A service evaluation exploring the effectiveness of a locally commissioned tier 3 weight management programme offering face-to-face, telephone and digital dietetic support

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1 INTRODUCTION

The challenge of obesity management is a major public health concern. Most adults in England (64%) are affected by overweight or obesity, with the prevalence of obesity continuing to rise.[1] The personal and economic burdens associated with this are well known. Adults who are affected by overweight or obesity are at a much higher risk of developing conditions including type 2 diabetes, heart disease, stroke and some cancers.[2] The associated annual National Health Service (NHS) costs attributed to overweight and obesity are projected to reach £9.7 billion by 2050, with wider costs to United Kingdom (UK) society predicted to reach £49.9 billion.[3]

In the UK, there are four tiers of weight management service to support people who are affected by overweight or obesity 1) universal interventions which typically include identification and reinforcement of healthy eating and physical activity messages, offered population-wide; 2) lifestyle interventions and pharmacotherapy often as part of a multi-component weight management service; 3) specialist services inclusive of a multi-disciplinary team (MDT) and specialist assessment; and 4) pre-operative assessment with the possibility of bariatric surgery supported by a multidisciplinary team.[4] The National Institute for Health and Care Excellence (NICE) guidelines state that referral to a tier 3 service should be considered if the underlying causes of obesity need to be assessed; if the person has needs that cannot be managed adequately in tier 2 weight management services; if conventional treatment has been unsuccessful; if drug treatment is being considered for a person with a Body Mass Index (BMI) greater than 50 kg/m^2; or if bariatric surgery is being considered.[5]

Traditional tier 3 services have typically been delivered as face-to-face interventions[6-8] and evidence suggests that programmes that provide contact with a dietitian are associated with greater weight loss.[9] However, face-to-face care can be inconvenient for patients which might increase attrition[10] and can also be time-, cost-, and resource-intensive. Furthermore, evidence suggests that frequent support can enable more effective behaviour change[11], which

can be challenging to achieve with face-to-face care. To parry this, focus has shifted to the advancement of interactive digital technologies, with the potential for lower-cost scalability, as a means to enable health systems to better manage a growing and ageing population with an increasing presence of obesity-related co-morbidities.[12-13] For example, several recent systematic reviews and meta-analyses have demonstrated that mobile phone interventions can result in modest weight loss and might therefore be a useful tool for promoting weight loss among adults who are affected by overweight or obesity.[14-16]

Furthermore, we have seen a significant increase in demand of telehealth technologies to support healthcare in recent times due to the health and safety risks posed to patients and healthcare professionals by the COVID-19 outbreak. The COVID-19 crisis has led to extraordinary transformations of service delivery using telehealth technologies, leading to a conception of the likelihood of their continued heightened presence post COVID-19.[17]

Thus, digital healthcare has the potential to improve safety, efficiency, accessibility and personalisation of healthcare interventions,[18] but it is imperative to consider the context within which these interventions are delivered. Studies examining efficacy under controlled circumstances are frequently impractical and uneconomical in real-world interventions and do not necessarily establish their effectiveness in free-living conditions.[19] These concerns are potentially decisive because effectiveness is what matters to patients and commissioners. Yet to date there has been no evaluation of a tier 3 weight management service offering traditional methods *and* digital service provision. Therefore, the purpose of this study was to evaluate the effectiveness of an aspect of a locally commissioned tier 3 weight management programme offering face-to-face, telephone, and digital (smartphone application) support and to compare the effectiveness of each intervention in everyday practice.

MATERIALS AND METHODS

The aim of this observational study was a retrospective examination of weight change in patients referred to an NHS weight management programme. The study was a service

evaluation and was carried out after institutional ethical approval. No data were collected outside of routine clinical care and all databases were anonymised.

Participants

Outcome data were collected for patients attending the Way to Wellness programme provided by Oviva UK Ltd. as part of a tier 3 weight management programme based in Wakefield, UK, which was jointly commissioned by the NHS and local authority. Due to local commissioning specifications, slight variations to the British Obesity & Metabolic Surgery Society (BOMSS) commissioning criteria were observed; and other elements of the tier 3 service (NHS Consultant provision and physical activity services) were delivered by other providers. Eligible patients were over the age of 18-years with a BMI ≥ 45 kg/m^2 or ≥ 40 kg/m^2 with a complex comorbidity. In exceptional circumstances, patients were considered eligible if they did not meet the BMI criteria, but it was agreed by the local commissioner and programme provider that weight management support from other tiers would be inadequate for their needs. Exclusion criteria for this service included patients with an active eating disorder, unstable medical condition, unstable psychiatric disorder, women who were pregnant or breastfeeding, and patients who were not ready to change, defined by those who did not sign a pledge to declare their commitment to the programme. Patients included in the evaluation started care from 1st January 2018 and were discharged from the core programme before 31st December 2018.

Procedures and outcomes

Patients first attended a consultation and medical review with an NHS Consultant Physician. During this consultation, obesity-related comorbidities were screened for and investigated where appropriate.

