British Journal of Nutrition (2026), 135, 546–558 doi:10.1017/S0007114524001338
© The Author(s), 2024. Published by Cambridge University Press on behalf of The Nutrition Society. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

A personalised nutrition intervention for adolescent depression: a mixed-methods feasibility pilot study

Susan C. Campisi[1,2], Megan Liang[1], Samantha J. Anthony[3,4], Elizabeth Dettmer[5,6] and Daphne J. Korczak[1,7]*

[1]*Neuroscience and Mental Health, The Hospital for Sick Children, Toronto, Canada*
[2]*Nutrition and Dietetics Program, Clinical Public Health Division, Dalla Lana School of Public Health, University of Toronto, Toronto, Canada*
[3]*Child Health Evaluative Sciences Program, The Hospital for Sick Children, Toronto, Canada*
[4]*Factor-Inwentash Faculty of Social Work, University of Toronto, Toronto, Canada*
[5]*Department of Psychology and the Healthy Living Clinic, The Hospital for Sick Children, Toronto, Canada*
[6]*Department of Paediatrics, Temerty Faculty of Medicine, University of Toronto, Toronto, Canada*
[7]*Department of Psychiatry, Temerty Faculty of Medicine, University of Toronto, Toronto, Canada*

(Submitted 17 January 2024 – Final revision received 21 June 2024 – Accepted 31 July 2024 – First published online 29 October 2024)

Abstract

Randomised controlled trials have demonstrated the benefit of diet modification to improve diet quality in the treatment of adult major depressive disorder (MDD). However, research examining nutritional interventions for adolescents with MDD is sparse. This pilot study examined the feasibility of a personalised nutrition intervention for adolescents with MDD. Ten adolescents with MDD and their parents recruited from a tertiary care setting participated in an 8-week, single-arm mixed-methods study. Feasibility was assessed using five criteria (demand, acceptability, implementation, adaptation and limited efficacy testing) alongside qualitative interviews. The intervention involved four bi-weekly virtual nutrition counselling sessions with a stepped approach to dietary change, menu planning, grocery delivery and educational eHealth messages. Study participants sought positive changes in diet, health and lifestyle for adolescents and family-wide benefits. Recruitment challenges included concerns about managing mood fluctuations, anticipated dietary restrictions and the potential time and effort required for diet adherence. Feedback based on interviews emphasised moderate to high acceptability, satisfaction with menu planning and counselling and recognition of the benefits of trying new foods and sustaining positive dietary changes beyond the study. Improvements in depression symptoms (Cohen's $d = 0{\cdot}36$, 95 % CI (–0·24, 3·36)), parent food modeling (Cohen's $d = 0{\cdot}24$, 95 % CI (–0·43, 1·16) and the family food environment (Cohen's $d = 0{\cdot}61$, 95 % CI (–0·04, 2·61)) were observed. This nutrition intervention was feasible for adolescents with MDD and was acceptable to both parents and depressed adolescents. These preliminary data suggest that further examination of the intervention and its potential benefits on depression symptoms and family food dynamics are warranted.

Keywords: **Dietary intervention: Pilot: Adolescents: Depression**

Depression is a major contributor to the global disease burden[1,2]. With an estimated worldwide prevalence of 31·53 million cases (95 % CI: 27·2, 36·5), depression impacts physical and mental well-being, leading to socio-economic consequences, reduced quality of life and an increased burden on healthcare systems[3]. As approximately 70 % of adult mental health disorders, including depression, emerge in childhood or early adolescence[4], the public health impact of adolescent-onset depression may be even greater, as depression is both an independent source of impairment as well as a risk factor for other chronic health conditions later in life (e.g. obesity, type two diabetes mellitus, ischaemic heart disease)[5–7]. Despite advances in treatments, many children and adolescents do not respond to first-line depression treatment(s), and treatment resistance occurs in 30–40 % of cases[8]. As highlighted by the 2018 Lancet Commission on Psychiatry and the 2021 State of the World's Children Report, there is an urgent need for innovative therapeutic interventions for children and adolescents with depression[9,10].

Diet modification offers promise in improving both mental and physical health. Lifestyle factors such as healthy eating have been shown to play a pivotal role in the treatment and prevention of numerous non-communicable chronic diseases, and their impact on mental health is being increasingly

Abbreviations: AIM, acceptability of intervention measures; FIM, feasibility of intervention measures; MDD, major depressive disorder.

* **Corresponding author:** Daphne J. Korczak, email daphne.korczak@sickkids.ca

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

recognised[11,12]. Some of the physiological pathways hypothesised to be affected by diet in relation to depression include oxidative stress[13], inflammation[14,15], mitochondrial function[16], the gut microbiome (via the gut–brain axis)[17] and disruptions of tryptophan–kynurenine metabolism[18]. Research in adults has demonstrated an association between greater adherence to healthy diets, such as the Mediterranean diet and reduced depressive symptoms[19–22]. In addition, greater adherence to healthy dietary patterns is associated with lower depressive symptoms among both clinical and community-based samples of adolescents[21,23,24] and adults[21,25,26]. Moreover, among adolescents with major depressive disorder (MDD), lower dietary quality is associated with higher depressive symptoms[27].

As adolescence is a developmental period during which dietary habits become entrenched[28], and as unhealthy dietary patterns track between adolescence and adulthood[29,30], the period of adolescence represents a potential window of opportunity for intervention to improve eating behaviours lifelong. However, factors that influence adolescent food choices are complex and are also nested in family factors, such that interventions targeting adolescent dietary patterns must also be multifaceted. Thus, nutrition interventions should encompass the adolescent food environment and include elements that address nutrition literacy[31], family eating habits and practices[32,33], peer influences[34], school environments[35] as well as broader cultural and societal norms[36,37].

The overarching objective of this study was to assess the feasibility of a novel personalised nutrition intervention for adolescents with MDD using a mixed-methods study design. The secondary objective was to gather preliminary data to inform a larger, appropriately powered study to test the personalised nutrition intervention's effectiveness in improving dietary intake and depressive symptoms.

Methods

Study design

This 8-week open, single-arm study assessed the feasibility of implementing a personalised nutrition intervention, based on the principles of a Mediterranean diet, among adolescents with MDD. The study combined quantitative and qualitative data to more completely evaluate the intervention and the study protocol[38].

This study was approved by The Hospital for Sick Children Research Ethics Board #1000079300 on March 20, 2022. Recruitment and intervention delivery occurred from May 2022 to July 2023. All adolescents and their guardians provided written informed consent. The study was registered at the US National Institutes of Health (ClinicalTrial.gov) #NCT06175052.

Participants

The study recruited ten adolescent–parent dyads. Adolescents were recruited from the Children's Integrated Mood and Body (CLIMB) depression program at The Hospital for Sick Children (SickKids), a tertiary care children's hospital in Toronto, Canada. The CLIMB programme receives referrals from primary care clinicians in the community via the centralised intake programme in the outpatient psychiatry department at SickKids. Adolescents referred to the CLIMB programme undergo semi-structured diagnostic interviews by a trained staff member using the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS)[39], and psychiatric diagnoses, including MDD, are confirmed following a review with a child and adolescent psychiatrist. Dyads who expressed interest in participating in the current study provided their consent and completed screening questionnaires to determine their eligibility. Participants received usual clinical care during the study. Details regarding the CLIMB programme have been published elsewhere[40].

Study inclusion criteria were the following: adolescent age 11–17 years; diagnosis of MDD as defined by the Diagnostic and Statistical Manual for Mental Disorders 5th edition (DSM-5)[41]; access to the internet and a computer or smartphone and a parent willing to participate. Adolescents were excluded if they already adhered to a high-quality diet (i.e. a score ≥ 8 on the KIDMED[42]); met the criteria for an eating disorder based on the K-SADS[39] semi-structured interview; were currently participating in other dietary programs or studies or were actively attempting to increase or decrease body weight; had a chronic medical condition not including MDD or had an unstable psychiatric disorder (e.g. manic symptoms, active suicidal ideation). Parents and/or legal guardians of adolescents were eligible to participate if they lived with the adolescent at least half of the time and had access to the internet and a computer or smartphone.

Sample size

This study, designed to assess the feasibility of a dietary intervention for adolescents with depression, employed a sample of ten participants. Other feasibility studies conducted among adolescents with depression use similar sample sizes ranging from 10 to 13 participants[43–45]. This feasibility stage focussed on gathering initial data regarding participant recruitment, intervention adherence and data collection procedures. A sample size of ten enabled evaluation of these aspects and will inform the design of a future pilot study with a more robust sample size capable of yielding statistically significant results.

