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Identifying preferred features of weight loss programmes for adults with, or at risk of, type 2 diabetes: a discrete choice experiment with 3,960 adults in the UK

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Identifying preferred features of weight loss programmes for adults with, or at risk of, type 2 diabetes: a discrete choice experiment with 3,960 adults in the UK

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Preferred features of weight loss programmes

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Twitter summary:
Tailoring programmes to individual preferences could increase participation by around 17 percentage points from (25% to 42%).

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~~Identifying preferred features of weight loss programmes for adults with, or at risk of, type 2 diabetes: a discrete choice experiment with 3,960 adults in the UK~~

Abstract

Objective: To understand preferences for features of weight loss programmes among adults with, or at risk of, type 2 diabetes in the UK.

Research Design and Methods: A discrete choice experiment with 3,960 UK adults living with overweight, (675 with type 2 diabetes). Preferences for seven characteristics of weight loss programmes were analysed. Simulations from choice models using the experimental data predicted uptake of available weight loss programmes. Patient groups comprising those who have experience with weight loss programmes, including from minority communities, informed the experimental design.

Results: Preferences did not differ between people with or without type 2 diabetes. Preferences were strongest for the type of diet. Healthy eating was most preferred relative to total diet replacement (TDR) (OR=2.24, 95%CI: 2.04-2.44). Individual interventions were more popular than groups (OR=1.40, 95%CI: 1.34-1.47). People preferred programmes offering weight loss of 10-15 kg (OR=1.37, 95%CI: 1.28-1.47) compared with 2-5kg. Online content was preferred over in-person contacts (OR=1.24, 95%CI: 1.18-1.30). There were few differences in preferences by gender and ethnicity though weight loss was more important for women than for men, and individuals from ethnic minority populations identified more with programmes where others shared their characteristics. Modelling suggested that tailoring programmes to individual preferences could increase participation by around 17 percentage points (68% in relative terms)~~%~~.

Conclusions: Offering a range of weight loss programmes targeting the preferred attributes of different patient groups could potentially encourage more people to participate in weight loss programmes and support people living with overweight to reduce their ~~cardiovascular risk~~weight.

Highlights:

- Weight loss programmes are recommended to improve outcomes in type 2 diabetes but require patient commitment
- Evidence for preferences for these types of programmes is key for guiding patients to weight loss programmes that are most likely work for them
- Important features of weight loss programmes were the style of diet, individual (versus group), amount of weight loss, and online delivery (versus in-person).
- Weight loss was more important for women than for men, and individuals from ethnic minority populations identified more with programmes where others shared their characteristics and
- Tailoring programmes to individual preferences could increase participation by around 17 percentage points (from 25% to 42%).”

Weight loss improves multiple cardiometabolic risk factors, and evidence demonstrates that the likelihood of remission from type 2 diabetes is linearly related to weight loss. One effective intervention, being implemented in the NHS in England, is a total diet replacement (TDR) programme with specially prepared, nutritionally complete products replacing all meals (1). Although TDR programmes are known to be effective, about 75% of people decline an invitation to participate in these programmes (1). Thus, there is a need to identify alternative weight loss programmes for people with type 2 diabetes and living with overweight or obesity, yet are unwilling to try a TDR programme. Understanding which features of weight loss programmes appeal and how preferences vary across individuals' characteristics could help healthcare systems to provide more suitable and effective weight loss programmes for diverse patient groups.

There are no systematic reviews of quantitative preference studies for weight loss programmes. In three small studies, adults living with overweight and obesity variously expressed a preference for weight loss programmes that: involved diets and exercise rather than diets only; required less exercise; maximised weight loss; had more clinician involvement; were personal rather than group-based; offered tailored versus generic support; were cheaper; and required lower travel times to access (2-4). A study which included 55 people with metabolic syndrome enrolled in a weight loss programme, found that participants initially preferred flexible diets over restricted meal programs and group-based exercise programs over individual ones. However, over the course of 16 weeks, the cost of the program became the dominant factor influencing their preferences (5). Crane et al. (6) enrolled 221 men (77% non-Hispanic) of low socioeconomic status. Participants preferred online over in-person weight loss interventions, small rather than large changes in diets, and weight loss interventions that did not incorporate competition over those that did. However, none of these studies included more than 4 options for weight loss programme characteristics, which does not represent the wide variety of diet and weight loss programmes available.

The aim of this study was to measure preferences for different features of weight loss programmes, representative of the wide variety of dietary approaches to weight loss currently available, and using a large, representative sample of UK adults living with overweight or obesity, including a specific subgroup with type 2 diabetes. We used a discrete choice experiment to identify preferences; a method shown to have good predictive ability for corresponding real world behaviours (7).

Research Design and Methods

Sampling

Participants were recruited by Qualtrics using email lists that members of the general public had signed up to, and were paid for participating in studies. We included UK adults (18 years or older) with a reported body mass index (BMI) of 25 kg/m^2 or more. Quotas (age, gender, and region) based on the UK census, were used to increase the representativeness. In addition, we collected participants with type 2 diabetes, but without quotas because these participants are harder to find.

Discrete choice experiment

A DCE is an experimental technique used widely in health sciences to understand people's preferences by asking them to make specific choices. Here, participants were presented with a choice of two weight loss programmes. Each programme was defined by a set of attributes, such as the type of diet and the amount of weight lost, and the variation in each attributes is referred to as a level. By making a series of choices between a weight loss programme with one set of attributes and levels and the other with alternative attributes and levels, participants implicitly reveal the degree to which each attribute is important to them and the value they place on each level of the attribute.

This DCE was designed according to health-based experimental design principles, ranging from technical considerations such as design efficiency to participant-centred considerations such as making the checking experimental tasks were as clear as possible to participants in advance (8-10). Individuals made 10 choices. In each task, individuals chose between two alternative weight loss programmes and an opt-out, "neither of these". The alternatives in the choice tasks were described by attributes and levels (below) representing different characteristics of weight loss programmes. A questionnaire collected sociodemographic information.

Attributes and levels

Seven attributes, each with a set of its own levels, described the characteristics of weight management programmes in the choice tasks. These are summarised in Table 1. The full descriptions attributes as presented to respondents in the survey, are shown in supplement 1.

The attributes and levels were based on several sources of evidence: a rapid review of current weight loss programmes available in the UK; one-to-one interviews with eight people with experience of weight loss programmes (hereafter referred to as our public advisory group, PAG), collaborative working with a member of the research team drawn from the general public to represent their views; and consulting subject matter experts, including researchers, clinicians, commissioners, and providers of weight loss programmes to the NHS. Our public advisory group members were recruited from the general public, including individuals from traditionally underserved populations including ethnic minority populations and people of low socioeconomic status (11). A focus group with 10 members of the public with relevant experience helped to maximise understanding of the experiment by discussing drafts and refining the descriptions of the attributes. For example, the TDR type of diet was expressed as "all meal replacement products" as this wording was clearer to focus group participants.

A Bayesian D-efficient design was used to generate the set of choice tasks (10). Priors were obtained from a pilot study of 51 individuals. Individuals were randomized to four blocks of 10 choice tasks. Each individual answered 10 choice tasks, balancing concerns of learning and respondent fatigue (12). Our sample size was sufficient to ensure statistical power based on the pilot parameter estimates (13). An example of a choice task is presented in Supplement 2. To make the choice tasks more realistic, restrictions were imposed on the design to prevent the appearance of combinations of attributes. For example, the "printed information only" level of the attribute "way of taking part" was not allowed to be in the choice if the "size of support session" attribute was "group-based". This is because it is not possible to deliver only printed information in a group support setting and so having this combination appear in the choice tasks would have been implausible~~For example, the printed information only way of taking part did not appear with group-based size of support session because it is not possible to deliver printed information in a group setting~~. The full set is listed in Supplement 3.

Randomisation to weight loss information

~~In~~ During our formative public engagement~~,~~ few people knew that diabetes could be put into remission, and were unaware of the magnitude of weight loss required to achieve this. In response, we randomised respondents to one of two arms prior to the DCE, using the experiment-within-experiment approach (29). In one arm, the respondents were exposed to a prime explaining that in people with type 2 diabetes, a weight loss of 10kg or more (on average), improves chances of achieving normal glucose control without medications. In the other arm, no information was given. This allowed testing of whether preferences for weight loss programmes are affected by knowing the importance of marked weight loss for diabetes remission.

Data quality

Prior to the experiment respondents were given narrative and visual information describing the alternatives, attributes, and levels. A practice choice scenario prior to the experiment aimed to help

respondents understand how the choice scenarios worked. All information was framed to increase understanding, drawing on qualitative work and public input. We used a pilot study and asked respondents to report misunderstandings and/or difficulties and adjusted questions if needed. None of the respondents reported difficulties in understanding and none reported any discomfort in taking the survey.

We were concerned that respondents might race through the survey, paying limited attention, and not reflect their choices accurately. To mitigate this, "forced responses" prevented respondents from skipping past questions in the survey; an attention check was embedded part way through the survey; and a minimum time threshold of 2 minutes, based on pilot data, removed respondents who rushed through. Post-experiment questions on relative attribute importance assessed the consistency with the estimates from the models. Duplicate survey responses were rejected. Supplement 4 summarises.

Statistical analyses

Main analyses were pre-registered prior to collection of the data (14); full details in Supplement 5.

39,600 experimental choices between two alternative weight loss programmes and "neither of these" were the dependent variable in multinomial logistic (logit) regression models. Alternative-specific constants and dummy-coded attribute levels were independent variables. A joint coefficient on both weight loss programme alternatives was specified relative to the "neither of these" option. This yielded a direct measure of "any weight loss programme" versus "no weight loss programme". A nesting structure imposed on the model allowed for correlation between the weight loss programmes, the implication being that individuals first chose between "any weight loss programme" versus "no weight loss programme", and then between weight loss programmes conditional on choosing the "any weight loss programme" option. Attribute levels were treated as random parameters to allow for heterogeneity, assuming that preferences were normally distributed. We therefore estimated mixed nested logit models. Statistical significance was examined with t-ratios (i.e. two-tailed t-tests).

Simulating choice probabilities of weight loss programmes

The dependent variable in regression models was the selection of, "weight loss plan 1", "weight loss plan 2", or "neither of these". After estimation, we used the fitted model to predict (simulate) choice probabilities for each of these outcomes. That is, for each observation in the data, the model predicted a probability for all three outcomes, the sum of which is 1 (i.e. each individual has to choose something). The probability was calculated from the specific attribute values in a given choice task and the estimated parameter for each attribute. By summing the probability for "weight loss plan 1" and "weight loss plan 2", the probability of "any weight loss plan" was derived. Then, for each observation we recovered the probability of "any weight loss plan" and "neither of these" (or equivalently "not to have a weight loss plan").

Based on the estimated parameters, we simulated choices for any combination of attributes by setting the attribute values in the data and applying these to the model. In this way, we predicted probabilities of choosing weight loss programmes based on people's preferences of five different weight loss plans with different attributes, four of which were commonly used in the UK. A further simulation created a "most popular" weight loss programme possible with the attributes and levels used in the experiment, regardless of its availability in practice. Supplement 6 shows the attributes and levels of the five weight loss programmes. We used sample enumeration for simulation (15) with 95% Krinsky-Robb confidence intervals (16). We took means of predicted probabilities, rather than using hit rates since the latter supresses the probabilistic element of the model (17).

A known issue with stated responses in DCEs is hypothetical bias, where individuals' stated behaviours do not match those observed in the real world (18). We took corrective measures (19) that are described in full in the appendix: Correcting choice shares.

All analyses were conducted in R. Regressions use the *Apollo* package (17). Code scripts are available on request. Ethical approval was granted from OxTREC ethics committee at Oxford, REF: R81951/RE001.

Results

Our analytical sample comprised 3,960 individuals, including 675 (21%) with type 2 diabetes. See Supplement 7 for participant characteristics. The average age was 46, and similar for people with and without diabetes. Around 20% of participants were from ethnic minority populations (in line with the UK population). There were more men than women with type 2 diabetes, reflecting the population with type 2 diabetes. Just under half had a degree, similar to the proportion in UK, 47% (20). Region of residence was balanced across respondents with and without diabetes. Participants with type 2 diabetes had a higher mean BMI than those without (mean BMI=32.1, s.d.=5.9 vs. mean BMI=30.2, s.d.=5.0). Most participants (59%) had at least one long term health condition. Around 16% smoked. Two percent reported having had bariatric surgery. Sixty-three percent were currently working.

Comparison of preferences in people with and without type 2 diabetes and bariatric surgery

None of the interactions between the attributes and diabetes status were statistically significant (Supplement 8). In an additional analysis, we tested whether those that had received bariatric surgery had differential preferences for weight loss programmes. We did not find evidence that preferences differed so the pooled sample was used for all analyses.

Behavioural priming

There was no evidence that randomising participants to information about the amount of weight loss necessary to achieve remission from diabetes or no information influenced the outcome. There was also no evidence that this information was important in people with diabetes compared with those without it (Supplements 13 and 14) so the pooled sample was used in all analyses.

