not currently routinely used in ulcerative colitis.

***Mechanism of action.*** EEN is likely to exert its effects through a complex interplay between the host mucosal immune system and the luminal environment[87–89]. Still, specific mechanisms of action of EEN remain speculative only, with several mechanisms having been proposed (FIG. 2). However, although some of these hypothetical mechanisms are supported by evidence showing biological or microbiological changes during EEN, the direction of change is not always as expected and commonly leads to a microbial status that conflicts with that seen in healthy gut. One example of this issue is the observation that the faecal microbiota shifts towards dysbiosis during EEN[89–91]. In another paradox, preclinical studies have indicated that antigenic food components often found in enteral formulas, commonly in higher concentrations than seen in diet, such as maltodextrin, drive inflammation[84]. Clearly, further research is required to gain a greater understanding of the exact mechanisms by which EEN mediates the inflammatory processes within the bowel.

***Practicalities of EEN administration.*** There is variation in the use of EEN across IBD centres globally, particularly in the adult population, probably due to differences in clinician experience, access to dietitians and lack of guidelines for its use[76]. Adherence to EEN is a major limitation, with up to 40% of adult patients not completing EEN therapy[71,72], especially as the success of partial enteral nutrition (PEN) is reduced with lower adherence rates[71,92]. Adherence enablers include conscientiousness as a personality trait[93], patient self-efficacy, access to formula, characteristics of the formula and health system and social support[94]. These findings are consistent with real-world practice in which adherence to EEN can be improved through the support of the multidisciplinary team[71,72,76]. An optimal care pathway describing current evidence for best practice implementation of EEN in adults has been published and provides step-by-step guidance on its implementation[5], but the best method of transitioning from EEN to diet has not yet been established. Thus, current practice is for dietetic assessment of the patient for EEN to consider the patient's clinical, nutritional and social situation and the patient's own preferences. The dietitian's role is to negotiate with the patient in developing the most appropriate regimen by discussing expectations and the potential adverse effects of the therapy, as outlined in TABLE 2.

### *Crohn's Disease Exclusion Diet*

The first dietary strategy involving the consumption of real food that provides convincing evidence of reducing inflammatory activity in Crohn's disease comparable to that of EEN is the CDED with PEN (TABLE 3). The CDED comprises a three-phase step-down diet, starting with 6 weeks of PEN (providing 50% of nutritional requirement through formula) with an allowance of fourteen foods,

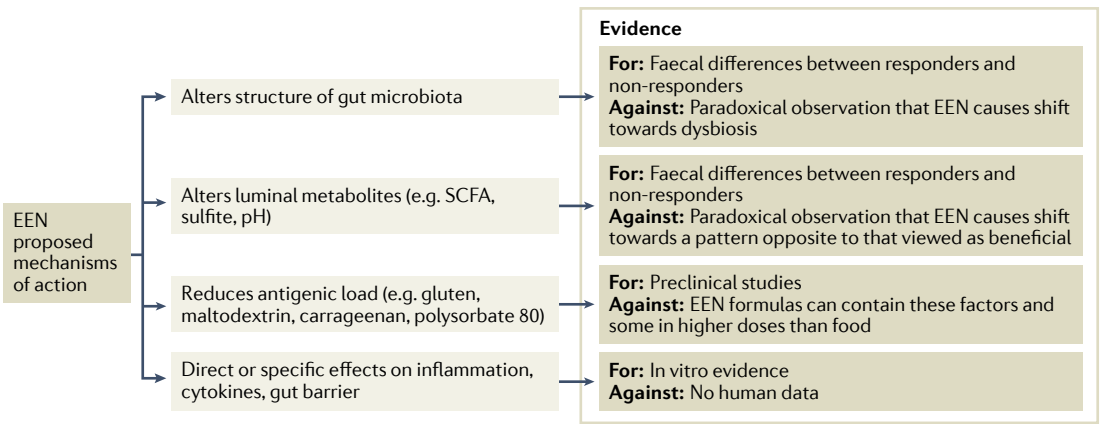


Fig. 2 | **Proposed mechanisms of action for exclusive enteral nutrition treating active Crohn's disease.** Several factors are thought to contribute to the mechanisms of action of exclusive enteral nutrition (EEN) but supporting evidence for their role is conflicting. SCFA, short-chain fatty acids.

Table 2 | **Management of possible adverse effects of exclusive enteral nutrition**

| Adverse effects | Potential management strategies | Recommended time point for monitoring adverse effects |
|---|---|---|
| Resistance to commencement | Thorough discussion of EEN expectations and adverse effects<br>Plans for short-term duration with regular reviews to reassess EEN continuation | Prior to EEN commencement |
| Unintentional weight loss or gain | Recalculation of estimated nutrition requirements and adjustment of prescribed regimen | After first week of EEN and thereafter |
| Dislike of formula | Change formula type and/or flavour | On trial of formula and/or commencement of EEN |
| Early satiety or excessive hunger | Adjustment of formula volume and/or frequency to increase or slow gastric emptying | After first week of EEN |
| Constipation | Consideration of contributing factors, ensure adequate total fluid intake, magnesium supplementation (ensuring no contraindications) | After first week of EEN and thereafter |
| Diarrhoea | Consider if indication of poor response, consider osmolarity of prescribed formula | After first week of EEN and thereafter |
| Headaches | Ensure adequate hydration and consider allowance of black tea and/or coffee for possible caffeine withdrawal | After first week of EEN |
| Non-adherence or 'slip-up' | Consider regimen: alter volume (i.e. decrease) to improve adherence or flavours<br>Practical suggestions to improve adherence (e.g. heat/freeze formula (if suitable for individual products), decant from packaging into cup)<br>Provide encouragement despite 'slip-ups'<br>Increase frequency of dietitian review<br>Possibly consider shorter duration of EEN programme, supported by improvements in CRP and faecal calprotectin in 2 weeks[92]<br>As last resort, consider encouraging a high percentage of PEN[197], with or without foods allowed on CDED | After first week of EEN and thereafter |
| Access to formula | Exploration of hospital and/or government subsidy programmes, if applicable | Prior to EEN commencement |