Core programme

Patients were then offered an initial 45-minute face-to-face consultation and a final 30-minute face-to-face session with a Specialist Weight Management Dietitian. Between these sessions, patients were offered one of three treatment interventions: 1) four 30-minute face-to-face appointments; 2) two hours of online coaching using the Oviva smartphone application (app) approved by NHS Digital; or 3) four 30-minute telephone appointments. All care within the core programme was delivered by the same dietitian and all patients received the same amount of clinician time within their care. The choice of treatment intervention was that of the clinician and patient according to patient preference and professional standards. The aim was to attend the final session of each intervention within 12-16 weeks of commencement. Flexibility was permitted to cater for changes to appointments and dietitian availability which resulted in the mean duration of the interventions being 19 ± 5 weeks, 15 ± 4 weeks, and 17 ± 2 weeks, for the Face-to-face, App and Phone interventions, respectively.

At the initial dietetic assessment, all patients undertook a full assessment and were able to select from a variety of dietary interventions, with support from their dietitian to determine the most appropriate approach. These included diet and lifestyle goal setting (65.5% of total participants), calorie counting (25.4%), a low-carbohydrate diet (2.4%), a partial meal replacement plan (5.9%) or intermittent fasting (i.e. 5:2 diet, 1.8%). The proportion of patients using each diet was similar between groups. Very low-calorie diets and total diet replacements were not supported in this programme.

For patients undertaking the Face-to-face and Phone interventions, follow-up appointments involved the patient and dietitian reviewing existing goals and progress and setting or re-establishing SMART goals at the end of every session.

Patients who were app coached were also guided by SMART goals. Patients that chose to be supported via online coaching were asked to track their food intake by uploading pictures of meals or snacks, or by sharing their daily intake through text messaging on the secure Oviva app. SMART goals were re-established when necessary. Patients were able to track their

physical activity levels, and were encouraged to share their thoughts and feelings with their dietitian via the app throughout the intervention. Patients with diabetes were also able to track their blood glucose levels. The dietitian reviewed progress and offered guidance allowing 15 minutes of coaching each week, the time typically split between Monday and Friday for eight weeks, providing a total of two hours of app coaching which was equivalent to the time offered for appointments in the Face-to-face and Phone interventions.

All patients had the opportunity to access up to six psychology support sessions from a Clinical Psychologist or Psychological Wellbeing Practitioner (45-minute initial consultation and 30-minute follow-up consultations) which were delivered face-to-face or via telephone with the aim of focussing on the psychological factors that contribute to weight gain to support the client to meet their weight loss goals. The focus of these sessions was food, eating and exercise but frequently involved discussion of broader psychological factors when they were contributory to unsuitable eating behaviours. Patients also had the opportunity for referral to an exercise-on-referral scheme. Monthly multi-disciplinary team meetings were held in person to discuss relevant patient cases and included the tier 3 dietitian and clinical psychologist, Consultant Physician, in addition to tier 4 dietitians and clinical psychologist.

The primary programme outcome was change in body mass, and all patients were encouraged to aim for a 5% reduction in baseline values with completion defined as attendance of more than 50% of dietetic sessions, which was the locally agreed key performance indicator (KPI) for the commissioned service. These values were recorded by the dietitian at baseline and at the end of the core programme using calibrated scales (Seca Ltd., UK). For those that did not attend the final face-to-face appointment, self-reported values were used if pictorial evidence of the scales was uploaded or the value was aligned with the patients' reported food intake, current progress, and weight trajectory. If a patient did not complete the core programme, baseline values were carried forward for analyses. Other outcomes of interest included change in BMI, intervention adherence (considered as the proportion of patients that completed 50%or attended 100% of dietetic sessions), the number of psychology support sessions undertaken,

and a Family and Friends Test which provided a score out of ten to describe the patients' satisfaction with the service.

The programme was guided by NICE public health (PH53)[19] and obesity guidelines (CG189).[5]

12-week follow up

Patients who completed and attended the final appointment of their core programme were offered the opportunity of a 12-week follow-up appointment. This appointment was booked at the final appointment within the core programme. The follow-up appointment was a prerequisite for those patients who wanted to be referred to tier 4 services for assessment for bariatric surgery, acting as a gateway to bariatric surgery, or optional for those wanting additional support. The follow-up appointment consisted of a 30-minute review by a nutritionist arranged 12 weeks after completion of the core programme. Body mass was also recorded at this time.