Preferences for weight loss programmes' ~~features~~attributes

Figure 1 presents the odds ratios (ORs) for weight loss programme choice for each of the attributes (Supplement 9 for model estimates). These reflect the sample level preferences for the attributes of weight loss programmes. These are point estimates of means of estimated normal distributions of preferences. The full distributions for each attribute level are presented in Supplement 10.

Participants expressed strongest preferences for the type of the diet. Total diet replacement diets were, all else being equal, the least popular choice, with healthy eating the most preferred relative to TDR (odds ratio (OR)=2.24, 95%CI: 2.04-2.44). Other types of diet were preferred to TDR, but to a lesser extent: calorie counting (OR=1.74, 95%CI: 1.61-1.88), food group based (OR=1.64, 95%CI: 1.52-1.77), intermittent fasting (OR=1.47, 95%CI: 1.36-1.58), and some meal replacement (OR=1.42, 95%CI: 1.31-1.53). People preferred relatively shorter (1-3 months (OR=1.14, 95%CI: 1.08-1.20) or 3-6 months (OR=1.20, 95%CI: 1.11-1.28)) programmes to those lasting longer than 12 months, but these preferences were weakly held (i.e. lower odds ratios compared to other features). Participants in general expressed no preferences about frequency of contact, except that weekly contact was preferred to monthly (OR=1.09, 95%CI: 1.03-1.16). Participants strongly preferred weight loss programmes that led to substantial weight losses (10-15kg) (OR for 10-15kg compared to 2-4kg=1.37, 95%CI: 1.28-1.47); programmes offering slightly greater or lesser weight losses than this were still preferred to those offering only small weight losses (5 to 9kg (OR=1.18, 95%CI: 1.12-1.24) and more than 15kg (OR=1.20, 95%CI: 1.13-1.26)). Participants preferred programmes that enrolled "people like me" to those that did not; or in the case that there was only an instructor, that the instructor was, "like me" (OR=1.07, 95%CI:

1.04-1.11). Participants preferred one-to-one support to treatment in a group setting (OR=1.40, 95%CI: 1.34-1.47). Talking in-person was less popular than talking online (OR=1.08, 95%CI: 1.03-1.13) or online content (OR=1.24, 95%CI: 1.18-1.30), which was the most popular option; participants were indifferent between talking in-person and simply receiving printed content (OR=1.02, 95%CI: 0.89-1.13).

Preferences for weight loss programmes' attributes: individual characteristics

We tested pre-specified interactions of gender, ethnicity, and BMI with the attributes, presented in full in Supplement 11. There was evidence of two interactions only. First, the average amount of weight loss mattered more for women, with women preferring greater weight loss more strongly than men. Second, people in an ethnic minority preferred group formats with people of the same background more strongly than White respondents. In a post hoc analysis, we found that higher weight loss was more strongly preferred by people with BMI>=40.

The results of the calibration (i.e. using data from a clinical trial to set our model's predictions to a level that was observed in real world behaviour) made a substantial impact on the predicted choice probabilities. The uncalibrated model predicted choice probabilities ranging from 0.64 to 0.89. (This is broadly in line with prior results (21) which is also a stated choice study without calibration.) This did not align with the study's clinical team's expectations, based on previous research on uptake to programmes in clinical trials and in routine care (22). With the correction applied, the predicted choice probabilities ranged from 0.22 to 0.42 which was based on the uptake observed in a UK-based clinical trial of TDR (1) and more plausible from our clinicians' perspective.

Figure 2 presents the simulated choice probabilities for five weight loss programmes. One of these was designed to represent the theoretically most popular programme based on the attributes and levels in the experiment, regardless of availability in practice. This featured online content, individual support, with 'an instructor like me', 10 to 15kg weight lost, weekly sessions, over a 3 to 6 month plan, and healthy eating. The simulated likelihood of participation was 0.42; 95%CI 0.39-0.44. That is, if offered to all participants, 42% of all the choices made would be this programme, and 58% of choices would be not to participate. The simulated likelihood of participation in the least popular of the four currently available programmes, group-based community weight management programmes, was 0.22; 95%CI 0.21-0.24. Other currently available weight loss programmes were between these two limits; participating in a TDR (all meals replaced by formula liquid products) (0.25; 95%CI 0.23-0.27), online 1:1 support for a "real food" weight loss diet (0.31; 95%CI 0.29-0.33) and online healthy eating information with low weight loss (0.33; 95%CI 0.31-0.35).

Sensitivity analyses

Mixed nested logit models were preferred to simpler nested logit models on the basis of improvements in model fit (using a Vuong test for non-nested models) and the appeal of allowing for heterogeneity in respondents' preferences, which mitigates the risk of parameter bias.

Including participants we excluded because they were enrolled even though we were over quota - i.e. the survey firm provided them even though they over sampled on some quotas - did not change the results (Supplement 12). Survey questions on relative attribute importance corroborated findings from the choice models.

Discussion

~~We estimated preferences for attributes of weight loss programmes included in the experimen~~This study estimated preferences for attributes of weight loss programmes to understand weight loss programme participation in a sample of individuals living with overweight and obesity~~t~~. The strongest preferences related to the type of diets, with TDR the least favoured amongst a set of six, and healthy eating

preferred most over TDR. The amount of weight lost and preferring weight loss programmes alone, rather than in a group, were also important features of weight loss programmes. There was no evidence that these preferences differed by whether people had or did not have type 2 diabetes. There was some evidence that women were more likely to prefer programmes that typically resulted in greater weight loss than men. Further, individuals from ethnic minority populations were more likely to prefer attending a group programme with other people from the same background than were White people. Lastly, we found evidence that those with high BMI preferred programmes that could deliver higher weight loss. There was no evidence that providing information on the need for larger weight loss to put type 2 diabetes into remission changed preferences overall or in people with type 2 diabetes.

Strengths of this study include an experimental design underpinned by rich sources of data. Using a scoping review of existing weight loss programmes and the input from a diverse group of people with experience of trying to lose weight and using weight loss programmes, clinicians, and other stakeholders ensured that we studied the features of programmes that are representative of the choice of weight loss programmes currently available, and described in a way that was understood by members of the public. We also used a large, nationally representative sample for our experiment. Oversampling people with type 2 diabetes meant we were able to assess whether preferences for weight management differed from the general population in this group and found no evidence that they did so by an important amount. We took steps to ensure the quality of the data and a series of sensitivity analyses to verify our findings. We used advanced modelling techniques to yield robust estimates. An experiment-within-experiment design allowed us to test the impact of a behavioural prime on preferences.

Limitations include that obesity-related behaviours are potentially subject to misreporting due to social stigma and/or social desirability bias (23). In this setting, it could have manifested in respondents choosing weight loss programmes more often than they otherwise might have. Indeed, discrete choice experiments are vulnerable to hypothetical bias; that is, what respondents report in surveys is not necessarily what they do in real life settings (18). This is potentially a limiting issue insofar as measured preferences may differ from those in reality. Some signals from the analysis help to mitigate these concerns. First, many individuals chose "neither of these" weight loss programmes (around 20% of all choices). Second, in the survey feedback, respondent comments such as, "…I avoided all intermittent fasting ones as I have tried it and hated it…" gave reassurance that the experiment worked as intended. Further, we took steps to mitigate this by designing the experiment based on available weight loss programmes in the real world, engaging users of weight loss programmes in our design processes, and using results from clinical trials to base our predicted choice probabilities on observed behaviours, which made a substantial difference to the predicted participation rates. Whilst using results from a clinical trial to calibrate our model improves the accuracy of our estimates, we note that trials are subject to forms of selection bias, in this case recruitment through primary care, that may mean the participation rate in trials differ systematically from routine practice. Both the estimated preferences and the predicted probabilities should be treated with some caution because they are ultimately hypothetical choices in an online experiment and not behaviour. Moreover, previous research (5) and clinical experience suggests that while many people believe they will not enjoy or have success with particular dietary programmes, notably TDR, this perception frequently changes over time based on direct experience. Therefore, it is important to acknowledge that a hypothetical choice may not necessarily reflect what people choose or have success with in practice. However, it is possible that understanding people's preferences for weight loss programmes could help to make more programmes available with characteristics that people will identify as the "right diet for them", and that may in turn promote uptake and adherence (24).~~Limitations include that obesity-related behaviours are potentially subject to misreporting due to social stigma and/or social desirability bias (23). In this setting, it could have manifested in respondents choosing weight loss programmes more often than they otherwise might have. We do not think this was a major issue since many individuals chose "neither of these" weight loss programmes (around 20% of all choices). Moreover, in the survey feedback, respondent comments such as, "…I avoided all intermittent fasting ones as I have tried it and hated it…" gave reassurance that the experiment worked as intended. Discrete choice experiments are vulnerable to hypothetical bias; that is, what respondents report in surveys is not necessarily what they do in real life settings (18). We took steps to mitigate this by designing the experiment based on available weight loss programmes in the~~

~~real world, engaging users of weight loss programmes in our design processes, and using results from clinical trials to base our predicted choice probabilities on observed behaviours, which made a substantial difference to the predicted participation rates. This notwithstanding, our predicted probabilities should be treated with caution because they are ultimately choices in an online experiment and not behaviour. Moreover, Previous research (5) and clinical experience suggests that while many people believe they will not enjoy or have success with particular dietary programmes, notably TDR, this perception frequently changes over time based on direct experience. Therefore, it is important to acknowledge that a hypothetical choice may not necessarily reflect what people choose and have success with in practice. However, it is possible that understanding people's preferences for weight loss programmes could help to make more programmes available with characteristics that people will identify as the "right diet for them", and that may in turn promote uptake and adherence (24).~~

Previous studies, (2-4,6,21,25), have found that individuals preferred interventions that: involved diets and exercise rather than diets only; required less exercise; maximised weight loss; had more clinician involvement; were personal rather than group-based; offered tailored versus generic support; were cheaper; minimised the risk of diabetes; and required lower travel times to access. Our results are not directly comparable because we focussed specifically on diet-based interventions and we found that the type of diet was the leading driver of preferences. In both Reed Johnson et al. (21) and Benning et al. (4), weight loss was more important than the type of diet (though the diet options were unspecific as "restrictive", "flexible" and "no diet"). Other studies, e.g. (21), have used cost as an attribute which will be important in settings where individuals pay for weight loss programmes, such as in the US.

There are important implications of these findings for the provision of weight loss programmes. Firstly, based on the results of recent trials (1,26) TDR is becoming the mainstay of dietary interventions for diabetes remission, yet was the least popular diet generally, despite the promise of significant weight loss. This finding may help explain the relatively low participation rate observed in the national rollout of this treatment in a pilot programme in the UK, and implies that active efforts may be needed to promote this approach. Secondly, the least popular option is a group-based community weight management programme, yet this is one of the most common options offered by local areas for the treatment of obesity or adopted by individuals looking to lose weight. Uptake may be enhanced by offering one of more of the more preferred features e.g. online resources or 1:1 support, subject to costs, and indeed many providers are now incorporating these aspects into their programmes.

The promise of at least 5 kg weight loss is also important, perhaps reflecting a sense of what is worthwhile. This goal may have been reinforced by targets outlined in many clinical guidelines which recommend initial "realistic" targets of around 5% weight loss (27). Whilst evidence suggests that greater weight loss brings greater clinical benefit and larger weight losses are certainly important, if the goal is diabetes remission, at a population level even small reductions are beneficial (1,28). Nonetheless, the unsurprising desire for substantial weight loss within relatively short periods of time should focus attention on more intensive programmes.

The notion of 'healthy eating' was very attractive to participants. However this was not precisely defined and in practice it may be harder to develop programmes universally perceived as 'healthy'. For example, there is considerable debate about the 'healthy' content of carbohydrate in the diet, especially for people with diabetes. TDR programmes are nutritionally complete, which is hard to achieve in energy-restricted diets based on 'usual' foods, yet their 'ultra-processed' nature may be perceived as unhealthy. Nonetheless, since the desire for a 'healthy diet' in association with the opportunity to lose weight is important, emphasising the nutritional value of any dietary intervention is important to enhance uptake.

This study suggests that the theoretically most preferred weight loss programme for the average participant would be available online, delivered 1:1 to the individual, supporting 10-15kg weight loss, with weekly contact, following a "healthy eating" type of diet, for 3 to 6 months, where the instructor or health coach shares characteristics of the individual. While such a programme is not currently

available, so it is at this time hypothetical, our modelling suggests that offering a programme such as this could increase participation by 17 percentage points, or 68% in relative terms,~~%~~ compared to TDR.

In conclusion, we have described patient preferences for attributes of weight loss programmes. It is possible that creating programmes that match these may increase uptake of weight loss programmes and these preferences can be used by commissioners to design pathways to support more people to access weight loss programmes.