These recommendations are based on clinician expert consensus unless otherwise stated. CDED, Crohn's Disease Exclusion Diet; CRP, C-reactive protein; EEN, exclusive enteral nutrition; PEN, partial enteral nutrition.

then some additional food allowances and reduced use of PEN in the second phase[95]. The therapeutic benefit of the PEN component is unknown, with an open-label pilot trial in 44 adults with mild ileal Crohn's disease indicating comparable clinical responses in those receiving the CDED between those with and without the support of PEN, based on CRP levels, faecal calprotectin levels and clinical disease scores[96]. This study was also the first to demonstrate endoscopic remission at 24 weeks in approximately one-third of patients using these diets as monotherapy. The proposed third and ongoing phase of the CDED that comprises further liberalization of food choice with no formula has yet to be examined for safety, particularly its potential effect on nutrition without PEN support[97].

After observational studies had suggested benefit in both children and young adults[98,99], a multicentre RCT in 78 paediatric patients with mildly active Crohn's disease[95] gave the first higher level of evidence of efficacy, showing high rates of response and corticosteroid-free remission of 75%, based on Crohn's disease activity indices and faecal calprotectin levels, similar to that with EEN.

The hypothesis behind the CDED is that dietary components that characterize a Western diet (low in fibre and high in fat, sugar and additives) all negatively alter the gut microbiota and thereby lead to the development of Crohn's disease. The CDED programme proposes to correct these dietary aspects to reverse the disease process[100]. The developers of the CDED claim that the diet aims to be high in fruits, vegetables, complex carbohydrates, total fibre, healthy oils and lean protein sources, but these statements do not necessarily match the description of the diet. For example, the first phase of the diet is highly restrictive, only allowing a select few fruits and vegetables that are to be peeled to reduce their fibre content. The CDED also aims to reduce the intake of gluten, dairy products, maltodextrin and particular food additives due to their pathogenic potential, based largely on animal studies[101–104], but most PEN formulas contain all these food components except gluten. Nonetheless, use of the CDED has provided quality evidence that real food can be used as part of induction therapy and offers a better-tolerated alternative to the exclusive use of enteral formula. Efficacy and safety regarding the third (maintenance) phase are eagerly awaited.

### *Other potential diets to treat disease*

The IBD community has been leading the demand for therapeutic diets, with survey data showing 86% of patients changed their diet after a diagnosis of IBD, most often without the guidance of a dietitian[105]. The preference is for diets with known pathogenic mechanisms (rather than pseudoscience) for which the effects of the

Table 3 | **Dietary therapies emerging since 2015 to treat established IBD**

| Diet | Rationale | Aimed for induction or maintenance therapy | Diet description | Evidence of efficacy | Safety considerations |
|---|---|---|---|---|---|
| Crohn's Disease Exclusion Diet (CDED)[95] | Restriction of all dietary components that negatively affect gut microbiota, mucus layer, intestinal permeability and/or translocation of bacteria as well as inclusion of foods proposed to positively influence these factors, will reduce intestinal inflammation in Crohn's disease | Both | Three-phase, step-down diet; first 6 weeks comprising PEN providing 50% nutrition + allowance of 14 foods containing protein, resistant starch or pectin | RCT for phases 1 and 2 in 78 paediatric patients with mildly active Crohn's disease showing improved inflammatory markers comparable to those during EEN<br>RCT in 44 adults with and without PEN showing induction of remission and mucosal healing in some | Phase 3 from 13 weeks onwards has not undergone formal investigation and remains restrictive<br>Concerns for negative effect on nutrition and psychosocial effects with phase 3, if recommended on an ongoing basis |
| Specific Carbohydrate Diet (SCD)[112] | Disaccharides and polysaccharides lead to carbohydrate fermentation and inflammatory microbiota, which damage the mucosa in IBD | Both | Avoidance of all grains, legumes, starchy vegetables manufactured foods and most dairy products | Symptomatic improvement in symptomatic patients (adult and paediatric) with mildly active Crohn's disease<br>Limited evidence for diet-specific effects on inflammatory markers | Rationale does not fit with experimental evidence<br>Concerns of ongoing restrictive diet with no nutrition support, backed by diet analysis showing inadequate calcium (carbohydrate and fibre not assessed, but probably low)<br>Data showing diet difficult to follow |
| Paleo Auto-Immune Protocol (AIP)[198] | Gluten and lectins cause intestinal inflammation, dysbiosis or symptomatic food intolerance in IBD | Both | Diet high in meat but avoidance of grains, legumes, nightshade vegetables, dairy products, coffee, alcohol, nuts and seeds, refined and/or processed sugars, oils and food additives | Very limited data showing symptomatic improvement in 15 patients with IBD with no inflammatory markers measured | Rationale does not fit with experimental evidence<br>Concerns of ongoing restrictive diet with no nutrition support and high meat consumption |
| Plant-based diet[199] | High intake of prebiotics will increase beneficial colonic bacteria leading to reduced inflammation in IBD | Both | Restriction of animal fat and protein<br>Semi-vegetarian diet also restricts sweets, bread, cheese, margarine, fast foods, carbonated beverages, juices and alcohol<br>Limit fish to half portion weekly and meat to half portion fortnightly | Observational study showing reduced risk of relapse in 16 patients with Crohn's disease in clinical remission | Risk to nutritional adequacy less concerning, but has not been assessed |
| Mediterranean diet[112] | High intake of plant-based foods and limited protein from meat has anti-inflammatory properties, which are beneficial for patients with IBD | Both | High intake of vegetables, fruits, cereals, nuts, legumes and unsaturated fat, such as olive oil<br>Moderate intake of fish, dairy products and wine<br>Low intake of saturated fat, meat and sweets | RCT improvement in symptoms, uncertain whether this is diet-specific<br>Limited evidence for effects on inflammatory markers | Safe, mostly in accordance with most healthy eating guidelines |
| CD-TREAT[200] | Diet that replicates composition of enteral formula using real food will show similar treatment effects in patients with Crohn's disease to EEN | Induction | Limited description of diet published<br>Avoidance of gluten, lactose, alcohol and fibre | Animal model showing similar effects on microbiota to EEN<br>Open-label observational trial in five children with Crohn's disease showed reduced faecal calprotectin levels | Unknown with limited diet description |