Statistical analyses

Data were extracted, verified, and anonymised from patient records and discharge letters by the Programme Lead Dietitian. Analyses were completed on an intention-to-treat (ITT) basis, with data imputed to account for people lost to follow-up for those who did not complete the core programme using baseline observation carried forward (BOCF). For those who attended the 12-week follow-up appointment, completer data only were analysed at this point due to it being an optional review. Statistical analyses were carried out using IBM SPSS Statistics version 26 (IBM, Armonk, USA) with alpha set at $P \leq .05$. Before analyses, data were explored to check assumptions of statistical tests. Normal distribution of data and identification of outliers and extreme scores were assessed via visual inspection of histograms and box plots and using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The effects of different treatment interventions on outcomes were then assessed by fitting linear models. Two-way (group-by-time) repeated measures analysis of variance (RMANOVA) was used to compare differences

in body mass and BMI at baseline and post-intervention for the core programme and 12-week follow-up separately. The sphericity assumption was checked using Mauchly's test with corrections (Greenhouse-Geisser when $\varepsilon < 0.75$ and Hyunh-Feldt when $\varepsilon \geq 0.75$) applied to the degrees of freedom when this was violated. Significant main effects were considered using post-hoc Bonferroni-corrected pairwise comparisons to control for familywise error rate. Effect sizes were quantified using the partial eta squared (η^2) statistic to examine the magnitude of differences between the three interventions, with values of 0.1, 0.3, and > 0.5 considered to be small, medium, and large effects, respectively. Prior to carrying out the RMANOVA's, possible covariates (age) and factors (sex) – that were not part of the main service evaluation but could influence the dependent variable – were included in a preliminary ANOVA analysis to check for independence of the predictor variable and were found to be non-significant. The Family and Friends Test (FFT) scores were compared using one-way independent ANOVA. For binary outcomes (e.g. achieving 5% weight loss or not), the effects of factors were tested by Pearson Chi-squared tests. The relationship between weight losses and measures of intervention adherence were examined by Pearson correlation coefficient or Spearman rank order.

3 RESULTS

Descriptive data

One hundred and sixty-nine patients (79.3% female) volunteered to commence the programme. For 14 (8.3%) cases no measure was available upon completion of the core programme, so baseline values were carried forward for analyses (see **Figure 1**). Most patients self-selected the App intervention (64.5%) over the Face-to-face (28.4%) and Phone (7.1%) interventions. For the whole cohort, the mean (± SD) age was 46.6 ± 13.8 years, and baseline body mass was 132.9 ± 20.9 kg. Mean baseline BMI was 48.3 ± 6.2 kg/m^2 with 96.4% of the participating population having a baseline BMI of 40 kg/m^2 or above (range 37.1 kg/m^2 to 66.2 kg/m^2). Characteristics for patients in each treatment intervention are detailed in **Table**

1. At baseline, 33% of patients were diagnosed with type 2 diabetes (26.6% for the App group, compared to 45.8% and 41.7% for the Face-to-face and Phone groups, respectively). Furthermore, a small proportion of patients were prescribed medications for weight loss or blood glucose control including orlistat (5.3%), glucagon-like peptide-1 analogues (6.5%) and sodium-glucose co-transporter-2 inhibitors (4.1%), but the proportion of patients using these did not differ between groups suggesting no associated impact on outcomes. Patients lost to follow-up were 4.2% (2/48), 6.4% (7/109) and 41.7% (5/12) for the Face-to-face, App and Phone interventions, respectively. Seventy participants (41.4%) attended the optional 12-week follow-up appointment. This included 21 patients for the Face-to-face intervention, 46 for the App intervention, and three for the Phone intervention. Due to insufficient data, it was decided to exclude the Phone intervention from the analyses for the 12-week follow-up.

Table 1 Patient characteristics and outcome measures by intervention at baseline and at completion of the core programme. Data are presented as intention-to-treat using BOCF.

	Face-to-face (*n* = 48) (female = 37;male = 11)		**App** (*n* = 109) (female = 88;male = 21)		**Phone** (*n* = 12) (female = 9;male = 3)	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Stature (m)	1.65	0.09	1.66	0.09	1.65	0.10
Age (years)	52.7	14.1	43.3*	12.4	51.9	15.6
Baseline mass (kg)	128.8	18.5	135.9	21.9	123.2	16.2
End mass (kg)	123.5**	18.4	129.8**	21.5	119.2**	18.2
Change in mass (kg)	-5.3	5.5	-6.1	4.9	-4	5.3

Percent change in mass	4.1%	-	4.5%	-	3.4%	-
Baseline BMI (kg/m^2)	47.4	5.7	48.9	6.4	45.3	6.2
End BMI (kg/m^2)	45.4**	5.6	46.7**	6.3	44**	6.5
Change in BMI (kg/m^2)	-1.9	1.9	-2.2	1.7	-1.5	1.9
Achieved 5% weight loss	47.9%	-	53.2%	-	33.3%	-
Achieved 10% weight loss	18.8%	-	18.3%	-	8.3%	-
Achieved 1 BMI unit loss	64%	-	74.3%	-	58.3%	-
Completed 50% of dietetic sessions	95.8%	-	96.3%	-	83.3%	-
Attended 100% of dietetic sessions including final F2F session	85.4%*	-	66.1%	-	33.3%*	-
Psychology sessions undertaken	2.2	2.2	2.2	2	0.8*	1.7
Prevalence of type 2 diabetes	45.8%	-	26.6%	-	41.7%	-
Proportion using orlistat	2.1%	-	5.5%	-	0%	-
Proportion using GLP-1 analogues	8.3%	-	6.4%	-	16.7%	-
Proportion using SGLT-2 inhibitors	6.3%	-	3.7%	-	0%	-

Note: * = Statistically significant compared to other interventions, assessed by RMANOVA (continuous variables) or Pearson Chi-squared test (categorical variables): all $P < .001$; ** = Statistically significant compared to baseline, assessed by RMANOVA: all $P < .001$. Abbreviations: BOCF = Baseline observation carried forward, BMI = Body Mass Index, GLP-1 = glucagon-like peptide-1, SGLT-2 = sodium-glucose co-transporter-2, SD = standard deviation.