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Attribute No.	Attribute	Levels
1	Way of taking part	*Talking in person, e.g. at a community centre*
		Talking online, e.g. app/zoom
		Online content only
		Printed information only
2	Size of support session	*Group-based*
		Only me
3	People (or instructor) are like me	*Yes*
		No
4	Amount of weight lost	*2kg to 4kg (4lb to 9 lb)*
		5kg to 9kg (11 lb to 1 stone, 6 lb)
		10kg to15kg (1 stone, 8 lb to 2 stone, 5 lb)
		more than 15kg (2 stone, 5 lb)
5	Visits	*One-off*
		Twice per week
		Once per week
		Twice per month
		Once per month
6	Length of [weight loss] plan	*Less than 1 month*
		1 to 3 months
		3 to 6 months
		6 to 12 months
		more than 12 months
7	Type of diet	*Calorie counting*
		All meal replacement products (TDR)
		Some meal replacement products
		Food-group-based
		Healthy eating
		Intermittent fasting

Table 1: Attributes and levels used in the discrete choice experiment.

[Insert Figure 1 here]

Figure 1: Odds ratios (ORs) of choosing weight loss programmes, by attribute. Point estimates and 95% confidence intervals are shown. For each attribute, the attribute levels are compared to the reference level (i.e. the omitted attribute level), which are shown in parentheses. The reference levels, indicated with an underscore prefix in the figure, are (corresponding attribute): Talking in person (1. Way of taking part), Group-based (2. Size of support session), People are not like me (3. People are like me), Weight Loss of 2 to 4 kg (4. Amount of weight lost), Monthly (5. Frequency of visits), More Than 12 Months (Length of plan), All Meal Replacement (Type of diet).

[Insert Figure 2 here]

Figure 2: Simulated choice probabilities for 5 weight loss programmes. See the appendix for attribute/level combinations. The choice probability of each weight loss programme is calculated in a different simulation from the same model (adjusting the model each time to resemble that particular weight loss programme). In the case of TDR, 25% of all the choices would be TDR and 75% would be not to participate; for the most popular, 42% of all the choices would be that weight loss programme and 58% would be not to participate.

Full title:
Identifying preferred features of weight loss programmes for adults with, or at risk of, type 2 diabetes: a discrete choice experiment with 3,960 adults in the UK

Running title:
Preferred features of weight loss programmes

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Twitter summary:
Tailoring programmes to individual preferences could increase participation by around 17 percentage points from (25% to 42%).

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Abstract

Objective: To understand preferences for features of weight loss programmes among adults with, or at risk of, type 2 diabetes in the UK.

Research Design and Methods: A discrete choice experiment with 3,960 UK adults living with overweight, (675 with type 2 diabetes). Preferences for seven characteristics of weight loss programmes were analysed. Simulations from choice models using the experimental data predicted uptake of available weight loss programmes. Patient groups comprising those who have experience with weight loss programmes, including from minority communities, informed the experimental design.

Results: Preferences did not differ between people with or without type 2 diabetes. Preferences were strongest for the type of diet. Healthy eating was most preferred relative to total diet replacement (TDR) (OR=2.24, 95%CI: 2.04-2.44). Individual interventions were more popular than groups (OR=1.40, 95%CI: 1.34-1.47). People preferred programmes offering weight loss of 10-15 kg (OR=1.37, 95%CI: 1.28-1.47) compared with 2-5kg. Online content was preferred over in-person contacts (OR=1.24, 95%CI: 1.18-1.30). There were few differences in preferences by gender and ethnicity though weight loss was more important for women than for men, and individuals from ethnic minority populations identified more with programmes where others shared their characteristics. Modelling suggested that tailoring programmes to individual preferences could increase participation by around 17 percentage points (68% in relative terms).

Conclusions: Offering a range of weight loss programmes targeting the preferred attributes of different patient groups could potentially encourage more people to participate in weight loss programmes and support people living with overweight to reduce their weight.

Highlights:

- Weight loss programmes are recommended to improve outcomes in type 2 diabetes but require patient commitment
- Evidence for preferences for these types of programmes is key for guiding patients to weight loss programmes that are most likely work for them
- Important features of weight loss programmes were the style of diet, individual (versus group), amount of weight loss, and online delivery (versus in-person).
- Weight loss was more important for women than for men, and individuals from ethnic minority populations identified more with programmes where others shared their characteristics and
- Tailoring programmes to individual preferences could increase participation by around 17 percentage points (from 25% to 42%).″

Weight loss improves multiple cardiometabolic risk factors, and evidence demonstrates that the likelihood of remission from type 2 diabetes is linearly related to weight loss. One effective intervention, being implemented in the NHS in England, is a total diet replacement (TDR) programme with specially prepared, nutritionally complete products replacing all meals (1). Although TDR programmes are known to be effective, about 75% of people decline an invitation to participate in these programmes (1). Thus, there is a need to identify alternative weight loss programmes for people with type 2 diabetes and living with overweight or obesity, yet are unwilling to try a TDR programme. Understanding which features of weight loss programmes appeal and how preferences vary across individuals' characteristics could help healthcare systems to provide more suitable and effective weight loss programmes for diverse patient groups.

There are no systematic reviews of quantitative preference studies for weight loss programmes. In three small studies, adults living with overweight and obesity variously expressed a preference for weight loss programmes that: involved diets and exercise rather than diets only; required less exercise; maximised weight loss; had more clinician involvement; were personal rather than group-based; offered tailored versus generic support; were cheaper; and required lower travel times to access (2-4). A study which included 55 people with metabolic syndrome enrolled in a weight loss programme, found that participants initially preferred flexible diets over restricted meal programs and group-based exercise programs over individual ones. However, over the course of 16 weeks, the cost of the program became the dominant factor influencing their preferences (5). Crane et al. (6) enrolled 221 men (77% non-Hispanic) of low socioeconomic status. Participants preferred online over in-person weight loss interventions, small rather than large changes in diets, and weight loss interventions that did not incorporate competition over those that did. However, none of these studies included more than 4 options for weight loss programme characteristics, which does not represent the wide variety of diet and weight loss programmes available.

The aim of this study was to measure preferences for different features of weight loss programmes, representative of the wide variety of dietary approaches to weight loss currently available, and using a large, representative sample of UK adults living with overweight or obesity, including a specific subgroup with type 2 diabetes. We used a discrete choice experiment to identify preferences; a method shown to have good predictive ability for corresponding real world behaviours (7).

Research Design and Methods

Sampling

Participants were recruited by Qualtrics using email lists that members of the general public had signed up to, and were paid for participating in studies. We included UK adults (18 years or older) with a reported body mass index (BMI) of 25 kg/m^2 or more. Quotas (age, gender, and region) based on the UK census, were used to increase the representativeness. In addition, we collected participants with type 2 diabetes, but without quotas because these participants are harder to find.

Discrete choice experiment

A DCE is an experimental technique used widely in health sciences to understand people's preferences by asking them to make specific choices. Here, participants were presented with a choice of two weight loss programmes. Each programme was defined by a set of attributes, such as the type of diet and the amount of weight lost, and the variation in each attributes is referred to as a level. By making a series of choices between a weight loss programme with one set of attributes and levels and the other with alternative attributes and levels, participants implicitly reveal the degree to which each attribute is important to them and the value they place on each level of the attribute.

This DCE was designed according to health-based experimental design principles, ranging from technical considerations such as design efficiency to participant-centred considerations such as making

the checking experimental tasks were as clear as possible to participants in advance (8-10). Individuals made 10 choices. In each task, individuals chose between two alternative weight loss programmes and an opt-out, "neither of these". The alternatives in the choice tasks were described by attributes and levels (below) representing different characteristics of weight loss programmes. A questionnaire collected sociodemographic information.

Attributes and levels

Seven attributes, each with a set of its own levels, described the characteristics of weight management programmes in the choice tasks. These are summarised in Table 1. The full descriptions attributes as presented to respondents in the survey, are shown in supplement 1.

The attributes and levels were based on several sources of evidence: a rapid review of current weight loss programmes available in the UK; one-to-one interviews with eight people with experience of weight loss programmes (hereafter referred to as our public advisory group, PAG), collaborative working with a member of the research team drawn from the general public to represent their views; and consulting subject matter experts, including researchers, clinicians, commissioners, and providers of weight loss programmes to the NHS. Our public advisory group members were recruited from the general public, including individuals from traditionally underserved populations including ethnic minority populations and people of low socioeconomic status (11). A focus group with 10 members of the public with relevant experience helped to maximise understanding of the experiment by discussing drafts and refining the descriptions of the attributes. For example, the TDR type of diet was expressed as "all meal replacement products" as this wording was clearer to focus group participants.

A Bayesian D-efficient design was used to generate the set of choice tasks (10). Priors were obtained from a pilot study of 51 individuals. Individuals were randomized to four blocks of 10 choice tasks. Each individual answered 10 choice tasks, balancing concerns of learning and respondent fatigue (12). Our sample size was sufficient to ensure statistical power based on the pilot parameter estimates (13). An example of a choice task is presented in Supplement 2. To make the choice tasks more realistic, restrictions were imposed on the design to prevent the appearance of combinations of attributes. For example, the "printed information only" level of the attribute "way of taking part" was not allowed to be in the choice if the "size of support session" attribute was "group-based". This is because it is not possible to deliver only printed information in a group support setting and so having this combination appear in the choice tasks would have been implausible. The full set is listed in Supplement 3.

Randomisation to weight loss information

During our formative public engagement few people knew that diabetes could be put into remission, and were unaware of the magnitude of weight loss required to achieve this. In response, we randomised respondents to one of two arms prior to the DCE, using the experiment-within-experiment approach (29). In one arm, the respondents were exposed to a prime explaining that in people with type 2 diabetes, a weight loss of 10kg or more (on average), improves chances of achieving normal glucose control without medications. In the other arm, no information was given. This allowed testing of whether preferences for weight loss programmes are affected by knowing the importance of marked weight loss for diabetes remission.

Data quality

Prior to the experiment respondents were given narrative and visual information describing the alternatives, attributes, and levels. A practice choice scenario prior to the experiment aimed to help respondents understand how the choice scenarios worked. All information was framed to increase understanding, drawing on qualitative work and public input. We used a pilot study and asked respondents to report misunderstandings and/or difficulties and adjusted questions if needed. None of

the respondents reported difficulties in understanding and none reported any discomfort in taking the survey.

We were concerned that respondents might race through the survey, paying limited attention, and not reflect their choices accurately. To mitigate this, "forced responses" prevented respondents from skipping past questions in the survey; an attention check was embedded part way through the survey; and a minimum time threshold of 2 minutes, based on pilot data, removed respondents who rushed through. Post-experiment questions on relative attribute importance assessed the consistency with the estimates from the models. Duplicate survey responses were rejected. Supplement 4 summarises.

Statistical analyses

Main analyses were pre-registered prior to collection of the data (14); full details in Supplement 5.

39,600 experimental choices between two alternative weight loss programmes and "neither of these" were the dependent variable in multinomial logistic (logit) regression models. Alternative-specific constants and dummy-coded attribute levels were independent variables. A joint coefficient on both weight loss programme alternatives was specified relative to the "neither of these" option. This yielded a direct measure of "any weight loss programme" versus "no weight loss programme". A nesting structure imposed on the model allowed for correlation between the weight loss programmes, the implication being that individuals first chose between "any weight loss programme" versus "no weight loss programme", and then between weight loss programmes conditional on choosing the "any weight loss programme" option. Attribute levels were treated as random parameters to allow for heterogeneity, assuming that preferences were normally distributed. We therefore estimated mixed nested logit models. Statistical significance was examined with t-ratios (i.e. two-tailed t-tests).

Simulating choice probabilities of weight loss programmes

The dependent variable in regression models was the selection of, "weight loss plan 1", "weight loss plan 2", or "neither of these". After estimation, we used the fitted model to predict (simulate) choice probabilities for each of these outcomes. That is, for each observation in the data, the model predicted a probability for all three outcomes, the sum of which is 1 (i.e. each individual has to choose something). The probability was calculated from the specific attribute values in a given choice task and the estimated parameter for each attribute. By summing the probability for "weight loss plan 1" and "weight loss plan 2", the probability of "any weight loss plan" was derived. Then, for each observation we recovered the probability of "any weight loss plan" and "neither of these" (or equivalently "not to have a weight loss plan").

Based on the estimated parameters, we simulated choices for any combination of attributes by setting the attribute values in the data and applying these to the model. In this way, we predicted probabilities of choosing weight loss programmes based on people's preferences of five different weight loss plans with different attributes, four of which were commonly used in the UK. A further simulation created a "most popular" weight loss programme possible with the attributes and levels used in the experiment, regardless of its availability in practice. Supplement 6 shows the attributes and levels of the five weight loss programmes. We used sample enumeration for simulation (15) with 95% Krinsky-Robb confidence intervals (16). We took means of predicted probabilities, rather than using hit rates since the latter supresses the probabilistic element of the model (17).

A known issue with stated responses in DCEs is hypothetical bias, where individuals' stated behaviours do not match those observed in the real world (18). We took corrective measures (19) that are described in full in the appendix: Correcting choice shares.

All analyses were conducted in R. Regressions use the *Apollo* package (17). Code scripts are available on request. Ethical approval was granted from OxTREC ethics committee at Oxford, REF: R81951/RE001.

