

Article

Feasibility study of an Online 24-hr Dietary Assessment Tool: myfood24, in a clinical population

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Abstract: myfood24 is a comprehensive self-completed online 24-hour dietary recall tool currently used for nutritional assessments in epidemiological research. However, its clinical application has been unexplored. This mixed methods prospective observational study explores the acceptability and usability of myfood24 in a clinical population, women with gestational diabetes (GDM). Women were recruited at their first diabetes antenatal clinic appointment. To assess acceptability and usability, they were asked to complete five 24-hour dietary recalls using myfood24 over two weeks and a user experience questionnaire; with a subset invited to participate in a one-to-one semi-structured interview. Of the 199 participants, mean maternal age was 33 years, mean booking BMI 29.7kg/m², 36% primiparous, 57% White, 33% Asian. Of these 121 (61%) completed myfood24 at least once and 73 (37%) completed the user questionnaire; 15 were interviewed. Usability of myfood24 was measured using the System Usability Scale (SUS) and found to be good (mean 70.9, 95%CI 67.1, 74.6). Interviews identified several areas for improvement, including optimising its use for mobile devices. myfood24 appears to be acceptable and have potential to support self-management and behaviour change for women with GDM but requires adaptation to record blood glucose results alongside real-time tracking of diet.

Keywords: 24-hour recall; nutrition assessment; technology assisted dietary assessment; gestational diabetes;

1. Introduction

Gestational Diabetes Mellitus (GDM) has onset or detection in pregnancy, most commonly in the third trimester. In the UK, screening is performed around 24-28 weeks gestation and uses an oral glucose tolerance test following fasting, to detect raised blood glucose levels. Rather than being universal, screening is usually targeted to those with established risk factors. i.e. women with body mass index (weight kg/height m²) above 30; previous large baby >4.5kg, previous GDM; ethnic family origin with higher prevalence of diabetes; family history of diabetes [1].

The main treatment aim is to maintain healthy blood glucose levels throughout the pregnancy to reduce the risks of complications for the mother and child; for example: macrosomia, stillbirth and birth-related trauma [2]. After giving birth, blood glucose levels usually revert to normal, however 50% of women with GDM will develop Type 2 diabetes within five years [1]. As with Type 2 diabetes, treatment of GDM initially focuses on dietary and lifestyle changes with a healthy diet recommended [1]. To achieve blood glucose targets, emphasis is placed on optimising the type of carbohydrate by encouraging low glycaemic index choices; and reducing the quantity. If within one to two weeks of dietary modification blood glucose levels are above the target range for pregnancy (fasting blood glucose below 5.3 mmol/L and one hour after meals below 7.8mmol/L), women will then require medication for diabetes for the remainder of pregnancy; for example, metformin tablets or insulin injections. The self-management behaviours required to achieve these levels, including dietary modification and frequent self-blood glucose monitoring are demanding and associated with increased levels of distress [3].

Standard care at diagnosis for women with GDM includes a dietary assessment, usually by a dietitian, from which education and negotiations for dietary changes will be based; progress may be reviewed at subsequent appointments [1]. As with other clinical populations requiring dietary management, typical dietary assessment methods include 24-hour dietary recalls undertaken with a dietitian or self-completion of paper food diaries. The level of detail acquired is variable and may include the frequency, amount and type of food. Gathering and interpreting this information requires time and skills for both health professionals and patients. Assessments may be inaccurate due to under-reporting, misinterpretation or the inability to account for day to day variations in intake [4].

The development and implementation of technology-assisted dietary assessment, including for example the use of websites, mobile phone cameras and mobile apps to log food intake, is providing an alternative to these traditional methods[5–9]. Such technologies in healthy populations are being shown to reduce costs [10], improve completion rates and increase the accuracy of the dietary assessment [5,7,10–12].

Given these favourable findings when using technology-assisted dietary assessment in healthy populations, their application in the management of medical conditions has begun to be explored [13,14]. They can provide a more consistent and complete assessment of both the type and quantity