Core Programme Analysis

RMANOVA revealed significant main effects of time for weight loss ($F_{1, 166} = 82.11$, $P < .001$, $\eta^2 = .33$) and BMI ($F_{1, 166} = 87.39$, $P < .001$, $\eta^2 = .34$). However, there were no main effects for group and no interaction effects. As such, patients in all three treatment interventions significantly reduced body mass and BMI (all $P < .001$) compared to baseline, but there were no differences in the amount of change between interventions ($P = 0.061$). The mean weight loss for the Face-to-face intervention was 5.3 ± 5.5 kg (4.1% of body mass), compared to 6.1 ± 4.9 kg (4.5%) for the App intervention, and 4 ± 5.3 kg (3.4%) for the Phone intervention. Similarly, mean changes in BMI were 1.9 ± 1.9, 2.2 ± 1.7, and 1.5 ± 1.9 BMI units for the Face-to-face, App, and Phone interventions, respectively. **Figure 2** shows the proportion of patients that achieved a reduction in body mass of 5% and 10%, in addition to the proportion that had a reduction in body mass equivalent to one BMI unit or more. These data are summarised in **table 1**.

12-week follow-up analysis

Patient characteristics are summarised in **table 2**. RMANOVA revealed a significant main effect of time for weight loss ($F_{1.9, 79.5} = 25.65$, $P < .001$, $\eta^2 = .48$) with post-hoc analyses revealing that body masses were significantly lower at the end of the core programme and at the 12-week follow-up appointment (both $P < .001$) compared to baseline for both treatment interventions. However, there were no differences between the end of the core programme and 12-week follow up. Likewise, a significant main effect of time for BMI ($F_{1.8, 78.7} = 27.96$, $P < .001$, $\eta^2 = .29$) revealed lower values at the end of the core programme and the 12-week follow-up (both $P < .001$) compared to baseline for both interventions, with no differences between the end of the core programme and 12-week follow-up ($P = 0.156$), neither was there

a statistically significant difference in weight losses between interventions from the start of the core programme to the end of the 12 week follow up (p=0.135). There were no significant main effects for group or interaction effects. **Figure 3** shows change in body mass for patients that opted for and attended the 12-week follow-up.

Table 2 Patient characteristics at baseline, completion of the core programme and at 12 week follow up of the programme for the Face-to-face and App interventions. Completer data is presented for both the core programme and 12-week follow-up data.

	Face-to-face (*n* = 21)			**App** (*n* = 46)		
	Baseline	**Core Prog**	**12w FU**	**Baseline**	**Core Prog**	**12w FU**
Stature (m)	1.66 ± 0.08	-	-	1.67 ± 0.09	-	-
Age (years)	52.9 ± 3.1	-	-	40.8 ± 11.6	-	-
Mass (kg)	129.9 ± 17	122.6 ± 15.8*	122.3 ± 16.7*	138.3 ± 22.6	130.2 ± 22.6*	129.1 ± 23.4*
Change in mass compared to baseline (kg)	-	-7.3 ± 5.6	-7.6 ± 9.3	-	-7.9 ± 4.8	-9.2 ± 7.6
Percent change in mass compared to baseline	-	5.5	5.6	-	5.9	6.8
BMI (kg/m^2)	47.4 ± 6.2	44.7 ± 5.5	44.6 ± 5.4	49.4 ± 6.9	46.5 ± 7	46.1 ± 7.2
Change BMI units compared to baseline (kg/m^2)	-	-2.7 ± 2	-2.8 ± 3.3	-	-2.9 ± 1.6	-3.3 ± 2.8

Achieved 5% weight loss	-	66.7	47.6	-	71.7	60.9
Achieved 10% weight loss	-	28.6	23.8	-	26.1	23.9
Achieved 1 BMI unit loss	-	85.7	76.2	-	89.1	87

Note: * = Statistically significant compared to baseline, assessed by RMANOVA: all $P < .001$. Data are presented as mean ± standard deviation unless indicated otherwise. Abbreviations: BOCF = Baseline observation carried forward, BMI = Body Mass Index.