Results

Our analytical sample comprised 3,960 individuals, including 675 (21%) with type 2 diabetes. See Supplement 7 for participant characteristics. The average age was 46, and similar for people with and without diabetes. Around 20% of participants were from ethnic minority populations (in line with the UK population). There were more men than women with type 2 diabetes, reflecting the population with type 2 diabetes. Just under half had a degree, similar to the proportion in UK, 47% (20). Region of residence was balanced across respondents with and without diabetes. Participants with type 2 diabetes had a higher mean BMI than those without (mean BMI=32.1, s.d.=5.9 vs. mean BMI=30.2, s.d.=5.0). Most participants (59%) had at least one long term health condition. Around 16% smoked. Two percent reported having had bariatric surgery. Sixty-three percent were currently working.

Comparison of preferences in people with and without type 2 diabetes and bariatric surgery

None of the interactions between the attributes and diabetes status were statistically significant (Supplement 8). In an additional analysis, we tested whether those that had received bariatric surgery had differential preferences for weight loss programmes. We did not find evidence that preferences differed so the pooled sample was used for all analyses.

Behavioural priming

There was no evidence that randomising participants to information about the amount of weight loss necessary to achieve remission from diabetes or no information influenced the outcome. There was also no evidence that this information was important in people with diabetes compared with those without it (Supplements 13 and 14) so the pooled sample was used in all analyses.

Preferences for weight loss programmes' attributes

Figure 1 presents the odds ratios (ORs) for weight loss programme choice for each of the attributes (Supplement 9 for model estimates). These reflect the sample level preferences for the attributes of weight loss programmes. These are point estimates of means of estimated normal distributions of preferences. The full distributions for each attribute level are presented in Supplement 10.

Participants expressed strongest preferences for the type of the diet. Total diet replacement diets were, all else being equal, the least popular choice, with healthy eating the most preferred relative to TDR (odds ratio (OR)=2.24, 95%CI: 2.04-2.44). Other types of diet were preferred to TDR, but to a lesser extent: calorie counting (OR=1.74, 95%CI: 1.61-1.88), food group based (OR=1.64, 95%CI: 1.52-1.77), intermittent fasting (OR=1.47, 95%CI: 1.36-1.58), and some meal replacement (OR=1.42, 95%CI: 1.31-1.53). People preferred relatively shorter (1-3 months (OR=1.14, 95%CI: 1.08-1.20) or 3-6 months (OR=1.20, 95%CI: 1.11-1.28)) programmes to those lasting longer than 12 months, but these preferences were weakly held (i.e. lower odds ratios compared to other features). Participants in general expressed no preferences about frequency of contact, except that weekly contact was preferred to monthly (OR=1.09, 95%CI: 1.03-1.16). Participants strongly preferred weight loss programmes that led to substantial weight losses (10-15kg) (OR for 10-15kg compared to 2-4kg=1.37, 95%CI: 1.28-1.47); programmes offering slightly greater or lesser weight losses than this were still preferred to those offering only small weight losses (5 to 9kg (OR=1.18, 95%CI: 1.12-1.24) and more than 15kg (OR=1.20, 95%CI: 1.13-1.26)). Participants preferred programmes that enrolled "people like me" to those that did not; or in the case that there was only an instructor, that the instructor was, "like me" (OR=1.07, 95%CI: 1.04-1.11). Participants preferred one-to-one support to treatment in a group setting (OR=1.40, 95%CI: 1.34-1.47). Talking in-person was less popular than talking online (OR=1.08, 95%CI: 1.03-1.13) or

online content (OR=1.24, 95%CI: 1.18-1.30), which was the most popular option; participants were indifferent between talking in-person and simply receiving printed content (OR=1.02, 95%CI: 0.89-1.13).

Preferences for weight loss programmes' attributes: individual characteristics

We tested pre-specified interactions of gender, ethnicity, and BMI with the attributes, presented in full in Supplement 11. There was evidence of two interactions only. First, the average amount of weight loss mattered more for women, with women preferring greater weight loss more strongly than men. Second, people in an ethnic minority preferred group formats with people of the same background more strongly than White respondents. In a post hoc analysis, we found that higher weight loss was more strongly preferred by people with BMI>=40.

The results of the calibration (i.e. using data from a clinical trial to set our model's predictions to a level that was observed in real world behaviour) made a substantial impact on the predicted choice probabilities. The uncalibrated model predicted choice probabilities ranging from 0.64 to 0.89. (This is broadly in line with prior results (21) which is also a stated choice study without calibration.) This did not align with the study's clinical team's expectations, based on previous research on uptake to programmes in clinical trials and in routine care (22). With the correction applied, the predicted choice probabilities ranged from 0.22 to 0.42 which was based on the uptake observed in a UK-based clinical trial of TDR (1) and more plausible from our clinicians' perspective.

Figure 2 presents the simulated choice probabilities for five weight loss programmes. One of these was designed to represent the theoretically most popular programme based on the attributes and levels in the experiment, regardless of availability in practice. This featured online content, individual support, with 'an instructor like me', 10 to 15kg weight lost, weekly sessions, over a 3 to 6 month plan, and healthy eating. The simulated likelihood of participation was 0.42; 95%CI 0.39-0.44. That is, if offered to all participants, 42% of all the choices made would be this programme, and 58% of choices would be not to participate. The simulated likelihood of participation in the least popular of the four currently available programmes, group-based community weight management programmes, was 0.22; 95%CI 0.21-0.24. Other currently available weight loss programmes were between these two limits; participating in a TDR (all meals replaced by formula liquid products) (0.25; 95%CI 0.23-0.27), online 1:1 support for a "real food" weight loss diet (0.31; 95%CI 0.29-0.33) and online healthy eating information with low weight loss (0.33; 95%CI 0.31-0.35).

Sensitivity analyses

Mixed nested logit models were preferred to simpler nested logit models on the basis of improvements in model fit (using a Vuong test for non-nested models) and the appeal of allowing for heterogeneity in respondents' preferences, which mitigates the risk of parameter bias.

Including participants we excluded because they were enrolled even though we were over quota - i.e. the survey firm provided them even though they over sampled on some quotas - did not change the results (Supplement 12). Survey questions on relative attribute importance corroborated findings from the choice models.

Discussion

This study estimated preferences for attributes of weight loss programmes to understand weight loss programme participation in a sample of individuals living with overweight and obesity. The strongest preferences related to the type of diets, with TDR the least favoured amongst a set of six, and healthy eating preferred most over TDR. The amount of weight lost and preferring weight loss programmes alone, rather than in a group, were also important features of weight loss programmes. There was no evidence that these preferences differed by whether people had or did not have type 2 diabetes. There

was some evidence that women were more likely to prefer programmes that typically resulted in greater weight loss than men. Further, individuals from ethnic minority populations were more likely to prefer attending a group programme with other people from the same background than were White people. Lastly, we found evidence that those with high BMI preferred programmes that could deliver higher weight loss. There was no evidence that providing information on the need for larger weight loss to put type 2 diabetes into remission changed preferences overall or in people with type 2 diabetes.

Strengths of this study include an experimental design underpinned by rich sources of data. Using a scoping review of existing weight loss programmes and the input from a diverse group of people with experience of trying to lose weight and using weight loss programmes, clinicians, and other stakeholders ensured that we studied the features of programmes that are representative of the choice of weight loss programmes currently available, and described in a way that was understood by members of the public. We also used a large, nationally representative sample for our experiment. Oversampling people with type 2 diabetes meant we were able to assess whether preferences for weight management differed from the general population in this group and found no evidence that they did so by an important amount. We took steps to ensure the quality of the data and a series of sensitivity analyses to verify our findings. We used advanced modelling techniques to yield robust estimates. An experiment-within-experiment design allowed us to test the impact of a behavioural prime on preferences.

Limitations include that obesity-related behaviours are potentially subject to misreporting due to social stigma and/or social desirability bias (23). In this setting, it could have manifested in respondents choosing weight loss programmes more often than they otherwise might have. Indeed, discrete choice experiments are vulnerable to hypothetical bias; that is, what respondents report in surveys is not necessarily what they do in real life settings (18). This is potentially a limiting issue insofar as measured preferences may differ from those in reality. Some signals from the analysis help to mitigate these concerns. First, many individuals chose "neither of these" weight loss programmes (around 20% of all choices). Second, in the survey feedback, respondent comments such as, "…I avoided all intermittent fasting ones as I have tried it and hated it…" gave reassurance that the experiment worked as intended. Further, we took steps to mitigate this by designing the experiment based on available weight loss programmes in the real world, engaging users of weight loss programmes in our design processes, and using results from clinical trials to base our predicted choice probabilities on observed behaviours, which made a substantial difference to the predicted participation rates. Whilst using results from a clinical trial to calibrate our model improves the accuracy of our estimates, we note that trials are subject to forms of selection bias, in this case recruitment through primary care, that may mean the participation rate in trials differ systematically from routine practice. Both the estimated preferences and the predicted probabilities should be treated with some caution because they are ultimately hypothetical choices in an online experiment and not behaviour. Moreover, previous research (5) and clinical experience suggests that while many people believe they will not enjoy or have success with particular dietary programmes, notably TDR, this perception frequently changes over time based on direct experience. Therefore, it is important to acknowledge that a hypothetical choice may not necessarily reflect what people choose or have success with in practice. However, it is possible that understanding people's preferences for weight loss programmes could help to make more programmes available with characteristics that people will identify as the "right diet for them", and that may in turn promote uptake and adherence (24).

Previous studies, (2-4,6,21,25), have found that individuals preferred interventions that: involved diets and exercise rather than diets only; required less exercise; maximised weight loss; had more clinician involvement; were personal rather than group-based; offered tailored versus generic support; were cheaper; minimised the risk of diabetes; and required lower travel times to access. Our results are not directly comparable because we focussed specifically on diet-based interventions and we found that the type of diet was the leading driver of preferences. In both Reed Johnson et al. (21) and Benning et al. (4), weight loss was more important than the type of diet (though the diet options were unspecific as "restrictive", "flexible" and "no diet"). Other studies, e.g. (21), have used cost as an attribute which will be important in settings where individuals pay for weight loss programmes, such as in the US.

There are important implications of these findings for the provision of weight loss programmes. Firstly, based on the results of recent trials (1,26) TDR is becoming the mainstay of dietary interventions for diabetes remission, yet was the least popular diet generally, despite the promise of significant weight loss. This finding may help explain the relatively low participation rate observed in the national rollout of this treatment in a pilot programme in the UK, and implies that active efforts may be needed to promote this approach. Secondly, the least popular option is a group-based community weight management programme, yet this is one of the most common options offered by local areas for the treatment of obesity or adopted by individuals looking to lose weight. Uptake may be enhanced by offering one of more of the more preferred features e.g. online resources or 1:1 support, subject to costs, and indeed many providers are now incorporating these aspects into their programmes.

The promise of at least 5 kg weight loss is also important, perhaps reflecting a sense of what is worthwhile. This goal may have been reinforced by targets outlined in many clinical guidelines which recommend initial "realistic" targets of around 5% weight loss (27). Whilst evidence suggests that greater weight loss brings greater clinical benefit and larger weight losses are certainly important, if the goal is diabetes remission, at a population level even small reductions are beneficial (1,28). Nonetheless, the unsurprising desire for substantial weight loss within relatively short periods of time should focus attention on more intensive programmes.

The notion of 'healthy eating' was very attractive to participants. However this was not precisely defined and in practice it may be harder to develop programmes universally perceived as 'healthy'. For example, there is considerable debate about the 'healthy' content of carbohydrate in the diet, especially for people with diabetes. TDR programmes are nutritionally complete, which is hard to achieve in energy-restricted diets based on 'usual' foods, yet their 'ultra-processed' nature may be perceived as unhealthy. Nonetheless, since the desire for a 'healthy diet' in association with the opportunity to lose weight is important, emphasising the nutritional value of any dietary intervention is important to enhance uptake.

This study suggests that the theoretically most preferred weight loss programme for the average participant would be available online, delivered 1:1 to the individual, supporting 10-15kg weight loss, with weekly contact, following a "healthy eating" type of diet, for 3 to 6 months, where the instructor or health coach shares characteristics of the individual. While such a programme is not currently available, so it is at this time hypothetical, our modelling suggests that offering a programme such as this could increase participation by 17 percentage points, or 68% in relative terms, compared to TDR.

In conclusion, we have described patient preferences for attributes of weight loss programmes. It is possible that creating programmes that match these may increase uptake of weight loss programmes and these preferences can be used by commissioners to design pathways to support more people to access weight loss programmes.