Study procedure

Following enrollment, adolescents and parents completed independent pre-intervention interviews. Adolescents completed baseline questionnaires about depression symptoms, dietary intake, nutrition knowledge and attitudes, parental food modelling as well as perceived intervention acceptability and feasibility. Parents completed baseline questionnaires about the family food environment and perceived intervention acceptability and feasibility.

Following the assessment, participants began the 8-week personalised nutrition intervention. Nutrition counselling session feedback was obtained via a questionnaire after each session. In Week 5 and Week 9 (1 week post-intervention), adolescent self-report and parent-report measures were repeated. Adolescents and parents completed independent post-intervention interviews following the completion of the

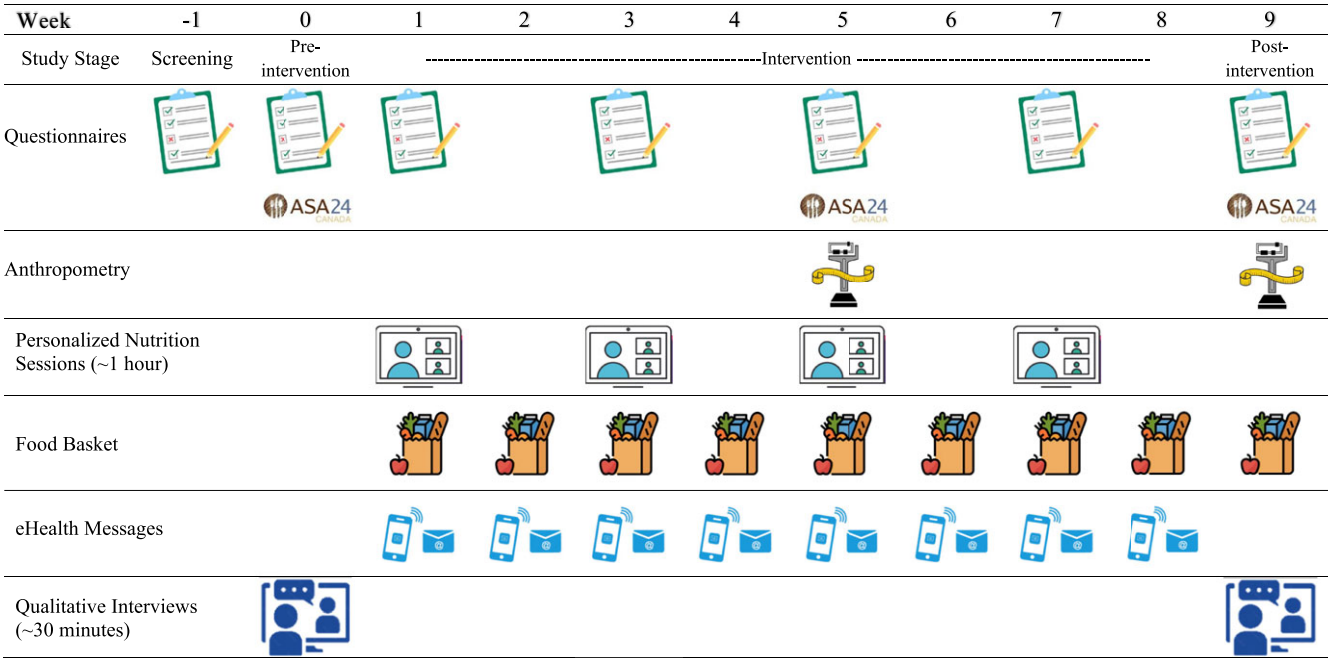


Fig. 1. Schedule of study assessments and activities.

intervention to elicit further feedback about their experiences. The study procedure is further detailed in Fig. 1.

Personalised nutrition intervention

The personalised nutrition intervention included four virtual nutrition counselling sessions, provided every 2 weeks for 8 weeks. The nutrition counselling sessions followed a structured five-step approach known as the 5A's (Assess, Advise, Agree, Assist and Arrange)[46]. At each nutrition counselling session, adolescent–parent dyads and the nutrition counsellor collaboratively set one nutrition goal (i.e. eating two or more servings of fruit per day) and one eating behaviour goal (i.e. eating breakfast regularly). A 1-week personalised menu plan was then co-created based on the principles of the Mediterranean diet (i.e. higher intake of fruit, vegetables, grains, legumes and lean protein and lower intake of red meats and processed foods) for use over the following 2 weeks, using 'That Clean Life' menu planning software[47]. Participants also received weekly grocery deliveries containing food items from the menu plan and weekly eHealth messages by email. The eHealth messages were tailored to reinforce the principles of a high-quality diet. An additional grocery delivery was sent to each dyad after completing the post-intervention assessments.

Quantitative measures

Quantitative measures were administered using REDCap[48], a secure web-based platform for data collection, with the exception of the 24-h dietary record, which was accessed via the secure website link[49].

Adolescent depression. Depression symptoms were assessed using the Centre for Epidemiological Studies Depression Scale for Children (CES-DC), a validated twenty-item self-report measure[50]. Participants rated their symptoms on a four-point Likert scale, with higher scores indicating more severe depression symptoms and a maximum total score of 60.

Dietary assessment. Adolescents' adherence to the personalised nutrition intervention was assessed using the KIDMED questionnaire, a sixteen-item self- or interviewer-administered measure[42]. Items related to lower adherence are assigned a value of –1 (4 items), and those related to higher adherence are assigned a value of +1 (12 items). Scores range from 0 to 12. A total score of ≤ 3 indicates poor adherence; a score of 4–7 indicates moderate adherence and a score of ≥ 8 indicates high adherence.

The intended method for assessing diet quality was the Healthy Eating Index-2015 (HEI-2015).[51] Two 24-hour dietary recalls at each time point were obtained using the National Cancer Institute's Automated Self-Administered 24-hour (ASA-24) Dietary Assessment, a validated instrument that employs the Automated Multiple-Pass Method[49]. The ASA24 instrument has been shown to be a valid measure of dietary quality that is sensitive to change in studies of short-term (4–8 weeks) dietary interventions in adolescents and adults.[52–56] The HEI-2015 is a scoring system based on density rather than quantity, with values ranging from 0 to 100. Total scores over 80 are categorised as good quality diets, those with scores 51–79 as needing improvement and those with scores ≤ 50 as being of poor quality. The HEI-2015 includes thirteen subgroups categorised into adequacy components and moderation components. Adequacy components are foods and nutrients that are encouraged, and higher scores reflect higher intakes. Moderation components are reverse-scored since they include foods and nutrients with recommended limits. Higher

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

moderation scores reflect lower intakes since lower intakes better align with recommendations.

Anthropometry. Pre-intervention BMI data were obtained from standardised assessments during clinic visits, as detailed elsewhere[40]. To evaluate the feasibility of including body weight data within the study protocol, participants were instructed to weigh themselves while wearing light clothing with a parent present, using their home scales. Self-reported weights were measured in duplicate and submitted electronically via REDCap.

Nutrition attitudes and knowledge. We assessed nutrition attitudes and knowledge using a Nutrition Attitudes and Knowledge (NAK) questionnaire, designed to evaluate children's understanding of the 2019 Canada Food Guide[57]. The questionnaire consists of four five-point Likert scale questions to measure positive attitudes about nutrition, as well as twenty multiple-choice and true/false questions related to Canada Food Guide food groups (drinks, whole grain foods, vegetables and fruit and protein foods).

Parent food modelling. Parental food modelling was evaluated with five items adapted from Cullen's scale, each rated on a four-point Likert scale from 'Never' to 'Always,' which has been used to predict diet outcomes in adolescent samples[58].

Family food environment. Parents used the Family and Nutrition and Physical Activity questionnaire, a twenty-item tool on a four-point Likert scale, to assess their family's food environment and practices. Higher scores indicate healthier home food environments[59].

Acceptability and feasibility of intervention measures (AIM and FIM)[60]. The AIM and FIM are self-reported four-item measures that are scored using a five-point Likert scale ranging from 'completely disagree' (1) to 'completely agree' (5) with higher scores indicating greater acceptability or feasibility. While there are no established cut-off scores for interpreting AIM and FIM data, most research evaluates the intervention's reception by examining mean scores[61]. The maximum score achievable for each measure is 20. Higher mean scores for each item (closer to 5) indicate greater acceptability and feasibility.