Intervention engagement and service satisfaction

The number of psychology support sessions undertaken by the patients in the Phone group was significantly less than for the other groups (0.8 ± 1.7 vs 2.2 ± 2.2 for the Face-to-face, and 2.2 ± 2 for the App group) ($P = .03$), but the association between weight loss and number of psychology support sessions ($r = 0.58$) did not reach statistical significance. Intervention adherence, in terms of the number of patients completing half of the dietetic sessions was 95.8%, 96.3% and 83.3% for the Face-to-face, App and Phone interventions, respectively; 85.4%, 66.1% and 33.3% of patients attended all the dietetic sessions. Service satisfaction, as measured by the family and friends test score out of 10, was administered by text message. There were no significant differences in responses between Face-to-face (10 ± 0), App (9.6 ± 0.8) and Phone (10 ± 0) ($P = .261$); forty-two participants responded to the text message, giving a response rate of 24.9%.

4 DISCUSSION

The premise for advocating digital healthcare as part of weight management support for people who are affected by overweight or obesity is predicated on the assumption that it can

improve efficiency, accessibility, and personalisation of healthcare services. Fundamentally, whether effectiveness in real-world settings is comparable or superior to more traditional interventions, such as face-to-face delivery, could be decisive in terms of its value as a public health strategy. To the authors' knowledge, this is the first evaluation of part of a locally commissioned tier 3 weight management programme offering a range of interventions including digital support in everyday practice. The main findings were that Face-to-face, App and Phone interventions all resulted in significant weight loss compared to baseline values. Furthermore, differences between the interventions did not reach statistical significance meaning that a similar amount of weight loss was achieved using these approaches, including digital healthcare. Pragmatically, this could increase the weight management treatment options by reducing inconvenience, time burden and travel for individuals who otherwise might not engage with traditional face-to-face support, and from a healthcare delivery perspective offers cost-savings on resources such as clinic rooms and clinician travel time including instances where patients did not attend appointments.

Modest weight loss (~5% of initial body mass) induces clinically significant health benefits in risk factors for cardiovascular disease and type 2 diabetes.[21-22] In the present service evaluation, half of all patients (i.e. from all three interventions) achieved this criterion. More patients in the App intervention (53%) achieved the 5% weight loss target compared to the other interventions (48% for Face-to-face and 33% for Phone, respectively) although the difference between groups did not reach statistical significance. Similarly, modest decreases in BMI might have an important impact on population health. It has been suggested that weight reduction to the magnitude of approximately one BMI unit, can reduce the risk of all-cause mortality by 6%, and provide significant risk reduction as both a preventative and therapeutic treatment for type 2 diabetes.[19] In this study, the number of patients in the App intervention that reduced their initial mass by one BMI unit or more was 74%, compared to 64% for the Face-to-face group, and 58% for the Phone group. These data compare favourably to other weight management programmes commissioned by the NHS[23-25] and to self-referring, fee-

paying commercial weight management programmes.[26] Yet, this also highlights the challenges facing weight management services because around one in two patients did not reach this weight loss target, which is consonant with meta-analyses for commercial weight loss programmes.[27] The use of Total Diet Replacements have demonstrated significant weight losses in the context of weight management and diabetes remission services[28-29]; it is therefore likely that their provision within this programme would have increased weight losses achieved, highlighting the key role that this dietary intervention can play in driving further and more significant weight losses within weight management services.

Nevertheless, the importance of modest weight loss should not be underestimated. The prevalence of diabetes is known to increase in a linear fashion as BMI levels increase with a prevalence rate of up to one quarter for populations with severe obesity (i.e. BMI ≥ 40 kg/m^2).[30] Furthermore, data collected for the Health Survey for England demonstrated that half of the population who have a BMI > 25 kg/m^2 and ≥ 40 years of age have prediabetes.[31] Therefore, it is encouraging that the strongest associations between changes in weight loss and health outcomes are frequently seen for glycaemic control, with clinically significant improvements observed with as little as 2% to < 5% reduction in initial mass.[32] Although weight losses of greater magnitude are associated with greater improvements in risk factors,[32] it is likely that more than half of patients who opted to receive the App intervention in the present service evaluation benefitted from clinically significant changes in important health outcomes. Given that the interventions in the current programme were relatively short, it is possible that greater weight losses would have been achieved with a longer intervention, as per the findings of other studies[33], however due to the short-follow up period in this study we were unable to validate longer-term outcomes. Forty-one percent of patients chose to attend the 12-week follow-up appointment. Patients were able to maintain weight loss, but there were no further significant reductions in body mass at this point.

The average baseline BMI (48.3 kg/m^2) in this study was higher than those reported in previous studies,[25-27] and is in line with guidelines for referral to tier 3 weight management

services. A novel finding therefore is that dietetic interventions using traditional delivery mechanisms such as face-to-face support or smartphone apps can also be effective for individuals who are affected by severe obesity, at least over a period of 4-5 months. Considering that digital healthcare has possible advantages compared to other modes of support, such as greater time- and cost-effectiveness and potential for broad dissemination and scalability,[34] it could improve the capacity of NHS-led programmes to support people that are obese. In the current service, almost two thirds of participants opted for the App intervention revealing the broad appeal of this method of support, which is conceivably unsurprising considering that 79% of UK adults personally use a smartphone.[35] The mean age of patients that self-selected the App intervention was significantly lower than for the other treatment groups, which supports evidence that younger demographics are the main users of health apps.[36] Uptake of the weight management programme was higher for women than men as seen elsewhere[24], and a similar proportion of men and women chose each intervention.