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Attribute No.	Attribute	Levels
1	Way of taking part	*Talking in person, e.g. at a community centre*
		Talking online, e.g. app/zoom
		Online content only
		Printed information only
2	Size of support session	*Group-based*
		Only me
3	People (or instructor) are like me	*Yes*
		No
4	Amount of weight lost	*2kg to 4kg (4lb to 9 lb)*
		5kg to 9kg (11 lb to 1 stone, 6 lb)
		10kg to15kg (1 stone, 8 lb to 2 stone, 5 lb)
		more than 15kg (2 stone, 5 lb)
5	Visits	*One-off*
		Twice per week
		Once per week
		Twice per month
		Once per month
6	Length of [weight loss] plan	*Less than 1 month*
		1 to 3 months
		3 to 6 months
		6 to 12 months
		more than 12 months
7	Type of diet	*Calorie counting*
		All meal replacement products (TDR)
		Some meal replacement products
		Food-group-based
		Healthy eating
		Intermittent fasting

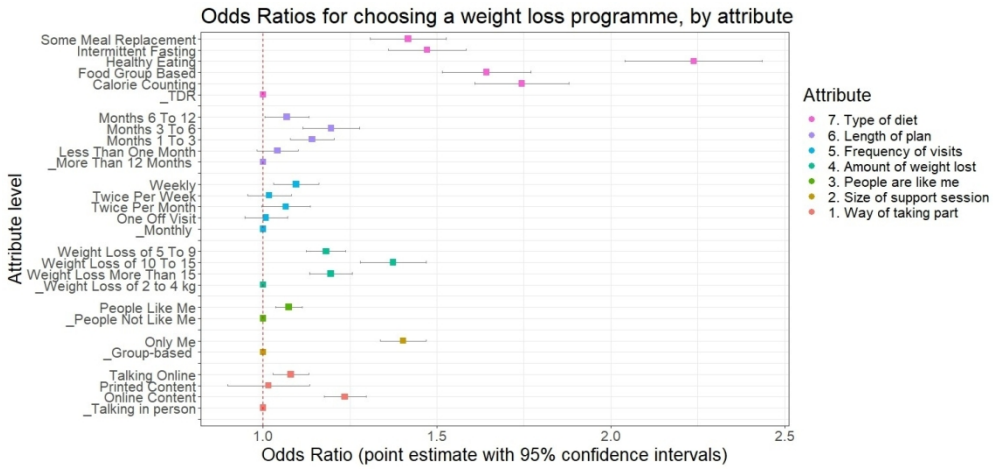
Table 1: Attributes and levels used in the discrete choice experiment.

[Insert Figure 1 here]

Figure 1: Odds ratios (ORs) of choosing weight loss programmes, by attribute. Point estimates and 95% confidence intervals are shown. For each attribute, the attribute levels are compared to the reference level (i.e. the omitted attribute level), which are shown in parentheses. The reference levels, indicated with an underscore prefix in the figure, are (corresponding attribute): Talking in person (1. Way of taking part), Group-based (2. Size of support session), People are not like me (3. People are like me), Weight Loss of 2 to 4 kg (4. Amount of weight lost), Monthly (5. Frequency of visits), More Than 12 Months (Length of plan), All Meal Replacement (Type of diet).

[Insert Figure 2 here]

Figure 2: Simulated choice probabilities for 5 weight loss programmes. See the appendix for attribute/level combinations. The choice probability of each weight loss programme is calculated in a different simulation from the same model (adjusting the model each time to resemble that particular weight loss programme). In the case of TDR, 25% of all the choices would be TDR and 75% would be not to participate; for the most popular, 42% of all the choices would be that weight loss programme and 58% would be not to participate.



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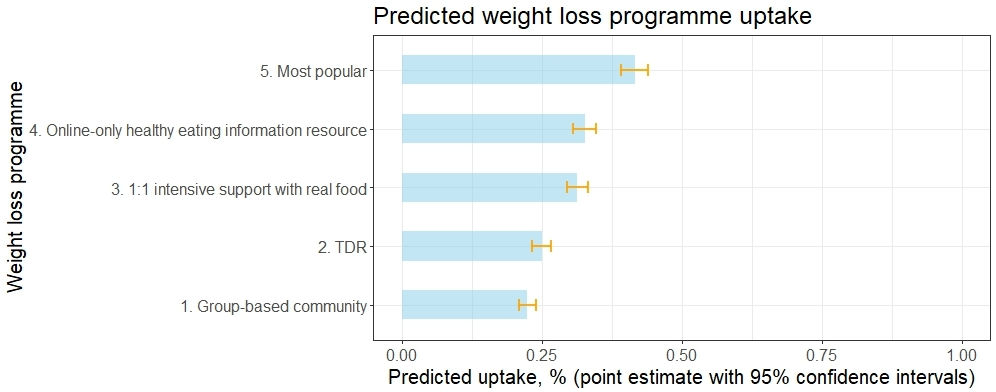
396x185mm (96 x 96 DPI)



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264x105mm (96 x 96 DPI)

SUPPLEMENTS

Supplement 1: Descriptions of attributes and levels presented in the survey to respondents

1. Way of taking part

The options for this feature are:

· Talking in person. This this is talking to someone or people in person, e.g. at a community centre.

· Talking online. This is talking to someone or people via an app/web page/zoom call

· Online content only. This is taking part with content online only (e.g. websites or apps). There is no talking to other people

· Printed information only. This is taking part only with printed materials – no in person or online interaction.

Note: we know that many weight loss plans are a mix of the options above. When considering these options, please think that the option on offer is the main way of taking part for that choice.

2. Size of support session

The options for this feature are:

· Group-based. There will be a group of people that you will interact with on the weight loss plan.

· Only me. Only you (and an instructor) will take part in this weight loss plan; there is no group activity.

3. People (or the instructor) are like me

The options for this feature are:

· Yes. The people in the group, or the instructor, are the same as you, i.e. people are people "like me". (For example: same age, same gender, same ethnicity, or about the same weight)

No. The people in the group, or the instructor, are not the same as you, i.e. people are not people "like me". (For example: different age, different gender, different ethnicity, or different weight)

4. Amount of weight lost

The options for this feature are:

· 2 to 4 kg (4lb to 9 lb). Losing just a small amount of weight, most people think that is around 2 to 4 kg.

· 5 to 9 kg (11 lb to 1 stone, 6 lb). Losing a medium amount of weight, most people think that is around 5 to 9 kg.

· 10 to 15 kg (1 stone, 8 lb to 2 stone, 5 lb). Losing a large amount of weight, most people think that is around 10 to 15 kg.

· More than 15 kg (2 stone, 5 lb). Losing a very large amount of weight, most people think that is more than 15kg.

5. Visits

The options for this feature are:

· Twice per week. Sessions occur two times each week

· Once per week. Sessions occur once each week

· Twice per month. Sessions occur two times each month, that's once every 2 weeks

· Once per month. Sessions occur once each month, that's once every 4 weeks

6. Length of weight loss plan

The options for this feature are:

· Less than 1 month

· 1 to 3 months

· 3 to 6 months

· 6 to 12 months

· More than 12 months

7. Style/intensity (type) of diet

The options for this feature are:

· Calorie counting. These diets ask you to count up the calories or "points" in each meal or snack you eat throughout the day, with the aim of not going over a target number of calories or points each day.

· All meal replacement products. You replace all of your "normal" meals, snacks, and calorie-containing drinks for a period of time, usually 1 to 4 months, with specially made shakes and soups.

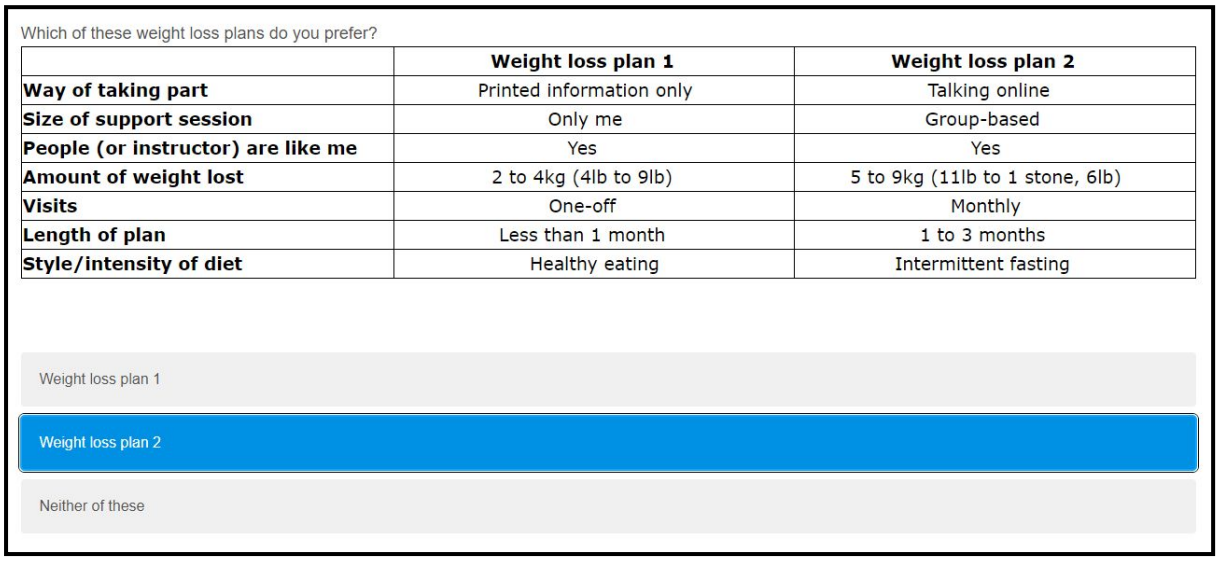
· Some meal replacement products. You replace most of your "normal" meals, snacks, and calorie-containing drinks with specially made shakes and soups, but you can continue to have one normal meal per day.

· Food-group-based (e.g. Low-carbohydrate, low-fat, or high-protein diets). These diets specify groups of foods that you should not eat (e.g. foods containing lots of carbohydrate, like bread, pasta, potatoes, rice, biscuits and cakes) or foods you should try to swap for your usual foods (e.g. choosing low fat options – margarine instead of butter, choosing low-fat yoghurt or cheese).

· Healthy eating. You make small changes to your usual diet to make it more healthy, like using different cooking oils, eating fewer sugary snacks, eating less junk food, and eating more fruit and veg.

· Intermittent fasting. A diet where you skip some meals, with medical support, with the intention of losing weight.

Supplement 2: example of an experimental choice task.



	Weight loss plan 1	Weight loss plan 2
Way of taking part	Printed information only	Talking online
Size of support session	Only me	Group-based
People (or instructor) are like me	Yes	Yes
Amount of weight lost	2 to 4kg (4lb to 9lb)	5 to 9kg (11lb to 1 stone, 6lb)
Visits	One-off	Monthly
Length of plan	Less than 1 month	1 to 3 months
Style/intensity of diet	Healthy eating	Intermittent fasting

Supplement 3: list of design restrictions.

Restriction number	Attribute names (numbers)	Rule	Rationale
1	Way of taking part (1)	If att 1 = Printed content -> att 2 = Individual	Cannot have group-based printed content
	Size of support session (2)		
2	Type of diet (7)	If att 7 = All meal replacement products -> att 6 <6 to 12 months	Cannot have TDR longer than 6 months
	Duration (6)		
3	Way of taking part (1)	If att 1 = Printed content -> att 5 = One-off	Must have a one-off for printed content
	Number of visits (5)		

Supplement 4: Breakdown of survey response quality checks

In total, 12,646 individuals responded to the survey. Our survey firm removed some responses for the following reasons. 30 of these were removed due to either duplicated or non-UK IP addresses (NB – the survey firm ran these checks on our behalf as we did not have access to IP addresses). 242 were removed for not reaching the minimum time limit or for failing the attention check embedded in the survey. 762 respondents were in excess of the quotas and rejected; 7,373 reported BMIs lower than the required threshold of 25.

Further to this, we removed some responses for respondents with implausible reported heights. A lower height threshold of two standard deviations below the mean was 144.6cm, which is approximately the threshold for being considered to have Proportionate Short Stature (PSS; sometimes referred to as dwarfism). Below this threshold were 115 individuals (2.8%). Whilst it is possible that some individuals were below this height threshold, this is well above what might be expected based the prevalence of PSS in the UK (around 1 in 25,000 (0.004%)). It is then unclear which of these entries are genuine and which were likely typographic errors of respondents. Therefore, we took a conservative approach and excluded entries where the height was below the threshold.