Satisfaction with the menu planning and nutrition counselling was rated by parents and adolescents independently following each counselling session using a five-point Likert scale ranging from 'very dissatisfied' (1) to 'very satisfied' (5).

Qualitative interviews

Semi-structured interviews were conducted using an interview guide and recorded virtually by members of the research team. The pre-intervention interview probed reasons for study participation and potential concerns, perceptions of the personalised nutrition intervention, participants' expectations of the study and motivation for enrollment. The post-intervention interview asked participants about their perspectives of the intervention as a whole and its individual components, including the nutrition counselling sessions, grocery delivery and eHealth messages. Participants were also asked about the factors that either hindered or facilitated their adherence to the personalised nutrition intervention.

Feasibility measures

Feasibility was evaluated based on the following key focus areas as delineated by Bowen *et al.*[62] – demand, acceptability, implementation, adaptation and limited efficacy testing. Qualitative interviews with youth and parents were integrated to enrich quantitative data for a more robust overall feasibility evaluation[63].

1. *Demand,* the extent to which the intervention would be accessed by adolescents with MDD, was measured quantitatively with the recruited rate. The recruitment rate was defined as the number of dyads enrolled in the study divided by the number of dyads approached to participate in the study. Demand was also assessed through pre-intervention qualitative interviews.

2. *Acceptability,* the extent to which the intervention was judged to be suitable to dyads, and fit with daily life activities, was assessed using the AIM. Acceptability was also assessed using post-intervention qualitative interviews. Satisfaction with the menu planning and nutrition counselling sessions was assessed using the quantitative satisfaction scores, and through post-intervention qualitative interviews.

3. *Implementation*, the degree to which the intervention and questionnaires can be delivered as proposed, was assessed using the FIM and by intervention adherence, participant attrition and the completion rate of the quantitative measures. Adolescent dietary adherence was assessed using the KIDMED questionnaire. The attrition rate was defined as the number of dyads who started the intervention divided by the number of dyads who completed the study, expressed as a percentage. The degree of missingness examined the proportion of missing data (i.e. potentially indicative of questionnaire fatigue or objectionable/unclear items).

4. *Adaptation*, the need to make intervention or procedural changes, was assessed through the qualitative interviews conducted post-intervention.

5. *Limited efficacy testing*, considered whether the intervention led to changes in depression symptoms at the mid-point and post-intervention. Limited efficacy was also assessed for secondary outcomes, including adolescent nutrition attitudes and practices, parent food modelling and the family food environment.

Data analysis

The analyses were descriptive and exploratory. Quantitative continuous data were reported as means and standard deviations; categorical data were reported as frequencies and proportions. Qualitative data obtained through audio-recorded, semi-structured interviews were transcribed verbatim, de-identified and subject to inductive thematic analysis using NVivo12 software[62,63]. The thematic analysis procedure followed the guidelines outlined by Braun and Clarke (2006)[64]. Initially, each member of the research team conducted an independent review of the transcripts to immerse themselves in the data and gain a comprehensive understanding. Subsequently, individual team members created initial codes, which were later collectively compared and synthesised to form

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

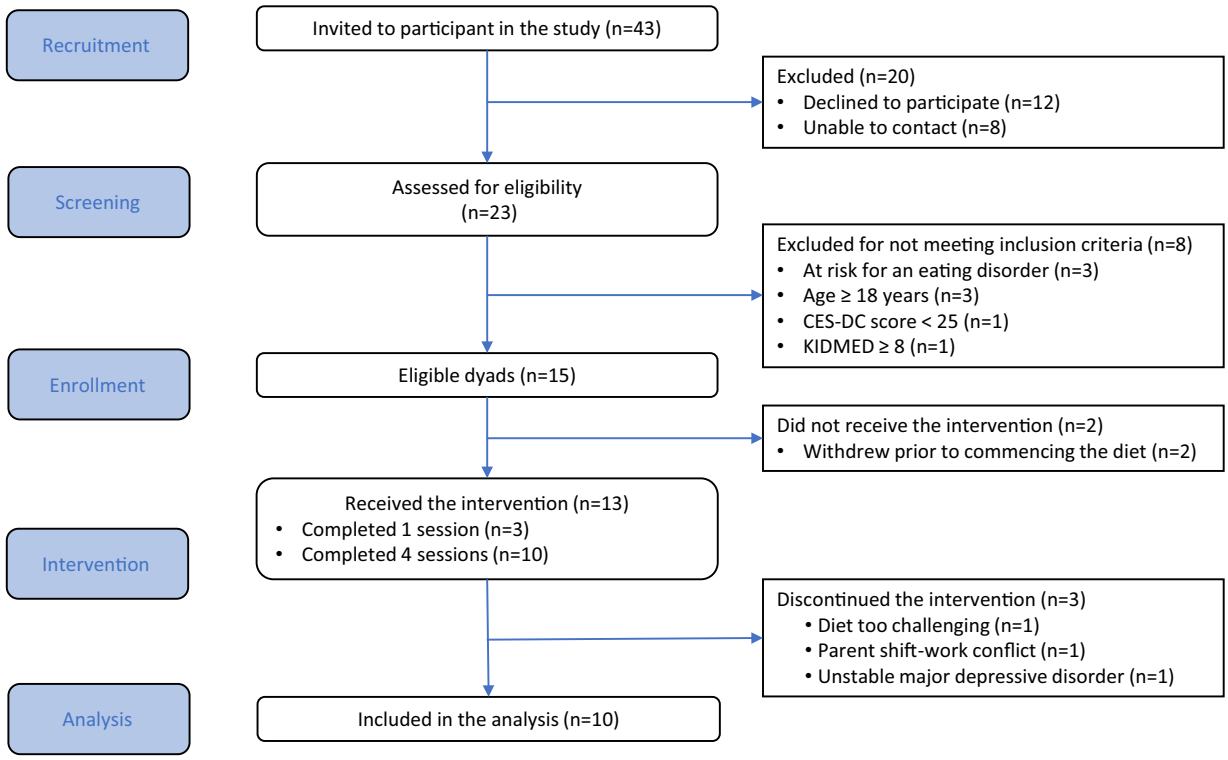


Fig. 2. CONSORT participant flow diagram.

overarching themes through collaborative discussions. Upon achieving consensus on the most representative themes and subthemes, excerpts were selected from the transcripts to support and illustrate each theme.

Limited efficacy testing was conducted through reported means, standard deviations (SD), effect sizes (i.e. Cohen's *d*) and 95 % CI. As this current study was not powered for hypothesis testing, effect sizes are reported to communicate the size and the direction of the potential treatment effect[65]. We used the guidelines by Cohen to interpret the magnitude of the effect sizes, namely small (0·2), moderate (0·5) and large (0·8)[66]. All quantitative analyses were performed using R statistical software[67].

Results

Forty-three adolescent–parent dyads were approached to participate in the study, twenty were not interested or did not respond to the invitation and eight did not meet the eligibility criteria. Fifteen dyads consented to participate in the study. Two dyads withdrew prior to commencing the study, and three dyads withdrew after completing one session: one found the diet too challenging and two withdrew for unrelated reasons (Fig. 2). Participating adolescents (n 10) had a mean age of 15·3 (SD = 1·4) years and were 100 % female. Participant characteristics are presented in Table 1. The study was well-tolerated with no adverse events reported.

Feasibility outcomes

Demand. Of the forty-three adolescent–parent dyads that were approached to be part of the study, fifteen consented to be part of the study, resulting in a recruitment rate of 40 % (see flow diagram, Fig. 2). Pre-intervention interviews offered further insight into reasons for participating in the study and anticipated barriers to study participation (Table 2).

Motivations for study participation were categorised into six subcategories (labelled 1·1–1·6). Firstly (1·1), parents (n 3) and adolescents (n 2) highlighted the perceived benefits for the entire family, emphasising the belief that involvement in the study would bring positive changes not only to adolescents but also to the well-being of the family as a whole. Secondly (1·2), parents (n 1) and adolescents (n 4) expressed hope for potential improvements in their adolescents' eating habits and considered study participation as a means to positively influence adolescents' dietary choices. Thirdly, parents (n 3) and adolescents (n 1) reported that another motivating factor for study participation was their desperation to improve depression symptoms (1·3). Parents (n 4) also expressed a strong desire for adolescents to become more self-aware of their eating habits (1·4) and saw the study as an opportunity to foster greater self-awareness and healthier eating choices. Some adolescents (n 3) and parents (n 1) reported more altruistic motives, expressing a desire for their participation to benefit not only themselves but also others who might be in a similar situation in the future (1·5). Lastly, adolescents (n 3) expressed genuine interest in learning about nutrition (1·6), highlighting curiosity and eagerness to expand their knowledge in this area.