Table 3 (cont.) | **Dietary therapies emerging since 2015 to treat established IBD**

| Diet | Rationale | Aimed for induction or maintenance therapy | Diet description | Evidence of efficacy | Safety considerations |
|---|---|---|---|---|---|
| Low-sulfur diet[201] | Reduction in $H_2S$ and NO to distal colon through reduced protein:carbohydrate fermentation and sulfate reduction from dietary change will improve mucosal healing in ulcerative colitis | Both | Reduction in total protein, sulfur-rich proteins, sulfur-containing and nitrate-containing additives and increase in resistant starch and non-starch polysaccharides<br>Limited description of diet published | Targeted metabolite change in faeces overall achieved | Unknown, with limited diet description |
| Low-emulsifier or carrageenan diets[202] | Additives and possibly natural emulsifiers, including carrageenan will degrade mucosal barrier through altered gut microbiota and bacterial translocation, leading to intestinal inflammation | Both | No detailed food composition exists for quantitative estimates in food<br>Qualitative identification of additives reliant on food labelling with likely limitations | In vitro and animal studies, including a study showing that two emulsifiers induced colitis in genetically susceptible mice<br>A study in 20 patients with Crohn's disease showed diet feasibility for 14 days and improved symptoms and food-related quality of life | Limited diet description<br>Probably safe with restrictions predominantly on manufactured foods |
| Low-fat diet[203] | High-fat and animal meat diets associated with increased risk of developing ulcerative colitis, and reducing dietary fat will improve ulcerative colitis clinically and biochemically | Maintenance | Reduce fat to 10% of total calories<br>Reduce red meat to approximately half a serving daily<br>Include 25 g fibre | In a crossover RCT in 17 patients with ulcerative colitis in remission, a low-fat and high-fibre diet improved relative abundance of *Faecalibacterium prausnitzii* and serum amyloid A[a] compared with iSAD providing more fibre (18 g) from fruit and vegetables<br>Unclear whether fat or fibre or both linked to possible markers of ulcerative colitis relapse | Safe, in accordance with most healthy eating guidelines |
| Low-meat diet (FACES)[204] | A lower meat intake associated with quiescent Crohn's disease will prevent disease relapse | Maintenance | Reduce red and processed meat to one serving per month or less | A prospective randomized trial in 214 patients with Crohn's disease in remission showed no difference in relapse between low and high meat intakes | Risk to nutritional adequacy less concerning, but has not been assessed |
| Food exclusion based on IgG antibodies[205] | Digestive enzymes are lacking and undigested food components become antigenic, which leads to the activation of ulcerative colitis and reactions lead to food intolerance | Both | 6-month restriction of food based on presence of IgG antibodies specific to 14 food antigens, including egg, wheat, milk, corn, rice, soybean, chicken and others | Observational study in 97 patients with ulcerative colitis in remission or mild to moderately active disease on open-label IgG exclusion diet or unchanged diet showed lower stool frequency in exclusion group and no endoscopic differences<br>No specific rise in IgG antibodies in response to food in symptomatic compared with healthy asymptomatic people | Rationale does not fit with experimental evidence<br>Concerns for nutrition with potential restriction of multiple allergens |

Table 3 (cont.) | **Dietary therapies emerging since 2015 to treat established IBD**

| Diet | Rationale | Aimed for induction or maintenance therapy | Diet description | Evidence of efficacy | Safety considerations |
|---|---|---|---|---|---|
| Novel ulcerative colitis exclusion diet (UCED)[206] | Alteration of dietary components that may adversely affect goblet cells, mucus permeability and microbiome composition, to reduce inflammation in ulcerative colitis | Induction | Two-phase diet of reduced exposure to sulfated amino acids, total protein, animal fat, saturated and polyunsaturated fat and food additives, with exposure to tryptophan and natural sources of pectin and resistant starch | A prospective open-label pilot study in paediatric patients with mild–moderate UC showed improvement in clinical disease activity scores | Risk to nutritional adequacy, limited description of the diet and yet to be assessed<br>Noted to have reduced energy intake and weight loss |

EEN, exclusive enteral nutrition; IBD, inflammatory bowel disease; iSAD; improved standard American diet; PEN, partial enteral nutrition; RCT, randomized controlled trial. [a]Marker of mucosal inflammation.

dietary manipulation on those mechanistic targets have been evaluated and are scientifically better understood. TABLE 3 summarizes the efficacy of diets aimed to treat active IBD since 2015. Some of the more commonly known diets are described herein.