Rigorous clinical interventions for obesity typically require face-to-face contact but frequently suffer from low adherence and high attrition,[12,19] although some evidence suggests that smartphone apps can increase engagement and adherence particularly through the provision of frequent tailored feedback.[37] Nonetheless, in the current intervention, adherence (those attending 100% of dietetic sessions) was greater for the Face-to-face group compared to the App group, although there were no significant differences in attrition rates (number of patients lost to follow up) (4.2% and 6.4% for the Face-to-face and App groups, respectively). Despite this, there was no difference seen in weight loss outcomes. The final session for all pathways was a face-to-face session, so if patients completed the app or telephone sessions but did not attend the final face-to-face session, they were not considered to have attended 100% of the sessions. This may offer reason as to why numbers regarding 100% attendance were lower in the App and Phone group if they did not want to or it was not convenient to attend face-to-face, which suggests potential usefulness in a fully remote pathway to encourage attendance of all sessions within a programme. The Phone group had significantly lower adherence and

greater attrition rates (42%) compared to the other treatment options, suggesting this type of intervention may be less effective in real-world settings, since adherence is considered a prerequisite for the success of behavioural interventions. However, due to the small sample in the Phone intervention it is difficult to draw conclusions regarding the clinical effectiveness for this group. Patient satisfaction for the service was rated highly for the App group (mean score of 9.6 ± 0.8 out of 10) and was no different to the Face-to-face group, although the response to the FFT was voluntary and was not received from all individuals. Taken together, these data demonstrate that the impact and acceptability of the weight management service compare well against long-term obesity and overweight pharmacotherapy,[38-39] and that smartphone app support is at least as effective as traditional behaviour change techniques.[9] We have shown that digital support can produce quantitatively significant impact on weight outcomes comparable to more resource-intensive, face-to-face approaches in free-living patients.

There are several limitations which should be considered alongside the findings of this study. As this was a service evaluation, a control group was not included, and results were based on people who were 'ready to change' by opting to join a weight management service. As such, they cannot be considered a random sample of the population affected by obesity. Furthermore, the interventions were only carried out in one geographical region, West Yorkshire, and might not be nationally representative. Patients were also able to choose their treatment intervention according to preference which resulted in unequal sample sizes for the three groups. This can reduce statistical power and increases the likelihood of a type I error.[40] The proportion of patients with type 2 diabetes was lower in the App intervention, although this likely reflects the lower mean age for this group. A further limitation is that patients were not followed up at 12 months, because this was beyond the remit of the current evaluation. Furthermore, it should be noted that the 12-week follow-up data is not representative of the full cohort, just those who requested the additional follow-up or those who wanted to pursue bariatric surgery. Nevertheless, this paper provides valuable preliminary data and we

recommend that future research considers the longer-term effects on weight loss maintenance when comparing different modes of service delivery including digital care provision.

There are also several strengths of the current study that should be discussed. The purpose was not to compare the efficacy of the weight management service with other treatments, but rather to consider its effectiveness as it runs in practice with people aiming to reduce their body mass in everyday life. This is important because interventions to improve health frequently bring about intended effects under highly controlled circumstances but often fail to demonstrate benefits in real-world contexts, and this dissonance is frequently overlooked. Furthermore, weight outcomes for digital healthcare interventions are often likely to be assessed via self-report and should be interpreted with caution, but were recorded by healthcare professionals in the current service evaluation at the end of the core programme and the optional 12-week follow-up. The results are also based on a locally commissioned tier 3 weight management service using a population of patients with severe obesity with a higher average BMI compared to previously published evaluations. Additionally, we have presented data using BOCF for the core programme analysis, as opposed to complete case data. Although all imputation methods have limitations, BOCF provides a more conservative approach for assessing service effectiveness and is recommended for quantifying weight loss outcomes.[9, 41]

In conclusion, by undertaking the Way to Wellness weight management programme, around one half of patients achieved clinically meaningful weight loss of 5% from baseline. The patient interventions and delivery modes were chosen by patients in a real-life setting showing that one size may not fit all, so having intervention options may be advantageous. There were no differences between treatment groups meaning that on average patients lost similar amounts of weight regardless of which intervention they used. Alternative dietary interventions, such as total diet replacements could also be considered in such services to drive further weight losses. The smartphone application intervention was well received with acceptable adherence and attrition rates compared to more traditional face-to-face support. As such, we provide

evidence to suggest that digital healthcare deserves a prominent place among a variety of dietetic support options that can be used to bring about weight loss in everyday practice. This might prove valuable if such interventions can circumvent some of the resource and additional costs attributed to face-to-face support. Digital care provision offers potential to scale which could yield great benefits, even when more modest weight losses are achieved. Future research should aim to establish the long-term effects including clinical outcomes such as blood pressure, lipids, and blood glucose levels.