Participants also identified anticipated barriers to intervention adherence, which were categorised into two subcategories (labelled 2.1 and 2.2). The first subcategory (2·1), anticipated barriers to intervention adherence, encompassed a range of potential practical difficulties. Parents (n 5) and adolescents (n 4)

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

Table 1. Participant characteristics (Mean values and standard deviations; Numbers and percentages)

Characteristic	Mean	SD
Adolescent (*n* 10)		
Age (years)	15·3	1·4
Sex (% female)	10	100
Anthropometry		
BMI (pre-intervention)	21·3	2·7
Race/ethnicity		
White/Caucasian	5	50
Mixed	2	20
South Asian/Asian	2	20
Other	1	10
	n	**%**
Gender		
Cis female	7	70 %
Did not respond	3	30 %
Sexual orientation		
Heterosexual	3	30 %
Non-heterosexual	3	30 %
Did not respond	4	40 %
Living situation		
Two parent household	5	50 %
Single parent household	5	50 %
Parent (*n* 10)		
Relationship to youth		
Mothers	7	70 %
Fathers	3	30 %
Household income		
< CAD 75 000/year	3	30 %
> CAD 75 000/year	3	30 %
Prefer not to answer	4	40 %

CAD, Canadian Dollar.

were concerned about managing fluctuations in the adolescent's mood, potential distractions from friends, deviation from current eating habits, intervention duration and potential scheduling conflicts with family activities such as summer holidays during the summer months, or extracurricular engagements during the school year. The second subcategory, dietary preferences (2·2), centred only on adolescents' concerns (*n* 2) that they may not like the food that comprised the nutrition intervention, due to their self-professed pickiness as eaters.

Acceptability. Acceptability was determined using the AIM and qualitative interviews. All adolescents and their parents completed the AIM questionnaires pre- and post-intervention. The AIM remained relatively consistent for both parents and adolescents pre- and post-intervention (AIM parent mean pre-intervention scores 17·90 (SD = 2·08) *v.* post-intervention scores 17·90 (SD = 1·91); AIM adolescent mean pre-intervention scores 15·78 (SD = 1·92) *v.* post-intervention scores 16·0 (SD = 2·11)

Parents expressed a high level of satisfaction with menu planning and nutrition counselling, while adolescents demonstrated an adequate level of satisfaction with menu planning and nutrition counselling (Fig. 3).

Post-intervention interviews were coded into three categories to facilitate the interpretation of acceptability data: (1) perceived benefits of study participation; (2) factors contributing to study satisfaction and (3) challenges to study participation. Table 3 summarises interview categories and representative quotes.

In the first category, 'Benefits to Study Participation,' participants recognised several advantages (labelled 1·1–1·3). Within the first subcategory (1·1), parents (*n* 4) and adolescents (*n* 4) recognised that the study provided an opportunity for adolescents to try new foods. This allowed them not only to expand their dietary choices but also to incorporate new food into their eating habits (1·2). Parents (*n* 5) and adolescents (*n* 4) expressed the intention to continue eating new food they tried during the intervention emphasising the sustainability of these positive changes beyond the study period. Lastly, one parent and one adolescent mentioned that the study involved family members outside the dyads outside the recruited dyads (1·3).

Within the second category, 'Factors Influencing Study Satisfaction', five subcategories emerged, elucidating the factors contributing to study satisfaction (labelled 2.1–2.5). One key aspect highlighted was the flexibility of the intervention's pace (2·1), as both parents (*n* 4) and adolescents (*n* 4) appreciated the ability to adapt the intervention to their individual goals and schedules. Another factor that emerged as contributing to adolescent satisfaction was the wide variety of acceptable foods that were available for them to select (2·2), which was mentioned by parents (*n* 3) and adolescents (*n* 3). This increased the feasibility of the intervention for adolescents in that they were able to meet their food goals while still enjoying their meals. Parents (*n* 1) and adolescents (*n* 4) also commended the menu planning software for its personalisation features, including grocery lists, menu plans and recipes (2·3). This feature not only simplified meal planning but also added a level of personalisation that resonated with participants, enhancing their overall experience. The virtual nature of the nutrition counselling sessions (2·4) was another factor positively influencing study satisfaction. Both parents (*n* 4) and adolescents (*n* 4) found virtual sessions convenient and appreciated the accessibility of nutrition counselling from the comfort of their homes. Lastly, grocery deliveries received positive feedback from adolescents (*n* 2) and parents (*n* 3) (2·5). This service streamlined the process of obtaining the novel ingredients for the intervention and allowed adolescents to explore new foods they may have not tried otherwise.

In the third category, 'Challenges to Study Participation,' two subcategories emerged and provided insights into the difficulties that participants faced during the study (labelled 3.1–3.2). Parents (*n* 2) and adolescents (*n* 2) thought that the time required for meal preparation was too lengthy (3·1). Parents (*n* 1) and adolescents (*n* 1) also raised implementation concerns about the intervention timing with respect to the time of year (3·2), suggesting that external factors could impact participation and adherence. Of note, however, participant perspectives regarding the optimal time of year in which to implement a new dietary intervention were discrepant, with some participants suggesting the stress-free summer time would be a better time, while others suggested that the more routinised academic year would allow for easier implementation.

Implementation. Implementation feasibility was determined using the FIM and by intervention adherence, participant attrition and completion rate of measures. Mean FIM scores for both parents and adolescents showed relative stability across pre- and

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

Table 2. Pre-Intervention qualitative interview themes, mentions and illustrative quotes, *n* 10

Theme/Subtheme	Number of times mentioned: Adolescent	Parent	Illustrative quote
1. Reasons for study enrollment			
1.1. Family benefit	2	3	*'So being that this is kind of a family study, I think that's probably a good thing. Because if it was, you know, we are sending you food that you have to make for yourself as a teenager, uh, I don't know if that would be successful. But as far as it being a family thing, maybe we'll cook together, maybe, you know, we'll learn together. [. . .] So this is a, a good learning opportunity for both of us.' - Parent_05*
1.2. Desire to modify eating behaviours	4	1	*'Hopefully, I'll be able to, like, discover more types of food and more types of cooking and stuff. So, I'll be able to maybe like, [. . .]be more motivated to incorporate that in my diet afterwards as well [. . .] and incorporate it into my life in college next year' - Adolescent_05*
1.3. Desperate and willing to embrace new depression management strategies	1	3	*'Of course, the goal is to let her feel better, right? It has been a struggle. So, like I mentioned, anything we are willing to try anything that would make her feel better.' - Parent_12*
1.4. Build adolescent agency for healthy eating habits	–	4	*'Sometimes if I don't feed her, she doesn't eat so it'd be nice for her to take control of this, benefiting her and herself, and wanting to do it for herself.' - Parent_04*
1.5. Contribute to research	3	1	*'I just want to be able to help in any way that I can and find any sort of solution to any problem that somebody might have.' - Adolescent_12*
1.6. Learn about nutrition	3	–	*'I'm gonna help cook it, I want to do that because I'm, I have a food and nutrition class. And I'm learning to cook, and I want to be able to learn to cook. And I want to be able to customize the ingredients that you guys give me into ways that I like it. And try and find different ways that I can cook myself health- healthier meals.' - Adolescent_12*
2. Anticipated barriers to intervention adherence			
2.1. Implementing diet into current lifestyle	4	5	*'I think like all teenagers, she's a little bit lazy when it comes to food. And so on the one hand, if I make it, she'll eat it. But on the other hand, you know, she would just as easily, you know, either eat nothing or eat, you know, unhealthy choices, either because it's easier, or because she's craving something, or maybe she's with friends or something like that.'- Parent_05*
2.2. Food preferences	2	–	*'I'm really nervous honestly, about uh making changes to my diet just because like I'm kind of embarrassed about how, like, how limited my diet is. Just because I don't know, I'm kind of a picky eater. And I just, I don't know, I- I'm nervous for that [. . .] the consistency too, um, to keep eating, like, on the I know, is not like an official plan, but it's still it's still going to be a change, and it's still going to have to be one that I'm gonna have to get used to. And I'm gonna have to actually, like, take some time, and like reinforce' - Adolescent_11*