***Specific carbohydrate diet.*** The specific carbohydrate diet (SCD) that was popularized in the mid-20th century was one of the first adopted by the IBD community (particularly in Crohn's disease). The rationale behind the diet — that disaccharides and polysaccharides damage the intestinal mucosa — is not consistent with scientific principles[106]. Nevertheless, observational and RCT evidence has shown symptomatic and inflammatory responses[107–111], and a large RCT in 194 adults with Crohn's disease showed the SCD improved symptoms in half and reduced faecal calprotectin levels in 35% of a subgroup, but these rates were matched by the comparator Mediterranean diet[112]. As there was no control arm, these results could be considered to represent placebo responses or equal benefit from both diets. Marked reductions in non-digestible carbohydrates in the SCD is likely to reduce symptoms via, for example, reduced fermentation and luminal distension (as with the fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAP) diet, discussed below), but the effects of the dietary manipulation on physiology and microbiology of the gut are minimal and non-specific[110,112]. However, the most informative data were obtained during the second 6 weeks in which patients were no longer provided with their food; almost one-third of patients on both the SCD and Mediterranean diets withdrew, largely due to a lack of interest and difficulty following the diet as well as lack of response requiring drug escalation. The safety of the restrictive SCD diet has not been well-established, which is of concern, as all published data were obtained in paediatric patients who were placed on the diet for up to 48 months[108]. Assessment of the diet's nutritional adequacy is limited to analysis of eight children who had followed the diet through dietitian guidance, including meal plans[113]. Protein and most micronutrients met US recommended dietary allowances, but calcium intake was inadequate in six of eight patients, and the intakes of total carbohydrate and fibre, which was of most concern in those on the diet, were not assessed.

***Mediterranean diet.*** The Mediterranean diet comprises a high intake of olive oil and plant-based foods (fruit, vegetables, legumes, wholegrains), moderate amounts of fish, dairy products and alcohol, and limited red meat[114]. This diet has generated a lot of interest as a result of data indicating its role in IBD disease prevention (discussed in Step 4); however, data on the Mediterranean diet as an interventional diet are limited. As outlined already, an RCT provided evidence that a Mediterranean diet led to symptomatic improvement in a similar proportion of patients as the SCD, with little evidence of reduced intestinal inflammation[112]. Observational data in 153 patients with ulcerative colitis following total proctocolectomy with an ileal pouch anal anastomosis (IPAA) and pouchitis showed that a 'Mediterranean diet score' was associated with reduced faecal calprotectin levels[115]. There are strong evidence-based grounds for the use of the Mediterranean diet to treat common comorbidities in IBD, such as cardiovascular disease, non-alcoholic fatty liver disease and depression[116–118].

***Low-emulsifier diet.*** Preclinical studies investigating links between dietary emulsifiers and IBD development have implicated the emulsifier, polysorbate 80, and the texture modifiers, carboxymethylcellulose and carrageenan in the genesis of intestinal inflammation. In vitro models have shown bacterial translocation[119–121] and increasing pathogenicity of gut microbiota following polysorbate 80 and carboxymethylcellulose administration[122]. The most compelling research has shown the induction of intestinal inflammation in mice that are highly susceptible to developing colitis on polysorbate 80 or carboxymethylcellulose administration[123]. The relevance of studying polysorbate 80 is questionable given that it is rarely found in the food supply[124] and the supplemental nature of the study design poorly translates to real-world settings since the mice were continuously exposed to large doses of the pure agent, rather than the agent in the matrices of food. Carrageenan, which is known to escape small bowel digestion, induces colitis in high doses in animal models[125], and in a 1-year randomized study in patients with ulcerative colitis in remission, none of seven patients on placebo showed relapse compared with three of five patients receiving 200 mg per day supplemental carrageenan[126]. Despite this result, carrageenan is found in some EEN formulas[84] and the

clinical relevance of emulsifiers found in the food supply is still to be established.

### *Translation to clinical practice*

The only high-quality, evidence-based dietary therapies for reducing intestinal inflammation in patients with IBD are EEN and/or CDED for induction of active Crohn's disease. All other diets have insufficient evidence to support their use in an evidence-based medicine approach and should be considered CAM. Likewise, there is no dietary therapy that can be recommended for the maintenance of remission. However, a lack of robust data for many dietary therapies does not stop our patients from trying them. Although anecdotal, some diets without compelling evidence of their ability to improve outcomes in individuals with irritable bowel syndrome (IBS) might have benefits in individual patients. There is risk associated with many of the restrictive-type diets to nutrition and psychological health, with many diets promoting poor or even disordered eating behaviour, particularly as many of these diets have no defined timeframes for use.