Conflicts of interest statement

R.H and L.J are employees of Oviva UK Ltd. Data analysis was completed independently by M.H at the University of Huddersfield who declares no conflict of interest.

ICMJE-generated Conflict of interest statements

Dr. Huntriss reports other from Oviva , during the conduct of the study; .

Dr. Haines has nothing to disclose.

Dr. Jones reports other from Oviva UK Ltd, during the conduct of the study; .

Acknowledgements (including author contributions)

R. H. was responsible for data collection. M.H. was responsible for data analyses. R.H. and M.H. were responsible for data interpretation and writing the manuscript. L.J. reviewed the data collection, analysis and manuscript.

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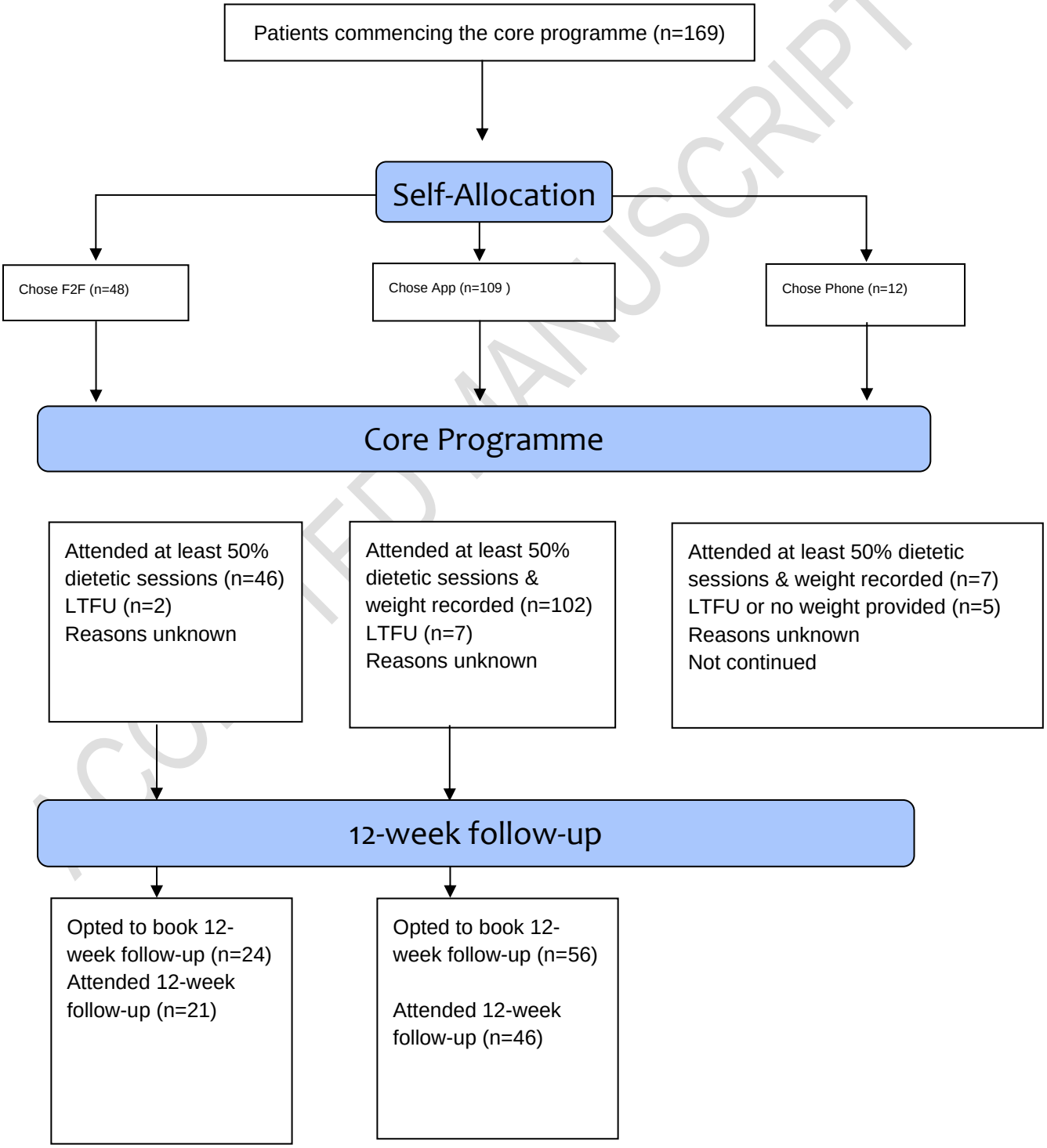
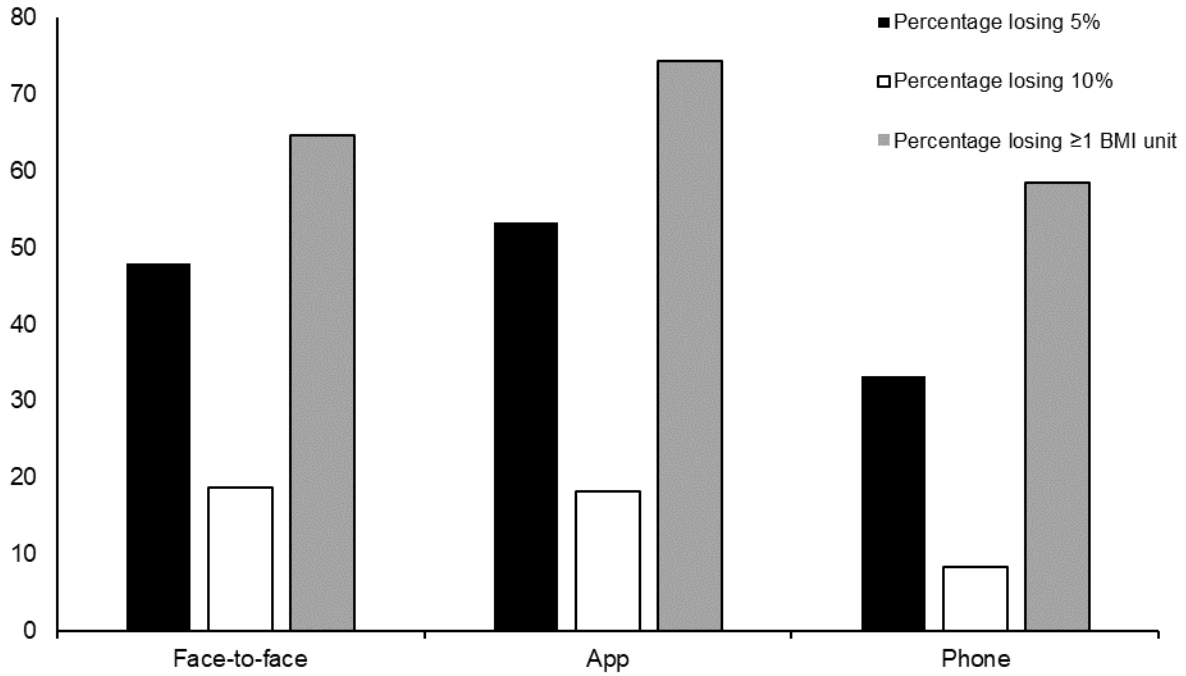
Fig 1. CONSORT style diagram to illustrate allocation and intervention phases. BOCF used for core programme analysis. Completer data used for 12-week follow-up analysis.