	Filtered out	Remaining responses
Total responses		12646
Duplicate IP	4	12642
Non-UK IP	26	12616
Speeding	87	12529
Failed attention check	155	12374
In excess of quotas	762	11612
Low BMI	7373	4239
Completes removed during data scrub	164	4075
Height lower threshold	115	3960
Analytical sample		3960

Supplement 5: choice modelling

Based on McFadden (1974), respondents were assumed to maximize their utility in making DCE choices. In this formulation, individuals reconcile their weight loss programme preferences for each of the available alternatives and choose that which maximizes their utility; that is, choosing their preferred weight loss programme, or no weight loss programme, as they are described by the attributes in the choice task. Respondents' utility is a linearly-additive function of weight loss programme attribute preferences.

$$U_{ni} = V_{ni} + \varepsilon_{ni} = \sum_{m}^{M} \beta_m \cdot x_{im} + \varepsilon_{ni} \quad (1)$$

U_{ni} is the utility for decision-maker *n* of alternative i, comprising deterministic and random utility; V_{ni} is the deterministic component of utility; ε_{ni} is the random component of utility; x_{im} is the *m*th attribute-level of alternative i; and β_m is the mth preference parameter to be estimated. The deterministic component of utility comprises preferences for weight loss programmes (versus no weight loss programme), weight loss programme attributes, and survey artefacts (left-to-right bias):

$$V_{ni} + \varepsilon_{ni}$$

$$= ASC_{no\ weight\ loss\ programme} + ASC_{left-to-right-bias} + \beta_{way\ of\ taking\ part} * Way\ of\ taking\ part + \beta_{size\ of\ support\ session} * Size\ of\ support\ session + \beta_{people\ like\ me} * People\ like\ me + \beta_{amount\ of\ weight\ lost} * Amount\ of\ weight\ lost + \beta_{visits} * Visits + \beta_{length\ of\ plan} * Length\ of\ plan + \beta_{style\ (intensity)\ of\ diet} * Type\ of\ diet + \varepsilon_{ni} \quad (2)$$

ASC denotes an alternative-specific constant. $ASC_{no\ weight\ loss\ programme}$ captures the sample average preference for a not having a weight loss programme (versus having a weight loss programme) that is not captured by the attributes. $ASC_{left-to-right-bias}$ accounts for a tendency to choose alternatives presented on the left more often than those presented on the right. β are attribute-specific preference parameters. For each attribute, the levels are dummy-coded meaning that one is set to zero as a reference category against which preferences for the other levels are measured. There are then $L-1$ estimated parameters for each attribute, where *L* is the number of levels for that attribute. For example, for "size of support session" has 2 levels, "group-based" and "only me". We set "group-based" to zero and estimate one parameter (i.e., $L-1=2-1=1$) for the level, "only me". This measures the preference for a weight loss programme for "only me" versus a "group-based" weight loss programme. Exponentiating the estimated coefficients yields odds ratios. Odds ratios give the chances of choosing a weight loss programme in the presence of the attribute level relative to the chances of choosing the same weight loss programme except with the reference category of that attribute. The odds ratio for "only me" would give the chances of choosing a weight loss program that is delivered to the individual alone versus the chances of the same weight loss programme delivered in a group setting.

Estimation is operationalized by assuming a type-I extreme value error distribution on the error term and estimating choice probabilities for each alternative with a multinomial logit (MNL) model.

$$P_{ni} = \frac{exp\ (V_{ni})}{\sum_{j=1}^{n} exp\ (V_{nj})} \quad (3)$$

where P_{ni} is the probability that respondent *n* chooses alternative i from choice task J. In our data, every choice task had three alternatives (two weight loss programmes and no weight loss programme), thus $J = 3\ \forall n$.

Under the Independence of Irrelevant Alternatives (IIA) assumption of the MNL model, no correlation is assumed between alternatives. This is behaviourally unlikely in the case of the two weight loss programmes (versus no weight loss programme), the choices of which are likely related. A nested logit model allows for correlation between alternatives, in this case specifying a nesting structure with a "weight loss programme" group (with the two weight loss programmes) and a "no weight loss programme" group (containing the opt-out). We then estimate the probability of being in a group as well as the probability of weight loss programme choice, conditional on being in the weight loss programme group.

$$P_{ni,g} = P_{ni,g}(Group).P_{ni,g}(Group)$$

$$= \frac{exp\left(\sum_{i \in g}(V_{ni}/\lambda_g)\right)^{\lambda_g}}{\sum_{l=1\ldots L} exp\left(\sum_{i \in l}(V_i/\lambda_{nl})\right)^{\lambda_l}} \cdot \frac{exp\,(V_{ni}/\lambda_g)}{\sum_{j=1\ldots J} exp\,(V_{nj}/\lambda_g)} \quad (4)$$

where g is each group (weight loss programme or no weight loss programme) and λ_g is a within-group correlation parameter to be estimated. λ_g is restricted empirically to the range $\lambda_g \in [0,1]$ with a logit transformation, where $\lambda_g = 1$ is equivalent to the MNL.

Preference variation for weight loss programme attributes was modelled deterministically and randomly. For deterministic heterogeneity, the weight loss programme ASC and the attributes were interacted with individuals' characteristics listed in our analysis plan (gender, ethnicity, and education). In a post hoc analysis suggested by a referee, we assessed whether having a BMI>=40 modified preferences for the amount of weight loss achieved by adding a multiplicative interaction term. These parameters indicate weight loss programme and/or attribute preference variation according to those characteristics. Random preference heterogeneity was modelled using mixing distributions (Train, 2009). Parameters were treated as a normal distributions, thus each has a mean and a standard deviation to be estimated.

Combining the forms of heterogeneity, taking attribute size of support session as an example, we have,

$$\beta_{only\ me} = \mu_{only\ me} + \gamma_{only\ me}{}'Z_i + \theta_{only\ me} \quad (5)$$

where $\mu_{only\ me}$ is the mean and $\theta_{only\ me} \sim N(0, \sigma^2_{\theta,only\ me})$ is the standard deviation capturing unobserved preference heterogeneity across individuals for weight loss programmes where they are by themselves (versus group-based programmes). Normal distributions were specified for all attributes, and 500 draws were taken using the Modified Latin Hypercube Sampling algorithm (Hess et al., 2006). Z_i are three individual characteristics and $\gamma_{only\ me}$ are deterministic heterogeneity parameters measuring if preferences vary for weight loss programmes where people are by themselves across individual characteristics; for example if women's preferences for weight loss programmes where they are by themselves are different to men's. Models were specified with all interactions on covariates and all mixing distributions. Models were then refined to remove non-significant parameters for a parsimonious specification.

Correcting choice shares

If the choice shares in the data are not representative of real-world shares, in this case weight loss programmes, then the ASC, $ASC_{weight\ loss\ programme}$, can be recalibrated to match the target choice shares in model application, rather than the choice shares in the data, as shown in Train (2009). In this case, individuals may have focussed more on choosing between weight loss programmes rather than to

choose a weight loss programme or not. Accordingly, the model may predict much higher choices of weight loss programmes than would be seen in the real world. To mitigate this we used data from a clinical trial to set our base predictions to a level that was observed in real world behaviour, a procedure known as model calibration (Buckell and Hess, 2019). Specifically, we know that for a trial of TDR, uptake was around 25% (Lean et al., 2018).

Using TDR as an example, we would set the ASC for any weight loss programme, $ASC_{weight\ loss\ programme}$, and the other model parameters (that define TDR; these would vary for other weight loss programmes) to calculate the choice share for TDR that the uncalibrated model predicts on the estimate data. This choice share, $\widehat{CS}^0_{TDR}$, can then be compared to real-world. For example, in Lean et al. (2018), we know the uptake of TDR was 25%, which we will call the trial share of TDR, TS_{TDR}. If the predicted choice share of TDR exceeds the trial share, it needs to be reduced; with the opposite applying if the model underpredicts the trial share. This can be achieved by applying the formula,

$$ASC^1_{weight\ loss\ programme} = ASC^0_{weight\ loss\ programme} + ln\left(\frac{TS_{TDR}}{\widehat{CS}^0_{TDR}}\right)$$

Where $ASC^1_{weight\ loss\ programme}$ is the recalibrated choice share for TDR, i.e. $\widehat{CS}^1_{TDR}$. If this new choice share does not perfectly match the trial share, the process can be repeated until the two are perfectly aligned.

The same correction is then applied to all other forecasts of weight loss programmes.

Supplement 6: characteristics of simulated weight loss programmes

Attribute	Level	TDR	1:1 intensive support with real food	group based community	online-only healthy eating information resource	Most popular
Way of taking part	*Talking in person, e.g. at a community centre*	0	0	1	0	0
	Talking online, e.g. app/zoom	1	1	0	0	0
	Online content only	0	0	0	1	1
	Printed information only	0	0	0	0	0
Size of support session	*Group-based*	0	0	1	0	0
	Only me	1	1	0	1	1
People (or instructor) are like me	*Yes*	0	0	1	0	1
	No	1	1	0	0	0
Amount of weight lost	*2kg to 4kg (4lb to 9 lb)*	0	0	1	1	0
	5kg to 9kg (11 lb to 1 stone, 6 lb)	0	1	0	0	0
	10kg to15kg (1 stone, 8 lb to 2 stone, 5 lb)	1	0	0	0	1
	more than 15kg (2 stone, 5 lb)	0	0	0	0	0
Visits	*One-off*	0	0	0	1	0
	Twice per week	0	0	0	0	0
	Once per week	0	0	0	0	1
	Twice per month	1	1	0	0	0
	Once per month	0	0	1	0	0
Length of [weight loss] plan	*Less than 1 month*	0	0	0	1	0
	1 to 3 months	0	0	1	0	0
	3 to 6 months	1	1	0	0	1
	6 to 12 months	0	0	0	0	0
	more than 12 months	0	0	0	0	0
Type of diet	*Calorie counting*	0	0	1	0	0
	All meal replacement products	1	0	0	0	0
	Some meal replacement products	0	0	0	0	0
	Food-group-based	0	1	0	0	0
	Healthy eating	0	0	0	1	1
	Intermittent fasting	0	0	0	0	0

Characteristics of simulated weight loss programmes. TDR – an intensive weight loss programme with 1:1 support using TDR, 1:1 intensive support with real food – remote delivery of 1:1 support for an intensive weight loss programme where participants eating "real food" rather than meal replacement products, group based community - , group based community weight management programmes (e.g. WW™/Slimming World™, online-only healthy eating information resource - online-only healthy eating information resource (e.g. NHS digital weight management programme).

Supplement 7: Descriptive statistics of sample

	Continuous variables				Categorical variables					
	Mean	s.d.	min	max	Total		Overweight and Obesity		Type 2 Diabetes	
					N	%	N	%	N	%
Age: all	46.17	15.76	18	87						
Age: Overweight and Obesity	45.76	15.83	18	87						
Age: Type 2 Diabetes	48.16	15.23	18	81						
Gender										
Female					1930	48.7%	1669	50.8%	261	38.7%
Male					2014	50.9%	1603	48.8%	411	60.9%
Non-binary					12	0.3%	10	0.3%	2	0.3%
Prefer not to answer					4	0.1%	3	0.1%	1	0.1%
Ethnicity										
White					3273	82.7%	2726	83.0%	547	81.0%
Ethnic minority populations					687	17.3%	559	17.0%	128	19.0%
Education										
Degree or higher					1739	43.9%	1420	43.2%	319	47.3%
No degree					2221	56.1%	1865	56.8%	356	52.7%
Region										
North East					185	4.7%	148	4.5%	37	5.5%
North West					422	10.7%	353	10.7%	69	10.2%
Yorkshire and the Humber					357	9.0%	302	9.2%	55	8.1%
East Midlands					310	7.8%	263	8.0%	47	7.0%
West Midlands					375	9.5%	320	9.7%	55	8.1%
East of England					336	8.5%	282	8.6%	54	8.0%
London					518	13.1%	396	12.1%	122	18.1%
South East					536	13.5%	459	14.0%	77	11.4%
South West					339	8.6%	282	8.6%	57	8.4%
Northern Ireland					92	2.3%	78	2.4%	14	2.1%
Scotland					291	7.3%	238	7.2%	53	7.9%
Wales					199	5.0%	164	5.0%	35	5.2%
BMI: all	30.55	5.22	25.00	83.96						
BMI: Overweight and Obesity	30.22	5.02	25.00	83.96						
BMI: Type 2 Diabetes	32.13	5.87	25.05	77.16						
Long Term Health Conditions										
None					1542	38.9%	1542	46.9%	0	0.0%
One or more					2343	59.2%	1668	50.8%	675	100.0%
Prefer not to answer					75	1.9%	75	2.3%	0	0.0%
Smoking Status										

Current smoker	621	15.7%	491	14.9%	130	19.3%
Ex-smoker	1232	31.1%	990	30.1%	242	35.9%
Never smoked	2066	52.2%	1766	53.8%	300	44.4%
Prefer not to answer	41	1.0%	38	1.2%	3	0.4%
Had bariatric surgery						
Yes	67	1.7%	38	1.2%	29	4.3%
No	3877	97.9%	3232	98.4%	645	95.6%
Prefer not to answer	16	0.4%	15	0.5%	1	0.1%
Employment						
Currently working	2581	65.2%	2149	65.4%	432	64.0%
Not currently working	1332	33.6%	1089	33.2%	234	34.7%
Prefer not to answer	56	1.4%	47	1.4%	9	1.3%

Descriptive statistics for the entire sample, and separately by Overweight and Obesity, and Type 2 Diabetes. Mean – arithmetic mean, s.d. – standard deviation, min – minimum, max – maximum, N – number of individuals.