In the modern world, patients with IBD have more ready access to CAM diets than to diets guided by dietitians, and exposure to internet-led opinion seems to dominate over exposure to proven and published dietary concepts. Awareness of risks to eating behaviours and to nutritional status are seldom promoted, and the idea that they are only diets and trying them 'can do no harm' would generally be the norm. To prevent inappropriate and potentially dangerous self-experimentation with dietary therapies, early referral to an IBD dietitian, ideally at IBD diagnosis, will foster patient education on how to judge a diet on its merits. How a dietitian should approach a patient wanting to try a CAM dietary therapy is outlined in BOX 2.

## Step 3: complications of IBD

Dietary manipulation with the guidance of a dietitian is commonly used to alleviate or prevent IBD complications not specifically related to the inflammation itself. Only aspects with newer data are discussed here.

Box 2 | **Dietetic counselling on approaching a patient wanting to try a CAM dietary therapy**

- Explain the difference between functional and inflammatory symptoms and the importance of including objective markers of inflammation in assessing response to diet, which most internet-based diets do not include.
- Counsel the patient on the risks and benefits of the considered CAM diet.
- Offer evidence-based diets as an alternative, if applicable.
- If the patient elects to try a dietary therapy, involve the attending gastroenterologist so that the relationship between the chosen diet and medical therapy can be planned, and ensure that the patient will be adequately monitored with objective markers of disease, particularly as symptom improvement might falsely reassure the patient (and treating team) that the diet has controlled the inflammation.
- Educate the patient on the implementation of the chosen diet, seek to ensure adherence in social or uncontrolled environments, monitor nutritional adequacy, preferably with assessment of body composition, and fill known nutritional gaps through oral supplementation.
- Set precise timelines for the dietary implementation with arrangement for dietary review on its completion.

CAM, complementary and alternative medicine.

### *Symptoms with a non-inflammatory cause*

A common scenario in patients with IBD concerns gastrointestinal symptoms that are out of step with the perceived degree of intestinal inflammation. Functional gut symptoms, including those of IBS, are extremely common in the general population (approximately 10% worldwide)[127,128], but are present three times more commonly among individuals with IBD and are associated with impaired health-related quality of life[129]. These symptoms are often abdominal pain, altered bowel habit (diarrhoea and/or constipation) and bloating. As all of these symptoms can be related to active inflammation of the intestine, the key to defining the appropriate management is first to determine the degree of intestinal inflammation (for example, by determining faecal calprotectin level, or by endoscopy or imaging) and secondly, optimizing anti-inflammatory therapy according to the findings. The management of symptoms is potentially multimodal as several factors might contribute to them, each with its own dietary approach. These are outlined in TABLE 4 (REF.[130]).

The value the low FODMAP diet to control functional gastrointestinal symptoms has a substantial evidence base[131,132] and the low FODMAP diet now has a place in many national guidelines for the management of patients with IBS[133,134]. In symptomatic patients with quiescent IBD, observational studies have indicated improved symptom relief in at least 50% of patients[135,136], and in an RCT including 52 patients with IBD with quiescent disease (normal faecal calprotectin levels), approximately half of the patients achieved adequate symptom relief with a low FODMAP diet[137]. The diet, however, has little discernible effect on disease activity[137,138]. The application of restrictive dietary therapy in patients with IBD cannot be taken lightly for a few reasons. First, as outlined in Step 1, these patients are often already nutritionally compromised. Second, a FODMAP diet can impair food-related quality of life[139], and the high prevalence of anxiety and depression in this patient group[140] should be taken into consideration. Third, the diet might potentially have negative effects on the gut microbiota, reducing relative abundance of bacteria with putative health benefits (such as butyrate-producing bacteria and *Bifidobacterium* spp.)[138,141], although there is no evidence of negative health outcomes to support this fear. For these reasons, expert guidance is strongly recommended and data show that supervision by a FODMAP-trained dietitian improves the quality of the diet's application and likelihood that reintroduction of foods and personalized maintenance diets be completed[142], and should prevent both further nutritional compromise and inappropriate application of the diet. An alternative approach to a strict low FODMAP diet, 'FODMAP gentle', in which approximately ten foods very high in FODMAPs have been removed[143], has been developed for the management of individuals with IBS in whom there is concern that applying a temporary strict dietary restriction might exacerbate their gastrointestinal symptoms. However, the efficacy of the gentle approach has not been formally evaluated.

The only other therapeutic diet recommended by IBD dietary guidelines[15], based on knowledge of intestinal

Table 4 | **Dietary management of potential factors contributing to non-inflammatory symptoms in IBD**

| Contributing factors | Dietary management | Rationale |
|---|---|---|
| Functional gut symptoms (including IBS-like symptoms) | FODMAP diet | RCT evidence of efficacy as for IBS in IBD population[137] |
| Hypolactasia | Reduced lactose diet | Reduce osmotic and/or fermentative effect of malabsorbed lactose[207] |
| Coeliac disease | Gluten-free diet | Removes the causal protein[208] |
| Bile acid diarrhoea | Low-fat diet | Reduces bile acid output[209,210] |
| Small intestinal bacterial overgrowth | Elemental enteral formula; FODMAP diet | Reduces the density of bacteria in the intestine[a] (REFS[211–213]) |
| Pancreatic exocrine insufficiency | Matching pancreatic enzyme replacement therapy to current fat intake; avoid excessive fat intake | Low-fat diet not indicated as restricts energy intake and risk of inadequacy of fat-soluble vitamins; dosing and appropriate timing of enzyme therapy with each meal and snack is key for optimal response[214] |
| Proximal constipation in ulcerative colitis | Dietary laxatives including osmotic laxatives (e.g. prunes) and fibre; fibre supplements that hasten transit (e.g. wheat bran); FODMAP diet | No published reports of therapy; principles of management of constipation might or might not apply |
| Intestinal stenosis | Modified-fibre, low-fibre or low-residue diet, EEN; avoid FODMAP restriction | Maintain liquidity of intestinal contents; avoid non-digestible foods |
| Pelvic floor dyssynergia | Fibre supplements tailored to attain good consistency of faeces | Prevent hard stool that is difficult to pass[215] |