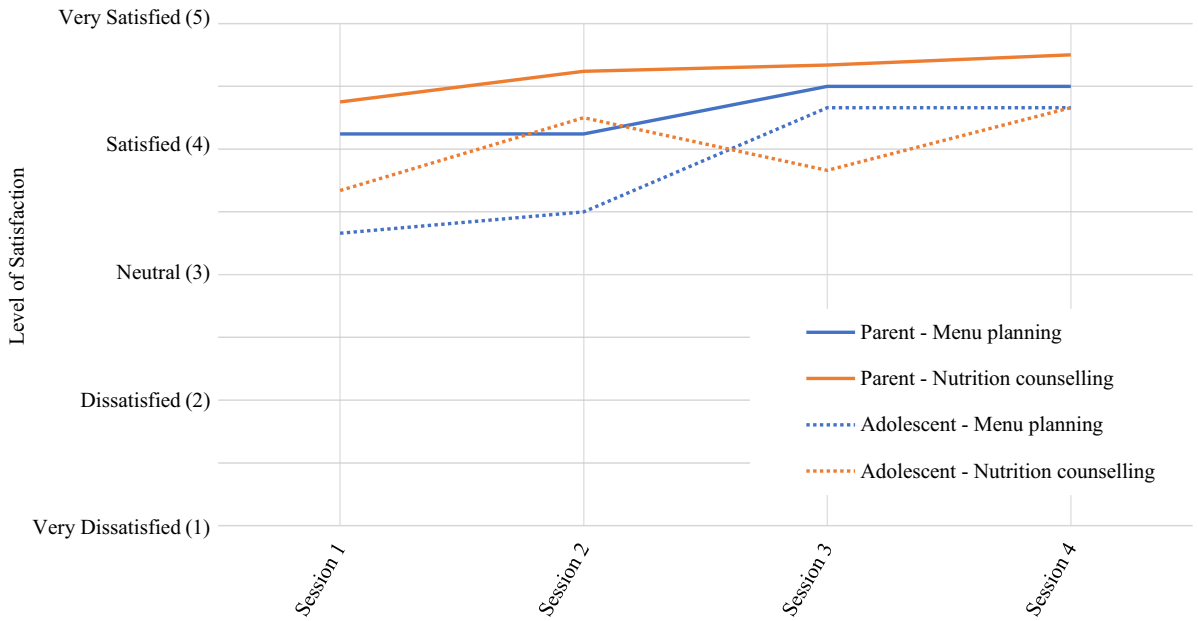


Fig. 3. Satisfaction scores for menu planning and nutrition counselling for adolescents and parents, by session (*n* 10).

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

Table 3. Post-Intervention qualitative interview theme, mentions and illustrative quotes, *n* 10

Theme/Subtheme	Number of times mentioned: Adolescent	Parent	Illustrative quote
1. Benefits of study participation			
1.1. Opportunity to try new foods	4	4	*'It was a good experience because I got to choose like a variety of different things that I haven't really tried before. [. . .] I was introduced to, like, new stuff. It kind of opened my eyes on like different things I could use in my meals in the future that I didn't really think of'- Adolescent_015*
1.2. Continue with new eating habits post-intervention	4	5	*'I definitely want to eat more healthy. So, I'll probably keep up; like one of my goals was eating four vegetables a day. So probably like keep up with that goal.' - Adolescent_008*
1.3. Involve family members in the process	1	1	*'My younger child had a positive experience as well because she is also affected by it because when I cook, she also gets to eat right. [. . .] It brought about good eating habits for her [younger daughter]. [. . .] So, it not only impacted the participant but the family member as well.'- Parent_002*
2. Factors influencing study satisfaction			
2.1. The program's flexible pace	4	4	*'Because, you know, [nutritionist's name] [. . .] was very flexible with, with uh what we could do and just concentrate on the small changes.' - Parent_011*
2.2. Finding healthy food choices	3	3	*'It's just um the ability to like substitute some of the foods or some of the recipes that weren't working, and also just trying to make like, small changes to uh my diet already. [. . .] And like, even when, like, stuff wasn't working like the nutritionist, you know, like, she was very quick to think of alternatives and um just things that uh things that would be good to change [. . .] I found out new grains and healthier alternatives' - Adolescent_011*
2.3. Menu planning software	4	1	*'Having the website that we used was really motivating. Because it, it laid out all of my options and stuff for me. And it was easy to sift through easy to look through. And like it, it helps like when you have things like written up like that it's way easier, and it motivates you to get more like, changes and get stuff done.' - Adolescent_012*
2.4. Virtual counselling sessions	4	4	*'Well, the virtual is definitely convenient. So, it's not really a hands-on thing right. Like, like the the person doesn't need to, . . . , you don't need to physically do anything. So, then I think that virtual is, is probably okay. For this, I mean, it definitely saves time and driving and parking and, you know, time and that kind of thing they more people are available to do it when it's convenient like that, right?'- Parent_005*
2.5. Grocery delivery	2	*3*	*'And it was also good because like, once you have that food, there's really no excuse to, you know, have a go to waste. [. . .] So, it was good to also have that [the deliveries] as an incentive to eat better and follow the planning' - Adolescent_011* *'And not having to think about it, too, was handy. Because that, you know, buying the ingredients is sometimes half the battle and having it available was really helpful, too. So it was all good.' Parent_011*
3. Challenges to study participation			
3.1. Long meal preparation time	2	2	*'[There were] definitely like difficult parts of it. [. . .] everything kind of has to be made, like by scratch kinda, or like, everything has to be cooked, like, it's not a fast food or anything type of diet. And so, because of that, like it kind of made I guess, preparation for things a bit longer.' - Adolescent_010*
3.2. Timing of the intervention	1	1	*'As we started this, and then school hit, it was really hard to do a lot of the things once we got into our hectic lifestyle, you know, [. . .] just the practicality of trying to do these new things on a very hectic schedule with other kids and you know [participant's name]'s brother having hockey and my work, you know, in the evenings and stuff. So that was our own challenges.' - Parent_008* *'Um, just because like at the summer, like in the summer at my cottage, it was just not the ideal sort of place doing it. [. . .] I didn't necessarily have time to like, prep food and stuff like' - Adolescent_004*

post-intervention assessments. Parents' scores averaged 15·80 (SD = 2·78) pre-intervention and increased slightly to 16·60 (SD = 2·84) post-intervention. Similarly, adolescents' scores remained steady at 16·33 (SD = 2·06) pre-intervention and 16·00 (SD = 1·89) post-intervention. Over the 8-week intervention, adherence to the diet, as assessed by the KIDMED, demonstrated improvement with a large effect size between baseline and midpoint (Cohen's $d = 0{\cdot}80$, 95 % CI (0·24, 2·41)), and a moderate effect size between baseline and post-intervention (Cohen's $d = 0{\cdot}64$, 95 % CI (0·15, 1·33))). Of the thirteen dyads that initiated the study, ten completed the study for an attrition rate of 23 %. Reasons for withdrawing from the study included personal (non-intervention) reasons (*n* 2) and a challenging diet (*n* 1) (Fig. 2).

While all REDCap measures achieved 100 % completion across all three timepoints, dietary data collection using the ASA-24 had suboptimal completion rates. Six participants completed at least one ASA-24 recall at baseline and mid-point, including two incomplete baseline recalls with implausibly low daily caloric intake (less than 500 kcal). At the final time point, four participants completed a single ASA-24; one participant provided an incomplete recall with a similarly low caloric intake. The low completion rate prevented the assessment of diet quality using the HEI-2015. Completion of the anthropometric data was 90 % at the midpoint and 70 % at the end of the study time point.

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

Table 4. Effect size (Cohen's *d*) for outcome measures at pre-intervention, mid-point and, post-intervention, *n* 10 (standard deviations and 95 % CI)

Measure	Pre-intervention	SD	Mid-point	SD	Post-intervention	SD	Cohen's *d*	95 % CI
CES-DC	33·67	10·91	30·67·	8·23	29·1	7·20	0·18	–0·49, 1·11¶
							0·36	–0·24, 3·36†
PMQ	14·11	7·52	NA		15·60	5·42	0·24	–0·43, 1·16
FNPA	46·2	5·63	NA		50·4	3·92	0·61	–0·04, 2·61
Nutrition knowledge	14·8	5·43	NA		15·50	3·03	0·11	–1·10, 0·53
Nutrition attitudes	17·33	2·00	NA		18·00	1·70	0·36	–0·25, 1·33

CES-DC, Center for Epidemiological Studies Depression Scale for Children; PMQ, Parent Modelling Questionnaire; FNPA, family and nutrition and physical activity; NA, not assessed. ¶pre-intervention *v.* midpoint; †pre-intervention *v.* post-intervention.