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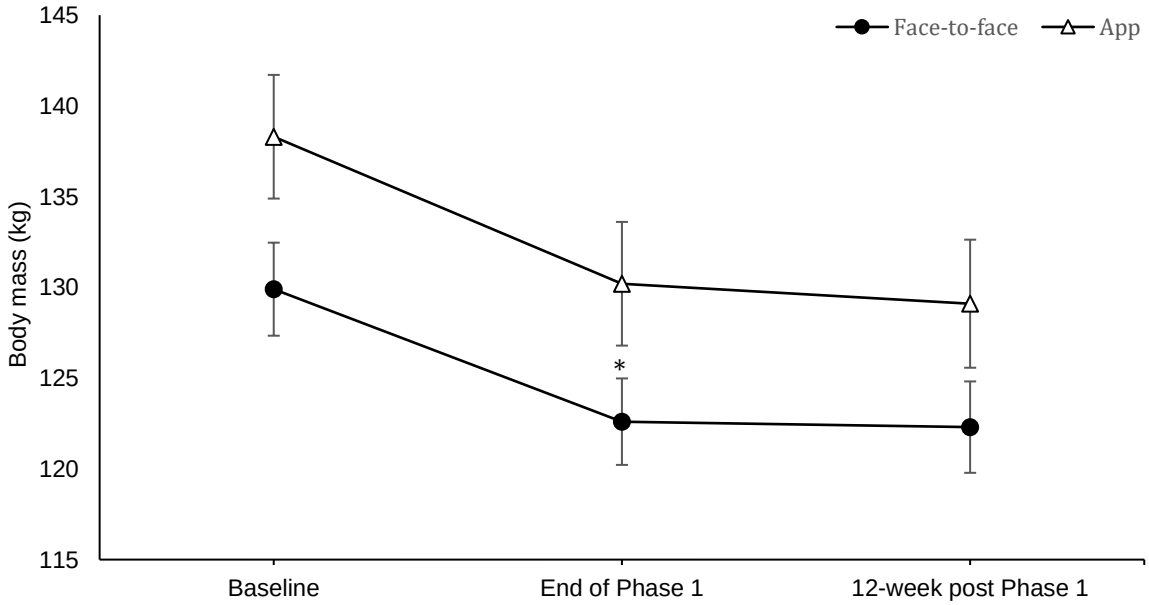

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