EEN, exclusive enteral nutrition; FODMAP, fermentable oligosaccharides, disaccharides, monosaccharides and polyols; IBD, inflammatory bowel disease; IBS, irritable bowel syndrome; RCT, randomized controlled trial. [a]Documented in faeces; assumed to occur in small intestine.

physiology rather than trial evidence, is a modification of fibre intake in patients with strictures to avoid bowel obstruction (TABLE 4). Over the decades, the custom of applying a low-residue diet across all patients with IBD has gradually reduced, due to evidence for the value of better and more targeted strategies[15]. Despite this aspect, many IBD-related patient advocacy groups and clinicians still recommend the use of fibre restriction during a flare. Evidence for the use of fibre restriction to control symptoms other than in those with strictures and obstructive symptoms is lacking and its use is not recommended nor is it supported by IBD guidelines.

Other diets have been used in symptomatic patients with IBD. In a survey in 145 patients with IBD, almost one-third of patients considered themselves to be gluten-sensitive[144], 20% had tried a gluten-free diet at one time and approximately 6% followed the diet[59,144,145]. However, the gluten story is not clearcut, with a New Zealand survey-based study in 256 patients with IBD showing that over half of patients associated wholegrain wheat bread with symptom onset and exacerbation, but one-third of patients associated white bread with a reduction in their symptoms[146]. Whether avoidance of wheat and/or gluten or whether the concomitant reduction in FODMAPs is causally linked to the self-reported benefits of a gluten-free diet in patients with IBS and self-reported gluten sensitivity[147], or neither, is not known.

### *Nutrition for surgical considerations*

It is well-established that good nutritional status before surgery improves surgical outcomes[148]. Formal Enhanced Recovery After Surgery (ERAS) programmes, which aim to reduce surgical stress, maintain postoperative physiological function and enhance mobilization after surgery, have been used in the management of patients undergoing colorectal surgery for many years[149], with good efficacy in reducing postoperative morbidity and mortality, and their use is supported by authoritative guidelines[150]. An ERAS programme specific for elective colorectal surgery is described elsewhere[150].

Specifically in 61 patients with IBD scheduled for elective surgery, the ERAS protocol promoted increased weight (particularly fat-free mass), and body composition was maintained at 4 weeks after surgery[21]. Resumption of oral feeding, starting with clear fluids for 1 day, then variations of low-residue diets were thought to be associated with the observed short hospital length of stay and fast recovery of bowel function, but this aspect has not been confirmed with a control comparator[21]. Application of the ERAS protocol is supported by the European Society of Coloproctology–European Crohn's and Colitis Organisation committee for surgery in Crohn's disease[151], but apparently not for ulcerative colitis. Also in line with ERAS in those scheduled for elective surgery, EEN has been effective not only in improving nutritional status and improving complication rates but also in reducing the burden of inflammatory disease[152–155]. Indeed, in one retrospective case–control study of the use of EEN in 51 adults with Crohn's disease, 25% of patients avoided their planned surgery completely[152].

### *Postsurgical states*

There is no specific diet that is recommended for a patient with ileostomy and colostomy, but food avoidance is common, mainly to reduce gas and output[156], and survey data from individuals with an ileostomy who had received dietary advice from a stoma nurse, dietitian, surgeon, support association and/or stoma product supplier, felt the advice was conflicting[157]. There has been little development in research related specifically to the role of diet in patients with a stoma, besides the potential for a low FODMAP diet to reduce high outputs and fluid and sodium manipulation essential in those with a high-output ileostomy[15].

Many patients with an IPAA experience increased stool frequency, urgency, incontinence and seepage, with symptoms persisting overnight, and up to 50% of patients develop pouchitis by 10 years[158,159]. Antibiotic therapy remains the first-line therapy for pouchitis, suggesting a microbial component in its pathogenesis and, therefore, an avenue for the use of diet as therapy, given its ability to influence pouch microbial composition and metabolic activities. Evidence to date is comprehensively reviewed elsewhere[160].

In patients with an IPAA, intake of at least 1.5 servings of fruit daily protected against pouchitis at 12 months,

but vegetable or grain intake did not[161]. Another cross-sectional study showed that adherence to a Mediterranean diet was associated with lower rates of pouchitis[115]. The evidence for the role of diet as a treatment for active pouchitis remains equivocal, with three small studies showing that EEN and inulin supplementation have variable effects on clinical symptoms and limited effects in changing inflammatory markers[162–164].