Adaptation. Participant feedback from post-intervention interviews highlighted some procedures requiring adaptation. Participants also made several suggestions with respect to adaptation of the intervention for the study team to consider: adolescents (*n* 6) reported that they either did not receive or did not read the eHealth messages; one adolescent suggested making the menu planning software accessible to both the nutritionist and participants, to allow adolescents to explore recipes at their own pace; two parents expressed interest in having more frequent (weekly instead of biweekly sessions) to discuss study progress; three parents expressed interest in receiving more information about the principles of the Mediterranean Diet during the initial nutrition counselling session and two parents recommended providing paper copies of menu plans and recipes for their convenience.

Limited efficacy testing. Effect sizes for adolescent and parent-reported outcome scores are presented in Table 4. Small effects on depressive symptoms were observed (Cohen's $d = 0{\cdot}36$, 95 % CI (–0·24, 3·36)). We also observed improvements in parent food modelling (Cohen's $d = 0{\cdot}24$, 95 % CI (–0·43, 1·16)), adolescent nutrition attitudes (Cohen's $d = 0{\cdot}36$, 95 % CI (–0·25, 1·33)) and substantial enhancements in the family food environment (Cohen's $d = 0.\ 61.$ 95 % CI (–0·04, 2·61)). Adolescents' nutrition knowledge was average at 74 % (14·8/20) pre-intervention and 78 % (15·5/20) post-intervention, corresponding to a negligible increase (Cohen's $d = 0{\cdot}11$, 95 % CI (–1·10, 0·53)).

Discussion

The current study examined the feasibility of implementing a novel 8-week personalised nutrition intervention among adolescents with MDD. We assessed the feasibility of this intervention across various dimensions, encompassing demand, acceptability, implementation and a preliminary exploration of its efficacy.

In this study focusing on a new intervention for adolescents with MDD and their parents, we achieved a recruitment rate of 43 %. This is similar to a dietary intervention study for young adults (mean age of 19·6 years) with depression (40 %)[68] and a trial of a dietary intervention for adults with MDD (42 %)[69]. Among studies of adults, younger age, male gender and lower socio-economic status have been associated with decreased research participation[70,71]. However, fewer studies have examined factors affecting the recruitment of children and adolescents for dietary intervention studies, and we are not aware of any research that has examined correlates of research participation of adolescent and parent dyads in this field. Among the broader literature regarding child and adolescent research recruitment, no significant associations were observed between age or gender; however, higher parental educational level has been associated with higher enrollment rates[72]. Further investigation into factors affecting recruitment, particularly for dietary inventions, is warranted.

The pre-intervention interviews provided insight regarding motivations and barriers to study participation and offered potential areas for adjustment to the recruitment strategy. Parents' reasons for study participation aligned with some adolescents' reasons but not always to the same degree. For example, both parents and adolescents were hopeful that the intervention would improve depression symptoms, with parents also sharing their own feelings of desperation with respect to finding an effective treatment for their child's depression. More adolescents than parents expressed altruistic motivations for participating in the current study, which aligns with adolescent motivation in similar research[73]. Both parents and adolescents foresaw challenges when it came to incorporating a higher-quality diet into their existing lifestyles. These challenges included practical obstacles, such as the perceived time and effort required, as well as managing mood fluctuations related to adolescent depression symptoms. Additionally, maintaining adherence to the personalised nutrition intervention was seen as a potential hurdle, influenced by individual food preferences and dislikes. Finally, juggling busy schedules, including school, extracurricular activities and holiday plans, posed yet another obstacle to successful diet integration. However, only adolescents mentioned selective food preferences as a barrier to intervention adherence. Common reasons for declining research participation in the current study (e.g. parent was too busy, might dislike included foods) also align with those of previous research[74]. This suggests that addressing potential barriers to recruitment proactively, by highlighting the personalised and adaptable nature of the dietary intervention, will be important in future research to improve recruitment rates.

Convergence of quantitative and qualitative data including responses to validated questionnaires and themes generated from parent and adolescent interviews in the current study suggests that a personalised nutrition intervention is acceptable among adolescents with depression and their parents. The high

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

level of intervention acceptability and satisfaction among adolescents and parents indicates that the programme was generally well-received. Furthermore, satisfaction with menu planning and nutrition counselling was generally high, with parents reporting slightly higher satisfaction than adolescents. The attrition rate of 23 % indicates moderate success in retaining participants throughout the intervention and is similar to other adolescent lifestyle interventions (i.e. general nutrition and/or exercise) for depression (15–35 %)[75–77]. Post-intervention interviews revealed that participants recognised several benefits of study participation, such as trying new foods, expanding dietary choices and involving family members in the process. Other factors contributing to the acceptability and satisfaction with the intervention included the flexibility of the dietary components, the availability of acceptable food choices, personalised menu planning software, virtual nutrition counselling and the convenience of grocery deliveries.

The ASA-24, a self-reported dietary intake measure, had the lowest completion rates among the study measures, and many reports contained missing data. To address this issue, more support may be required when completing this measure in future trials. For example, ASA-24 assessments could be conducted during nutrition counselling sessions, or alternate dietary measures could be incorporated to collect self-report data via REDCap or employ novel, specialised, food photography apps to document participants' dietary intake.

This study offers preliminary evidence for the effectiveness of the intervention in reducing depressive symptoms among adolescents with MDD. Additionally, the improvement in diet quality (KIDMED score) suggests a positive impact on dietary habits. These preliminary results are consistent with the only other study that has conducted a dietary intervention aimed at reducing depression symptoms among young people with depression, which reported lower self-reported depression symptoms using the Center for Epidemiologic Studies Depression Scale – Revised and high dietary compliance[68]. Furthermore, the current study provides early evidence for improvements in parent food modelling, adolescent nutrition attitudes and the family food environment. The negligible change in adolescent nutrition knowledge may be attributed to the already reasonably high levels of participants' nutrition knowledge at baseline and the lack of formal nutrition education during counselling sessions, which may have limited the potential for significant improvement.

Limitations

The interpretation of the efficacy of the intervention should be considered with caution, as the focus of this study was on feasibility. Moreover, the absence of a control group makes it challenging to determine whether the observed positive impacts can be attributed solely to the intervention or if other variables (i.e. the non-specific benefits of meeting regularly with an interested health professional) also contributed to the improvements in depressive symptoms observed. Additionally, as the study period was reasonably brief (8 weeks), whether the dietary and depression changes found in the current study will be sustained in the longer term is not known[78–80]. Data regarding the effect of the intervention on dietary intake should be interpreted with caution, given both the small initial sample size and the incomplete data, as three participants did not complete the intervention. It is also possible that social desirability bias may have affected self-reported dietary intake and health outcomes; however, adolescents with MDD have been shown to report their energy intake at levels comparable to that of other adolescents, indicating similar potential effects of social desirability bias on dietary intake reporting irrespective of MDD diagnosis[81–83]. The potential effect of medication on appetite was not explicitly explored in this pilot study. Future trials with larger sample sizes should address this limitation by including an examination of the intervention's potential effects on underlying appetite trends. This examination should consider the potential influence of disease course and medications used in clinical care. Finally, FIM and AIM scores reflect data from participants who completed the entire study. Three participants who withdrew after the first session are therefore excluded from the presented FIM and AIM results.

Conclusions

This study found that a newly developed personalised nutrition intervention was feasible according to the criteria outlined by Bowen *et al.*[62] for adolescents with MDD and their families. Future studies should consider recruitment strategies that mitigate hesitation about dietary change by proactively highlighting the flexible and customisable nature of the personalised nutrition intervention that accommodates individual food preferences. These insights lay the groundwork for future research examining the potential effectiveness of family-based, personalised nutrition interventions in the treatment of adolescent depression.

Acknowledgements

The authors would like to acknowledge the participants of the study. We would also like to acknowledge Jacky Au, Logan Wilkinson and Hemantika Mahesh, who were part of the initial protocol development and assisted with data collection. We would like to thank Enid Selkirk for her qualitative analysis input and Isabella Rodrigues who assisted with the thematic qualitative analysis.

This work was supported by the Psychiatry Endowment Fund Seed Grant by SickKids' Hospital Psychiatry Association and the Garry Hurvitz Centre for Brain & Mental Health. Susan C Campisi was supported in part by the SickKids RestraComp Postdoctoral Award and by the Canadian Institutes of Health Research (CIHR) grant number 409 491. The funders had no role in the study.