Supplement 8: Nested logit models including interactions with type 2 diabetes status

	All		
	Estimate	Rob.std.err.	Rob.t-ratio(0)
left to right bias	-0.052	0.017	-2.963
wlp	-0.117	0.062	-1.875
talking online	0.050	0.021	2.384
online content	0.163	0.022	7.452
printed content	0.116	0.044	2.648
only me	0.255	0.019	13.407
people like me	0.018	0.015	1.182
weight loss 5 to 9	0.162	0.021	7.668
weight loss 10 to 15	0.225	0.024	9.324
weight loss more than 15	0.153	0.023	6.567
one off visit	-0.014	0.027	-0.530
twice per week	-0.006	0.028	-0.227
weekly	0.075	0.025	3.012
twice per month	0.042	0.031	1.342
less than one month	0.041	0.027	1.551
months 1 to 3	0.094	0.024	3.938
months 3 to 6	0.109	0.028	3.855
months 6 to 12	0.044	0.026	1.717
calorie counting	0.451	0.034	13.098
some meal replacement	0.313	0.035	8.956
food group based	0.370	0.035	10.438
healthy eating	0.634	0.039	16.222
intermittent fasting	0.303	0.034	8.921
lambda wlp	7.928	3.626	2.187
wlp T2D	0.342	0.156	2.197
talking online T2D	-0.055	0.048	-1.136
online content T2D	-0.040	0.048	-0.829
printed content T2D	-0.091	0.114	-0.793
only me T2D	0.010	0.047	0.206
people like me T2D	0.032	0.037	0.857
weight loss 5 to 9 T2D	-0.020	0.050	-0.409
weight loss 10 to 15 T2D	-0.009	0.056	-0.165
weight loss more than 15 T2D	0.033	0.054	0.599
one off visit T2D	-0.012	0.066	-0.188
twice per week T2D	0.104	0.069	1.512
weekly T2D	-0.027	0.061	-0.432
twice per month T2D	0.070	0.077	0.902
less than one month T2D	-0.012	0.062	-0.200
months 1 to 3 T2D	-0.013	0.059	-0.226
months 3 to 6 T2D	0.001	0.071	0.010

months 6 to 12 T2D	-0.038	0.065	-0.582
calorie counting T2D	-0.146	0.081	-1.804
some meal replacement T2D	-0.123	0.083	-1.476
food group based T2D	0.018	0.084	0.213
healthy eating T2D	-0.181	0.093	-1.954
intermittent fasting T2D	-0.052	0.081	-0.649
N	3960		
Obs	39600		
K	46		
LL	-40994.55		
Lambda	1.00		

Nested logit models including interactions with type 2 diabetes status. Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)).

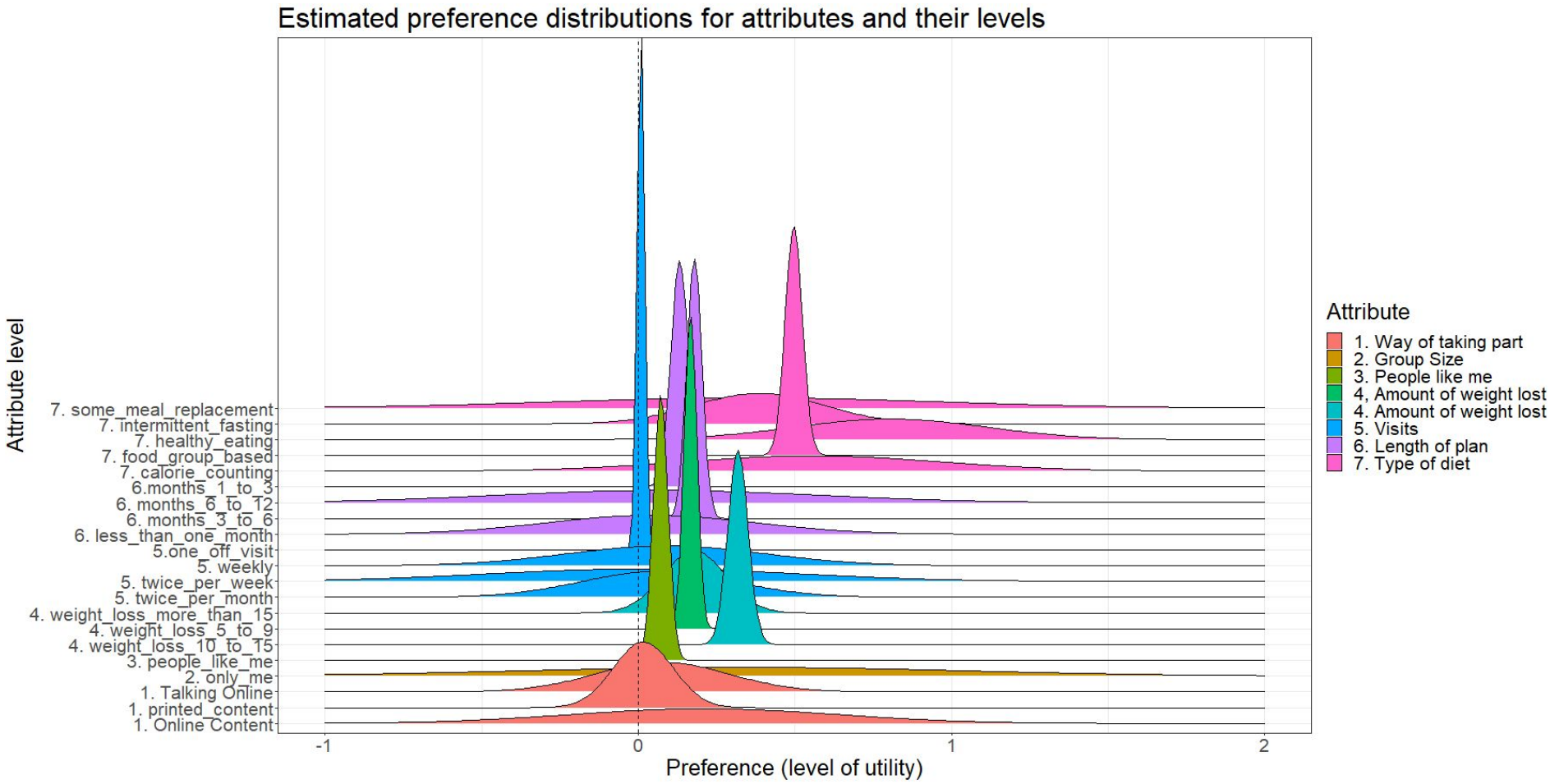
Supplement 9: Mixed nested logit

	Estimate	Rob.std.err.	Rob.t-ratio(0)
left to right bias	-0.059	0.021	-2.838
wlp mu	1.778	0.137	12.942
talking online mu	0.076	0.025	3.114
online content mu	0.212	0.025	8.524
printed content mu	0.016	0.060	0.262
only me mu	0.338	0.024	14.110
people like me mu	0.072	0.018	3.984
weight loss 5 to 9 mu	0.166	0.025	6.795
weight loss 10 to 15 mu	0.318	0.035	8.965
weight loss 10 to 15 primed	-0.039	0.040	-0.978
weight loss more than 15 mu	0.178	0.026	6.788
one off visit mu	0.008	0.031	0.267
twice per week mu	0.018	0.032	0.555
weekly mu	0.091	0.031	2.961
twice per month mu	0.064	0.034	1.885
less than one month mu	0.041	0.029	1.405
months 1 to 3 mu	0.132	0.028	4.732
months 3 to 6 mu	0.179	0.035	5.155
months 6 to 12 mu	0.066	0.030	2.199
calorie counting mu	0.556	0.040	14.032
some meal replacement mu	0.349	0.039	8.893
food group based mu	0.497	0.040	12.532
healthy eating mu	0.806	0.045	17.912
intermittent fasting mu	0.387	0.039	9.956
wlp sigma	3.931	0.117	33.575
talking online sigma	0.212	0.078	2.716
online content sigma	0.427	0.056	7.642
printed content sigma	-0.096	0.164	-0.583
only me sigma	0.715	0.033	21.674
people like me sigma	0.024	0.034	0.696
weight loss 5 to 9 sigma	-0.020	0.068	-0.291
weight loss 10 to 15 sigma	-0.032	0.120	-0.269
weight loss more than 15 sigma	-0.101	0.320	-0.315
one off visit sigma	0.012	0.065	0.188
twice per week sigma	0.496	0.057	8.763
weekly sigma	-0.316	0.089	-3.547
twice per month sigma	0.244	0.164	1.488
less than one month sigma	0.333	0.093	3.592
months 1 to 3 sigma	-0.028	0.040	-0.700
months 3 to 6 sigma	-0.024	0.045	-0.535
months 6 to 12 sigma	0.512	0.074	6.933
calorie counting sigma	-0.412	0.094	-4.396
some meal replacement sigma	0.616	0.071	8.654
food group based sigma	0.027	0.087	0.315
healthy eating sigma	0.306	0.128	2.392
intermittent fasting sigma	0.207	0.131	1.582
lambda wlp	12.390	0.671	18.459
N	3960		
Obs	39600		
K	47		
LL	-32792.24		
Lambda	1.00		

MLHS draws	500

Mixed nested logit model. Parameters “mu” are the estimated means of normal distributions; parametes “sigma” are the estimated standard deviations of the normal distributions. Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)), MLHS draws – number of modified Latin hypercube sampling draws.

Supplement 10: Estimated attribute preference distributions from the mixed nested logit model



Estimated attribute preference distributions from the mixed nested logit model. For each attribute level, the probability density function (PDF) is plotted using the estimated mean and standard deviation from the mixed nested logit model (that is, the area under the curve sums to 1).

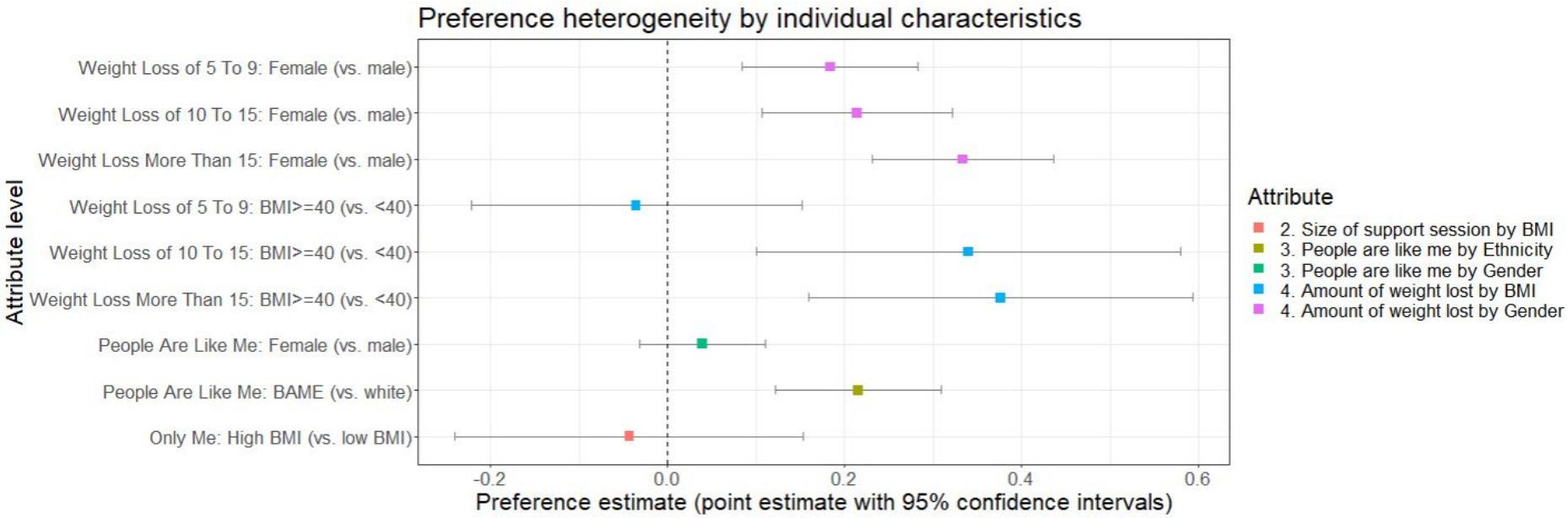
Supplement 11: Mixed nested logit with individual characteristics