### *Disordered eating behaviour*

Awareness by gastroenterologists of conditions associated with abnormal eating patterns has been highlighted as very poor[165]. 'Disordered eating' is a descriptive term that refers to irregular or maladaptive eating behaviours or habits that can have nutritional and psychosocial implications. 'Eating disorders' are diagnoses characterized by severe and persistent disturbance in eating behaviours together with distressing thoughts and emotions through specific diagnostic criteria. Specific conditions include anorexia nervosa, which is driven by an intense fear of gaining weight or becoming fat, and avoidant restrictive food intake disorder (ARFID), which involves a disturbance in eating resulting in persistent failure to meet nutritional needs often associated with interference with social functioning (such as inability to eat with others)[166]. Disordered eating is likely to have a spectrum of severity and, given the high prevalence (up to about 80%[167]) of food avoidance and restrictive dietary behaviours seen in IBD, this issue is a concern. Restrictive dietary habits in IBD are associated with impairment of food-related quality of life[168] and impaired nutritional status. Additionally, it should be noted that dietary restrictions for symptoms can worsen food-related quality of life[169].

Current eating disorder screening tools might be unsuitable for use in patients with IBD as the questions relate to food restriction, which might not consider restrictions that are necessary as part of IBD management[170]. Indeed, fear of symptoms from eating was identified as a reason for ARFID in 108 outpatients with IBD, which might a be different intention for restriction compared with those with an eating disorder in the wider community[171]. However, studies involving the formal psychiatric evaluation of adult and paediatric patients with IBD have shown that the risk of eating disorders is at least 30% greater than in the general population and siblings without IBD, whilst the absolute risk remains small[172,173]. Development and validation of a tool that takes symptoms into account when diagnosing eating disorders in patients with gastrointestinal disease are much needed.

In patients with IBD, there are many drivers for dietary change that are also considered risk factors for disordered eating, including fear of symptoms from eating and reduced appetite[171]. Patients with IBD have many of the confounding traits commonly seen in patients with eating disorders, including anxiety, depression, presentation at a young age, self-initiated diets, preoccupation with diet, poor body image and/or shame (particularly those with a stoma) and limited social networks[173,174]. The sources of dietary information are varied and the information is often conflicting and misleading, which, combined with dietary beliefs, creates confusion[168]. A qualitative study in 28 patients with IBD found specialist dietitian supervision was very uncommon amongst patients with IBD restricting their diet[175]. Furthermore, anorexia nervosa might be driven by the elevation of circulating cytokines, such as IL-6, which stimulates leptin sensitivity at the hypothalamus, driving satiety, and TNF promotes the action of anorexigenic peptides, as seen in studies in humans[176,177].

### *Translation to clinical practice*

The management of bowel symptoms that are not related to inflammation is often just as important clinically as the management of active disease, particularly given the widespread prevalence of functional and obstructive symptoms and their impact on quality of life. Emerging literature suggests that the management of IBD complications should be dietitian-led, as described in BOX 3.

## Step 4: preventing disease development

If diet is a key environmental factor in the genesis of IBD, then it is desirable that those at risk of developing IBD (for example, first-degree relatives of patients with IBD) be advised regarding appropriate dietary intake and habits for preventing its development. There are many studies that have investigated the association between diet and IBD, but the results of these studies are heterogeneous and inconsistent, and provide few insights, as reviewed elsewhere in detail[178].

Defining pre-disease dietary factors is determined via large prospective epidemiological cohort studies in which food intake is repeatedly assessed (via the Food Frequency Questionnaire) in a healthy population that is followed for decades for disease development. Examples are the Nurses' Health Studies (NHS I and II), the European Prospective Investigation into Cancer and Nutrition (EPIC), the Cohort of Swedish Men (CoSM), the Swedish Mammography Cohort (SMC), the Health Professionals Follow-up Study (HPFS), and the Danish Diet, Cancer and Health Cohort (DDCH). Limitations of these studies are that they are conducted in healthy adults with a median age above the high-risk peak age of IBD onset, only causal relationships between nutrient and disease are able to be established and little insight is provided on potential dietary therapies for established

Box 3 | **Dietitian-led management of common IBD scenarios**

- Functional gut symptoms: FODMAP modification for functional gut symptoms.
- Obstructive symptoms: varying degrees of fibre modification for obstructive symptoms seen in stricturing disease.
- Planned surgery: optimization of nutritional status (via oral, enteral or parenteral nutrition), ERAS programme, including consideration of exclusive enteral nutrition in Crohn's disease, when feasible.
- Ileoanal pouch: dietary manipulation for symptoms should be considered, but further research is needed for clear recommendations.
- Disordered eating: awareness by attending physicians needs to be improved; all patients who have changed their diet should be assessed by a gastrointestinal dietitian and referred for mental health support if risk of eating disorders is suspected.

FODMAP, fermentable oligosaccharides, disaccharides, monosaccharides and polyols; ERAS, enhanced recovery after surgery; IBD, inflammatory bowel disease.

disease. For example, dietary fibre seems to be protective against the development of Crohn's disease[179,180], yet formulas used in EEN are fibre-free[84].