S. C. C. conceptualised the study design, secured funding for the study, conducted the nutrition counselling sessions, developed the analysis plan, conducted the analysis and wrote and revised all drafts of the manuscript. M. L. conducted the qualitative analysis and reviewed the manuscript. S. J. A. and E. D. conceptualised the study design, developed the analysis plan, conducted the analysis and revised all drafts of the manuscript. D. J. K. conceptualised the study design, secured funding for the study, developed the analysis plan, revised all drafts of the

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

manuscript and provided senior supervision for all aspects of the study. All authors assisted in data interpretation and critically reviewed and approved the final manuscript.

There are no conflicts of interest.

References

1. Herrman H, Kieling C, McGorry P, *et al.* (2019) Reducing the global burden of depression: a Lancet–World Psychiatric Association Commission. *Lancet* **393**, e42–e43.
2. Liu Q, He H, Yang J, *et al.* (2020) Changes in the global burden of depression from 1990 to 2017: findings from the Global Burden of Disease study. *J Psychiatr Res* **126**, 134–140.
3. Santomauro DF, Mantilla Herrera AM, Shadid J, *et al.* (2021) Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet* **398**, 1700–1712.
4. Government of Canada (2006) *The Human Face of Mental Health and Mental Illness in Canada: Minister of Public Works and Government Services Canada Ottawa*. Ontario, Canada: Government of Canada.
5. Copeland WE, Alaie I, Jonsson U, *et al.* (2021) Associations of childhood and adolescent depression with adult psychiatric and functional outcomes. *J Am Acad Child Adolesc Psychiatry* **60**, 604–611.
6. Johnson D, Dupuis G, Piche J, *et al.* (2018) Adult mental health outcomes of adolescent depression: a systematic review. *Depress Anxiety* **35**, 700–716.
7. Hulvershorn LA (2021) Editorial: what are the 'Doses,' timing, and treatment of childhood depression that impact adulthood? *J Am Acad Child Adolesc Psychiatry* **60**, 570–572.
8. Zhou X, Michael KD, Liu Y, *et al.* (2014) Systematic review of management for treatment-resistant depression in adolescents. *BMC Psychiatry* **14**, 1–9.
9. Holmes EA, Ghaderi A, Harmer CJ, *et al.* (2018) The Lancet Psychiatry Commission on psychological treatments research in tomorrow's science. *Lancet Psychiatry* **5**, 237–286.
10. Keeley B (2021) The State of the World's Children 2021: On My Mind–Promoting, Protecting and Caring for Children's Mental Health. New York, NY: UNICEF.
11. Di Daniele N (2019) The Role of Preventive Nutrition in Chronic Non-Communicable Diseases. Basel, Switzerland: Multidisciplinary Digital Publishing Institute.
12. Firth J, Solmi M, Wootton RE, *et al.* (2020) A meta-review of 'lifestyle psychiatry': the role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. *World Psychiatry* **19**, 360–380.
13. Liu T, Zhong S, Liao X, *et al.* (2015) A meta-analysis of oxidative stress markers in depression. *PLoS One* **10**, e0138904.
14. Galecki P & Talarowska M (2018) Inflammatory theory of depression. *Psychiatr Pol* **52**, 437–447.
15. Colasanto M, Madigan S & Korczak DJ (2020) Depression and inflammation among children and adolescents: a meta-analysis. *J Affective Disord* **277**, 940–948.
16. Allen J, Caruncho HJ & Kalynchuk LE (2021) Severe life stress, mitochondrial dysfunction, and depressive behavior: a path-ophysiological and therapeutic perspective. *Mitochondrion* **56**, 111–117.
17. Capuco A, Urits I, Hasoon J, *et al.* (2020) Current perspectives on gut microbiome dysbiosis and depression. *Adv Ther* **37**, 1328–1346.
18. Pu J, Liu Y, Zhang H, *et al.* (2021) An integrated meta-analysis of peripheral blood metabolites and biological functions in major depressive disorder. *Mol Psychiatry* **26**, 4265–4276.
19. Lassale C, Batty GD, Baghdadli A, *et al.* (2019) Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Mol Psychiatry* **24**, 965–986.
20. Molendijk M, Molero P, Ortuno Sanchez-Pedreno F, *et al.* (2018) Diet quality and depression risk: a systematic review and dose-response meta-analysis of prospective studies. *J Affect Disord* **226**, 346–354.
21. Altun A, Brown H, Szoeke C, *et al.* (2019) The Mediterranean dietary pattern and depression risk: a systematic review. *Neurol, Psychiatry Brain Res* **33**, 1–10.
22. Psaltopoulou T, Sergentanis TN, Panagiotakos DB, *et al.* (2013) Mediterranean diet, stroke, cognitive impairment, and depression: a meta-analysis. *Ann Neurol* **74**, 580–591.
23. Orlando L, Savel KA, Madigan S, *et al.* (2022) Dietary patterns and internalizing symptoms in children and adolescents: a meta-analysis. *Aust New Zealand J Psychiatry* **56**, 617–641.
24. Campisi SC, Zasowski C, Shah S, *et al.* (2021) Do healthy dietary interventions improve pediatric depressive symptoms? A systematic review and meta-analysis. Adv Nutr 12, 1940–1954.
25. Swainson J, Reeson M, Malik U, *et al.* (2023) Diet and depression: a systematic review of whole dietary interventions as treatment in patients with depression. *J Affective Disord* **327**, 270–278.
26. Gianfredi V, Dinu M, Nucci D, *et al.* (2023) Association between dietary patterns and depression: an umbrella review of meta-analyses of observational studies and intervention trials. *Nutr Rev* **81**, 346–359.
27. Korczak DJ, Perruzza S, Chandrapalan M, *et al.* (2022) The association of diet and depression: an analysis of dietary measures in depressed, non-depressed, and healthy youth. *Nutr Neurosci* **25**, 1948–1955.
28. Birch LL & Fisher JO (1998) Development of eating behaviors among children and adolescents. *Pediatrics* **101**, 539–549.
29. Chong MF-F (2022) Dietary trajectories through the life course: opportunities and challenges. *Br J Nutr* **128**, 154–159.
30. Appannah G, Murray K, Trapp G, *et al.* (2021) Dietary pattern trajectories across adolescence and early adulthood and their associations with childhood and parental factors. *Am J Clin Nutr* **113**, 36–46.
31. Yurtdas Depboylu G, Kaner G, Suer M, *et al.* (2023) Nutrition literacy status and its association with adherence to the Mediterranean diet, anthropometric parameters and lifestyle behaviours among early adolescents. *Public Health Nutr* **26**, 2108–2117.
32. Hendrie G, Sohonpal G, Lange K, *et al.* (2013) Change in the family food environment is associated with positive dietary change in children. *Int J Behav Nutr Phys Act* **10**, 4.
33. Fleary SA & Ettienne R (2019) The relationship between food parenting practices, parental diet and their adolescents' diet. *Appetite* **135**, 79–85.
34. Contento IR, Williams SS, Michela JL, *et al.* (2006) Understanding the food choice process of adolescents in the context of family and friends. *J Adolesc Health: Offic Publ Soc Adolesc Med* **38**, 575–582.
35. Wordell D, Daratha K, Mandal B, *et al.* (2012) Changes in a middle school food environment affect food behavior and food choices. *J Acad Nutr Diet* **112**, 137–141.
36. Stok FM, Renner B, Clarys P, *et al.* (2018) Understanding eating behavior during the transition from adolescence to young adulthood: a literature review and perspective on future research directions. *Nutrients* **10**, 667.
37. Neufeld LM, Andrade EB, Ballonoff Suleiman A, *et al.* (2022) Food choice in transition: adolescent autonomy, agency, and the food environment. *Lancet* **399**, 185–197.
38. Molina-Azorin JF (2016) Mixed methods research: an opportunity to improve our studies and our research skills. *Eur J Manag Bus Econ* **25**(2), 37–38.