	Estimate	Rob.std.err.	Rob.t-ratio(0)
left to right bias	-0.060	0.021	-2.879
wlp mu	1.757	0.133	13.248
wlp sigma	3.939	0.106	37.064
talking online mu	0.072	0.040	1.819
talking online sigma	0.044	0.404	0.108
talking online female	-0.065	0.049	-1.342
talking online Ethnic minority populations	0.026	0.062	0.414
talking online higher education	0.104	0.050	2.100
online content mu	0.292	0.044	6.711
online content sigma	-0.465	0.044	-10.558
online content female	-0.115	0.050	-2.296
online content Ethnic minority populations	-0.109	0.061	-1.778
online content higher education	-0.012	0.050	-0.245
printed content mu	0.269	0.102	2.647
printed content sigma	0.220	0.160	1.376
printed content female	0.005	0.119	0.044
printed content Ethnic minority populations	-0.545	0.163	-3.336
printed content higher education	-0.318	0.127	-2.495
only me mu	0.357	0.041	8.673
only me sigma	0.719	0.033	21.754
only me female	-0.078	0.047	-1.680
only me Ethnic minority populations	0.058	0.059	0.974
only me higher education	0.044	0.048	0.906
only me BMI	-0.043	0.100	-0.430
people like me mu	-0.013	0.030	-0.426
people like me sigma	0.030	0.046	0.664
people like me female	0.040	0.037	1.082
people like me Ethnic minority populations	0.215	0.048	4.524
people like me higher education	0.035	0.039	0.898
people like me BMI	0.158	0.071	2.205
weight loss 5 to 9 mu	0.120	0.043	2.801
weight loss 5 to 9 sigma	-0.003	0.084	-0.038
weight loss 5 to 9 female	0.184	0.051	3.633
weight loss 5 to 9 Ethnic minority populations	-0.094	0.064	-1.466
weight loss 5 to 9 higher education	-0.045	0.051	-0.888
weight loss 5 to 9 BMI	-0.035	0.095	-0.370
weight loss 10 to 15 mu	0.184	0.051	3.576
weight loss 10 to 15 sigma	0.034	0.141	0.243

weight loss 10 to 15 primed	-0.020	0.020	-0.981
weight loss 10 to 15 female	0.214	0.055	3.889
weight loss 10 to 15 Ethnic minority populations	-0.005	0.072	-0.076
weight loss 10 to 15 higher education	0.031	0.058	0.532
weight loss 10 to 15 BMI	0.340	0.122	2.778
weight loss more than 15 mu	0.008	0.044	0.175
weight loss more than 15 sigma	-0.006	0.610	-0.009
weight loss more than 15 female	0.333	0.052	6.355
weight loss more than 15 Ethnic minority populations	-0.032	0.068	-0.474
weight loss more than 15 higher education	0.001	0.055	0.014
weight loss more than 15 BMI	0.376	0.111	3.398
one off visit mu	-0.067	0.052	-1.277
one off visit sigma	0.126	0.136	0.923
one off visit female	-0.105	0.063	-1.670
one off visit Ethnic minority populations	0.274	0.086	3.201
one off visit higher education	0.160	0.069	2.331
twice per week mu	-0.091	0.053	-1.711
twice per week sigma	-0.514	0.065	-7.865
twice per week female	-0.021	0.064	-0.324
twice per week Ethnic minority populations	0.341	0.080	4.233
twice per week higher education	0.106	0.066	1.599
weekly mu	0.050	0.049	1.034
weekly sigma	-0.212	0.206	-1.027
weekly female	-0.019	0.062	-0.301
weekly Ethnic minority populations	0.175	0.078	2.247
weekly higher education	0.064	0.066	0.972
twice per month mu	0.032	0.056	0.562
twice per month sigma	0.338	0.117	2.901
twice per month female	-0.126	0.074	-1.706
twice per month Ethnic minority populations	0.242	0.087	2.797
twice per month higher education	0.106	0.072	1.472
less than one month mu	0.072	0.049	1.475
less than one month sigma	0.230	0.173	1.334
less than one month female	-0.213	0.061	-3.485
less than one month Ethnic minority populations	0.078	0.077	1.014
less than one month higher education	0.142	0.068	2.100
months 1 to 3 mu	0.098	0.046	2.143
months 1 to 3 sigma	0.003	0.066	0.051
months 1 to 3 female	-0.076	0.057	-1.342
months 1 to 3 Ethnic minority populations	0.043	0.074	0.584
months 1 to 3 higher education	0.154	0.062	2.480
months 3 to 6 mu	0.092	0.056	1.651
months 3 to 6 sigma	0.005	0.077	0.062
months 3 to 6 female	-0.082	0.072	-1.133
months 3 to 6 Ethnic minority populations	0.219	0.093	2.367
months 3 to 6 higher education	0.213	0.084	2.553

months 6 to 12 mu	0.021	0.050	0.414
months 6 to 12 sigma	0.516	0.081	6.380
months 6 to 12 female	-0.050	0.064	-0.784
months 6 to 12 Ethnic minority populations	0.075	0.082	0.921
months 6 to 12 higher education	0.139	0.069	2.019
calorie counting mu	0.343	0.062	5.528
calorie counting sigma	-0.445	0.064	-6.979
calorie counting female	0.404	0.079	5.130
calorie counting Ethnic minority populations	-0.106	0.095	-1.122
calorie counting higher education	0.100	0.083	1.211
some meal replacement mu	0.225	0.064	3.539
some meal replacement sigma	0.666	0.076	8.740
some meal replacement female	0.248	0.082	3.020
some meal replacement Ethnic minority populations	0.101	0.097	1.036
some meal replacement higher education	-0.009	0.089	-0.101
food group based mu	0.219	0.061	3.584
food group based sigma	0.031	0.133	0.233
food group based female	0.375	0.077	4.841
food group based Ethnic minority populations	-0.036	0.096	-0.379
food group based higher education	0.249	0.083	3.007
healthy eating mu	0.464	0.068	6.811
healthy eating sigma	-0.256	0.142	-1.798
healthy eating female	0.499	0.089	5.618
healthy eating Ethnic minority populations	-0.126	0.103	-1.231
healthy eating higher education	0.310	0.090	3.444
intermittent fasting mu	0.192	0.061	3.128
intermittent fasting sigma	0.038	0.258	0.145
intermittent fasting female	0.257	0.080	3.196
intermittent fasting Ethnic minority populations	0.076	0.094	0.807
intermittent fasting higher education	0.175	0.078	2.246
lambda wlp	10.766	0.366	29.406
N	3960		
Obs	39600		
K	115		
LL	-32586.72		
Lambda	1		
MLHS draws	500		

Mixed nested logit model with individual characteristics. Parameters “mu” are the estimated means of normal distributions; parameters “sigma” are the estimated standard deviations of the normal distributions. Interactions of attributes are for female (vs. male), Ethnic minority populations (vs. White), higher education (vs. not higher education), and BMI>40 (vs BMI<=40). Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)), MLHS draws – number of modified Latin hypercube sampling draws.



Estimated preferences for weight loss programme attributes by individual characteristics. Point estimates and 95% confidence intervals are shown. Preference estimates are compared to zero (dotted line), with the x-axis denoting the sign and magnitude of the preference(s).

Supplement 12: Nested logit models including observations that were removed for data cleaning

	All		
	Estimate	Rob.std.err.	Rob.t-ratio(0)
left to right bias	-0.046	0.017	-2.691
no weight loss programme	-0.004	0.053	-0.081
talking online	0.044	0.019	2.354
online content	0.152	0.019	7.932
printed content	0.093	0.039	2.372
only me	0.251	0.017	14.651
people not like me	-0.027	0.014	-1.974
weight loss 5 to 9	0.150	0.019	7.925
weight loss 10 to 15	0.214	0.021	9.990
weight loss more than 15	0.151	0.021	7.353
one off visit	-0.017	0.024	-0.727
twice per week	0.008	0.025	0.312
weekly	0.059	0.022	2.623
twice per month	0.050	0.028	1.782
less than one month	0.035	0.024	1.471
months 1 to 3	0.092	0.021	4.277
months 3 to 6	0.103	0.026	4.008
months 6 to 12	0.032	0.023	1.409
calorie counting	0.416	0.031	13.594
some meal replacement	0.279	0.031	8.980
food group based	0.368	0.032	11.683
healthy eating	0.588	0.035	16.928
intermittent fasting	0.288	0.030	9.513
lambda wlp	9.345	1.067	8.761
N	4074		
Obs	40740		
K	24		
LL	-42178.49		
Lambda	1.00		

Nested logit models including observations that were removed for data cleaning. Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)).

Supplement 13: Test of behavioural prime interacted with weight loss

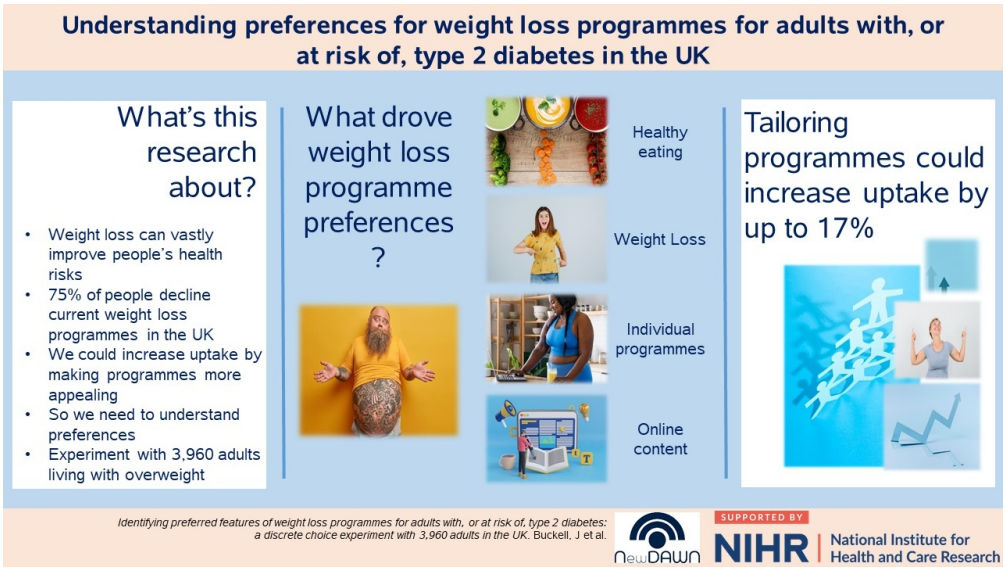
	Estimate	Rob.std.err.	Rob.t-ratio(0)
left to right bias	-0.051	0.017	-2.927
opt out	0.038	0.054	0.707
talking online	0.041	0.019	2.146
online content	0.155	0.020	7.945
printed content	0.100	0.040	2.513
only me	0.257	0.017	14.770
people not like me	-0.024	0.014	-1.754
weight loss 5 to 9	0.160	0.019	8.326
weight loss 10 to 15	0.229	0.029	7.792
weight loss 10 to 15 primed	**-0.010**	**0.037**	**-0.264**
weight loss more than 15	0.159	0.021	7.595
one off visit	-0.016	0.024	-0.669
twice per week	0.011	0.025	0.431
weekly	0.070	0.023	3.061
twice per month	0.054	0.029	1.883
less than one month	0.040	0.024	1.644
months 1 to 3	0.093	0.022	4.282
months 3 to 6	0.109	0.026	4.211
months 6 to 12	0.037	0.023	1.588
calorie counting	0.427	0.031	13.707
some meal replacement	0.292	0.032	9.241
food group based	0.374	0.032	11.666
healthy eating	0.604	0.035	17.064
intermittent fasting	0.294	0.031	9.575
lambda wlp	14.873	1.610	9.240
N	3960		
Obs	39600		
K	25		
LL	-41032.20		
Lambda	1.00		

Table AXXX: Nested logit model testing the interaction of the behavioural prime and weight loss attribute. The interaction term has been bolded is not statistically significant. Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)).

Supplement 14: Test of behavioural prime entered into the scale of utility

	Estimate	Rob.std.err.	Rob.t-ratio(0)
prime scale	**2.282**	**0.443**	**5.149**
left to right bias	-0.025	0.013	-2.000
opt out	-0.005	0.033	-0.159
talking online	0.022	0.012	1.778
online content	0.072	0.020	3.567
printed content	0.050	0.027	1.866
only me	0.111	0.024	4.548
people not like me	-0.012	0.009	-1.368
weight loss 5 to 9	0.064	0.016	3.936
weight loss 10 to 15	0.085	0.020	4.181
weight loss more than 15	0.063	0.018	3.542
one off visit	0.000	0.015	-0.029
twice per week	0.010	0.015	0.646
weekly	0.010	0.014	0.704
twice per month	0.017	0.017	1.015
less than one month	0.015	0.015	0.993
months 1 to 3	0.039	0.015	2.671
months 3 to 6	0.053	0.018	2.993
months 6 to 12	0.012	0.014	0.846
calorie counting	0.198	0.049	4.040
some meal replacement	0.128	0.035	3.687
food group based	0.176	0.042	4.209
healthy eating	0.271	0.064	4.210
intermittent fasting	0.130	0.036	3.556
lambda wlp	13.879	0.057	244.080
N	3960		
Obs	39600		
K	25		
LL	-42157.89		
Lambda	1.00		

Table AXXX: Nested logit model testing the behavioural prime on all attributes (i.e. the scale of utility). The scale parameter has been bolded is statistically significant. However, the overall fit of the model is considerably worse than the nested logit without this parameter. Rob.std.err - robust standard error, Rob t-ratio(0) – robust t-ratio versus 0, N – number of individuals, Obs – number of observations, K – number of estimated parameters, LL – Log-likelihood of the fitted model, Lambda – value of lambda derived from estimated nesting parameter (i.e. Lambda = exp(lambda wlp)/1+exp(lambda wlp)).



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