There are two broad approaches that have been applied to the analysis of such prospective population data: associations with specific food types and/or dietary components, and examining dietary patterns, in which multiple dietary factors are captured using a dietary pattern assessment tool. As reviewed in detail elsewhere, protein from meat, *trans*-fatty acids, ω-6 fatty acid and sweetened beverages are associated with the onset of ulcerative colitis[181–186], but oleic acid is protective[182]. In patients with Crohn's disease, protein intake double that of most dietary guidelines is associated with disease development[183], as is ultra-processed food (associated with a 40% increased risk of development)[187,188], but docosahexaenoic acid, dairy products, total fibre and certain polyphenols found in certain herbs, grapes and wine are protective[179,180,185,189–191]. However, inconsistencies exist. For example, 'fibre' was protective against Crohn's disease in both the NHS and EPIC cohorts, but total fibre and fibre from fruit, not cereals or vegetables, was protective in the NHS study, whereas fibre from cereals only was protective in the EPIC cohort. In ulcerative colitis, sweetened beverages were not associated with disease onset in the Swedish studies but were a risk factor in the EPIC cohort. Ultra-processed foods were not associated with developing ulcerative colitis in a prospective cohort study in 245,112 people with 488 incidence cases of ulcerative colitis[187]. It is important to be aware of the limitations of epidemiological data collection and analysis, including the hazard of confirmation bias in interpreting such data.

The second approach is to examine dietary patterns in which multiple dietary factors are captured, and a comprehensive assessment of diet is provided to account for complex interactions between nutrients and foods. This approach can be made *a priori*, in which indices or scores developed between diet and disease (for example, the Mediterranean diet score) are examined, or using an *a posteriori* approach, in which indices (for example, the Empirical Dietary Inflammatory Index (EDII)) are developed by statistical evaluation of associations with inflammatory markers (such as CRP and circulating cytokines levels) in the healthy population, and then the associations between the inflammatory indices and the development of IBD in the prospective cohort are determined.

The Mediterranean diet has received attention since, collectively, the dietary traits associated with protection from Crohn's disease — heavily plant-based, minimal in meat and moderate in dairy and fish — mimics such a diet[192]. Two prospective cohort trials have investigated the Mediterranean diet with different findings. A Swedish study ($n = 83{,}147$) found that a diet with a score reflecting a more Mediterranean-like diet protected against the development of Crohn's disease, but not ulcerative colitis[193], which contrasted with no association in the EPIC cohort. However, the Mediterranean diet scores used differed between the studies; in the study showing benefits of a Mediterranean-like diet, dairy products positively contributed to the score[193], whereas dairy products led to point deduction in the study showing no association[194].

The EDII was developed from NHS I and subsequently validated in NHS II and the HPFS. It defined 18 food groups that were positively or negatively associated with circulating inflammatory markers[195]. Individuals with EDII scores in the highest quartile had an increased risk of developing Crohn's disease (HR 1.51 relative to those in the lowest quartile), but there was no association with ulcerative colitis. However, the details revealed some surprising correlations, which are not in line with accepted principles of healthy eating. For example, some discretionary food groups, such as beer and pizza, had strong negative associations with Crohn's disease, and some whole foods, such as certain fish and vegetables, were positively associated[195]. This finding could be due to the choice of food groupings, some of which seem ambiguous. Examples include 'snacks', which is vague in food description and arguably could include fruit through to confectionery, and 'pizza', which had the strongest negative weight in the score. Indeed, the application of EDII across seven low-income to high-income countries found no association between EDII scores and Crohn's disease or ulcerative colitis development[196].

### *Translation to clinical practice*

Prospective epidemiological studies have provided evidence for a role of dietary intake, with respect to both patterns and specific foods and/or components, in the development of Crohn's disease, but less so for ulcerative colitis. Unfortunately, translation of details to actual preventive dietary advice is challenging with the potential of confirmation bias. Although the data might support a protective effect of dietary fibre and possibly a Mediterranean-style diet against Crohn's disease, such a conclusion is heavily supported by current dogma on healthy eating guidelines. If details are considered rather than concepts alone, one might recommend eating lots of snacks and pizza to prevent Crohn's disease, recommendations that clearly are contrary to current beliefs on healthy eating. Prospective comparative long-term population dietary interventional studies might provide more clarity, but whether they can ever be feasibly mounted to provide quality evidence is doubtful. Recommendations should therefore default to healthy eating guidelines.

## Conclusions

Diet has become an essential part of multidisciplinary IBD management through the disease course, from prevention of IBD development to treatment of active disease and complications of the disease, including malnutrition. A step-wise approach, as summarized in FIG. 1, has many advantages and should be directed by both the gastroenterologist and dietitian and supported by the wider team, to adequately assess the patient, in terms of nutritional status and food intake and/or eating behaviour, and, if appropriate, to tailor dietary therapy to reduce inflammation, relieve symptoms and improve nutrition and many other clinical outcomes.

Published online: 16 May 2022

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**Acknowledgements**
J.A.F. is supported by a Monash University Australian Postgraduate Award and Crohn's & Colitis Australia PhD Scholarship, S.L.M. is supported by an Alfred Research Trusts Small Project Grant, C.K.Y. is supported by a Crohn's & Colitis Australia Angela McAvoy Scholarship, E.P.H. is supported by the Crohn's & Colitis Foundation Litwin IBD Pioneers Program and a National Health & Medical Research Council Investigator Grant. The authors thank M. Justice for help with designing the initial draft of the figures.

**Author contributions**
The authors contributed to researching data, writing, and reviewing/editing the manuscript before submission. J.A.F., S.L.M., P.R.G. and E.P.H. were involved in discussion of content of the article.

**Competing interests**
P.R.G. has published a book on food intolerances. The Department of Gastroenterology has published an App, booklets and online educational courses on the Monash University FODMAP Diet, the proceeds of which go to the Department, not to individuals. The other authors declare no competing interests.

**Peer review information**
*Nature Reviews Gastroenterology & Hepatology* thanks Henit Yanai, who co-reviewed with Lihi Godny; Catherine Wall; and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.