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

39. Nishiyama T, Sumi S, Watanabe H, *et al.* (2020) The Kiddie Schedule for Affective Disorders and Schizophrenia Present and Lifetime Version (K-SADS-PL) for DSM-5: a validation for neurodevelopmental disorders in Japanese outpatients. *Compr Psychiatry* **96**, 152148.
40. Korczak DJ, Perruzza S, Chandrapalan M, *et al.* (2021) The association of diet and depression: an analysis of dietary measures in depressed, non-depressed, and healthy youth. *Nutr Neurosci* **25**(9), 1948–1955.
41. Vahia VN (2013) Diagnostic and statistical manual of mental disorders 5: a quick glance. *Indian J Psychiatry* **55**, 220–223.
42. Altavilla C & Caballero-Perez P (2019) An update of the KIDMED questionnaire, a Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr* **22**, 2543–2547.
43. Dopp RR, Mooney AJ, Armitage R, *et al.* (2012) Exercise for adolescents with depressive disorders: a feasibility study. *Depression Res Treat* **2012**, 257472.
44. Gaynor ST & Lawrence PS (2002) Complementing CBT for depressed adolescents with Learning through *In Vivo* Experience (LIVE): conceptual analysis, treatment description, and feasibility studY. *Behav Cognit Psychotherapy* **30**, 79–101.
45. Cotter EW, Hornack SE, Fotang JP, *et al.* (2020) A pilot open-label feasibility trial examining an adjunctive mindfulness intervention for adolescents with obesity. *Pilot Feasibility Stud* **6**, 1–11.
46. Sherson EA, Yakes Jimenez E & Katalanos N (2014) A review of the use of the 5 A's model for weight loss counselling: differences between physician practice and patient demand. *Fam Pract* **31**, 389–398.
47. That Clean Life (2014) Nutrition Planning for Health Professionals. https://thatcleanlife.com/ (accessed April 2022).
48. Harris PA, Taylor R, Minor BL, *et al.* (2019) The REDCap consortium: building an international community of software platform partners. *J Biomed Inform* **95**, 103208.
49. Conway JM, Ingwersen LA, Vinyard BT, *et al.* (2003) Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women. *Am J Clin Nutr* **77**, 1171–1178.
50. Radloff LS (2016) The CES-D scale. *Appl Psychol Meas* **1**, 385–401.
51. Krebs-Smith SM, Pannucci TE, Subar AF, *et al.* (2018) Update of the healthy eating index: HEI-2015. *J Acad Nutr Diet* **118**, 1591–1602.
52. Hall KJ (2021) *Application of the NCI's ASA24 with a Low Carbohydrate Diet to Achieve Weight Loss*. Phoenix, AZ: Grand Canyon University.
53. Lopez NV, Seeton VN, Heath CL, *et al.* (2023) Improvements in cardiometabolic effects and body composition outcomes following an online 8-week plant-based dietary and lifestyle worksite intervention. *Am J Lifestyle Med*.
54. Cheng J, Costacou T, Sereika SM, *et al.* (2023) Effect of an mHealth weight loss intervention on Healthy Eating Index diet quality: the SMARTER randomised controlled trial. *Br J Nutr* **130**, 2013–2021.
55. Naquin M (2018) *Examining Diet Quality and Sleep Duration in Overweight/Obese Adults in a Weight Loss Intervention*. South Kingstown, RI: University of Rhode Island.
56. Chiu S, Siri-Tarino P, Bergeron N, *et al.* (2020) A randomized study of the effect of replacing sugar-sweetened soda by reduced fat milk on cardiometabolic health in male adolescent soda drinkers. *Nutrients* **12**, 405.
57. Franco-Arellano B, Brown JM, Froome HM, *et al.* (2021) Development and pilot testing of the Nutrition Attitudes and Knowledge Questionnaire to measure changes of child nutrition knowledge related to the Canada's Food Guide. *Appl Physiol Nutr Metab* **46**, 1495–1501.
58. Loth KA, MacLehose RF, Larson N, *et al.* (2016) Food availability, modeling and restriction: how are these different aspects of the family eating environment related to adolescent dietary intake? *Appetite* **96**, 80–86.
59. Ihmels MA, Welk GJ, Eisenmann JC, *et al.* (2009) Development and preliminary validation of a Family Nutrition and Physical Activity (FNPA) screening tool. *Int J Behav Nutr Phys Act* **6**, 14.
60. Weiner BJ, Lewis CC, Stanick C, *et al.* (2017) Psychometric assessment of three newly developed implementation outcome measures. *Implement Sci* **12**, 108.
61. Mettert K, Lewis C, Dorsey C, *et al.* (2020) Measuring implementation outcomes: an updated systematic review of measures' psychometric properties. *Implement Res Pract* **1**, 2633489520936644.
62. Bowen DJ, Kreuter M, Spring B, *et al.* (2009) How we design feasibility studies. *Am J Prev Med* **36**, 452–457.
63. Pearson N, Naylor PJ, Ashe MC, *et al.* (2020) Guidance for conducting feasibility and pilot studies for implementation trials. *Pilot Feasibility Stud* **6**, 167.
64. Clarke V & Braun V (2017) Thematic analysis. *J Positive Psychol* **12**, 297–298.
65. Lee EC, Whitehead AL, Jacques RM, *et al.* (2014) The statistical interpretation of pilot trials: should significance thresholds be reconsidered? *BMC Med Res Method* **14**, 1–8.
66. Cohen J (2013) *Statistical Power Analysis for the Behavioral Sciences*. New York, NY: Academic press.
67. R Core Team (2023) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. https://www.R-project.org/ (accessed June 2023).
68. Francis HM, Stevenson RJ, Chambers JR, *et al.* (2019) A brief diet intervention can reduce symptoms of depression in young adults–a randomised controlled trial. *PloS one* **14**, e0222768.
69. Jacka FN, O'Neil A, Opie R, *et al.* (2017) A randomised controlled trial of dietary improvement for adults with major depression (the 'SMILES'trial). *BMC Med* **15**, 1–13.
70. Gul RB & Ali PA (2010) Clinical trials: the challenge of recruitment and retention of participants. *J Clin Nurs* **19**, 227–233.
71. Patel MX, Doku V & Tennakoon L (2018) Challenges in recruitment of research participants. *Adv Psychiatric Treat* **9**, 229–238.
72. Robinson L, Adair P, Coffey M, *et al.* (2016) Identifying the participant characteristics that predict recruitment and retention of participants to randomised controlled trials involving children: a systematic review. *Trials* **17**, 294.
73. Saarijarvi M, Wallin L, Moons P, *et al.* (2020) Factors affecting adolescents' participation in randomized controlled trials evaluating the effectiveness of healthcare interventions: the case of the STEPSTONES project. *BMC Med Res Methodol* **20**, 205.
74. van der Wurff ISM, Meyer BJ & de Groot RHM (2017) A review of recruitment, adherence and drop-out rates in *n*-3 polyunsaturated fatty acid supplementation trials in children and adolescents. *Nutrients* **9**, 474.
75. Jelalian E, Jandasek B, Wolff JC, *et al.* (2019) Cognitive-behavioral therapy plus healthy lifestyle enhancement for depressed, overweight/obese adolescents: results of a pilot trial. *J Clin Child Adolesc Psychol* **48**, S24–S33.
76. Philippot A, Meerschaut A, Danneaux L, *et al.* (2019) Impact of physical exercise on symptoms of depression and anxiety in pre-adolescents: a pilot randomized trial. *Front Psychol* **10**, 1820.
77. Egilsson E, Bjarnason R & Njardvik U (2021) Usage and weekly attrition in a smartphone-based health behavior intervention for adolescents: pilot randomized controlled trial. *JMIR Form Res* **5**, e21432.
78. Black AE, Prentice AM, Goldberg GR, *et al.* (1993) Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *J Am Dietetic Assoc* **93**, 572–579.
79. Goldberg GR, Black AE, Jebb SA, *et al.* (1991) Critical evaluation of energy intake data using fundamental principles

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press

of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *Eur J Clin Nutr* **45**, 569–581.
80. Podsakoff PM, MacKenzie SB & Podsakoff NP (2012) Sources of method bias in social science research and recommendations on how to control it. *Ann Rev Psychol* **63**, 539–569.
81. Campisi SC, Cost KT & Korczak DJ (2022) Food intake reporting bias among adolescents with depression. *Eur J Clin Nutr* **76**, 904–906.
82. Hebert JR, Clemow L, Pbert L, *et al.* (1995) Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. *Int J Epidemiol* **24**, 389–398.
83. Brener ND, Billy JO & Grady WR (2003) Assessment of factors affecting the validity of self-reported health-risk behavior among adolescents: evidence from the scientific literature. *J Adolesc Health* **33**, 436–457.

British Journal of Nutrition

https://doi.org/10.1017/S0007114524001338 Published online by Cambridge University Press