of food consumed. This data can be instantly analysed and provide feedback to the user and health professional. These features can provide additional support and education outside of the clinic setting [13,15,16] and health professionals in primary care reported that technology-assisted dietary assessment may promote self-efficacy and a sense of control over one's health condition [15]. Such tools also enable remote monitoring and follow up, potentially reducing the number of face-to-face appointments. Therefore, there could be substantial clinical benefits and cost reductions associated with their use. myfood24 is a self-completed online 24-hour dietary recall tool, incorporating elements of an automated multiple pass methodology [17]. Foods consumed are entered on the system, by selecting from a list of options; portion size is then selected, and the food is added to a meal event or time. Prior to submitting the completed recall, it prompts the user to check for omissions, e.g. snacks. The recall can be completed at one time, inputting all information from the previous 24-hour period. The myfood24 food database contains 45,000 foods including both generic and branded items, 5,600 with associated portion size images, and provides the user with an immediate nutritional analysis of their dietary intake. The tool was developed for large scale epidemiological studies in the UK population. Usability and acceptability testing of myfood24 has shown it is suitable to be used in UK teenager (System Usability Score (SUS) Median score 80) and adult populations (SUS Median score 73) and relative validity testing in teenagers showed good agreement with interviewer-administered assessments [18–20]. A validation study in adults which includes the use of biomarkers has been undertaken [21]. Whilst myfood24 is currently used for nutritional assessment in epidemiological research, its application in healthcare has not been explored.

This study examined the introduction of myfood24 in a clinical population for the first time. The aim of this feasibility study was to explore the acceptability and usability of myfood24 as a tool for recording dietary intake in women with GDM; thus, providing direction for the ongoing development and evaluation of this tool, both for use in clinical research and ultimately, routine clinical practice. The study also addressed secondary aims, including the association between dietary components and blood glucose levels, and the wider experiences of women with GDM, which are the subject of other publications.

2. Materials and Methods

2.1 Ethics

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol and subsequent amendments were approved by the South Central Oxford Research Ethics Committee C (reference 14/SC/1267).

2.2. Eligibility

Women attending for their initial appointment following the diagnosis of GDM at Leeds Teaching Hospitals NHS Trust Diabetes in Pregnancy Clinic, were eligible to participate, provided they could read and understand English and were not to be commenced on any diabetes medication.

2.3 Recruitment

Women were invited to take part by a research midwife who provided a Participant Information Sheet, addressed any questions relating to the study and secured informed consent to participate. The sample size of 200 was based on the sample size calculation for secondary research questions examining the association between dietary components and blood glucose levels. This was a considerably larger sample than required for usability and acceptability testing [22]. Guided by other qualitative research, a target of 15-20 interviews was planned to enable in-depth discussion relating to myfood24 and wider experiences of managing GDM [23]. As the aim was to interview both participants who had used the tool and those who chose not to, different recruitment methods were used. For those who had used myfood24, their interest could be indicated via the user questionnaire, and those who had never completed myfood24, were sent an email (see Figure 1). Informed consent for interviews was secured separately by the interviewer (ZD).

2.4 Study Design and data collection

This was a mixed method prospective observational study. The stages of the study and the participation at each stage can be seen in Figure 1. Participants consented for relevant demographic and clinical data to be retrieved from their health records.

2.4.1 Completing myfood24 dietary recalls

Antenatal care provision followed standard care guidelines for diabetes in pregnancy, which included ongoing self-monitoring throughout the pregnancy with self-blood glucose monitoring seven times a day and self-completion of paper food diaries. By taking part in the study, participants were requested to additionally complete five 24-hour recalls in a two-week period using myfood24. The process of accessing and completing a myfood24 dietary recall is illustrated in Figure 2.

The acceptability of a tool is demonstrated by the user's willingness to employ the tool for the task it is designed to support. Therefore, in this study, measuring completion rates of myfood24 is the main measure of acceptability along with the interview data.

2.4.2 User Questionnaire

Those who completed myfood24 on at least one occasion were emailed a link to complete the user questionnaire, administered by Bristol Online Survey (<https://www.onlinesurveys.ac.uk/>). The questionnaire consisted of multiple choice questions, Likert scales, yes/no responses and open-ended questions which covered demographic information, previous experience of using technology and food diaries, attitudes to technology and usability of myfood24. It included the SUS a validated, reliable tool for measuring usability [24]. This is a 10-item scale with the users asked to rate their level of agreement with 10 usability statements (1 = strongly agree; 5 = strongly disagree) which gives a total score from 0 - 100. Scores below 50 are unsatisfactory with 50 to 70 judged as marginal and above 70 considered good [25].

Usability considers user experience, user friendliness and ease of use [26]. The SUS score from the user questionnaire, along with the interview data was the main measure used to assess usability in this study.

2.4.3 Interviews

Interviews were semi-structured and followed a pre-designed flexible topic guide, exploring women's views and experiences of using myfood24. The interviews sought to contextualise the completion rates and findings from the user questionnaire, exploring beyond the practical aspects relating to usability and acceptability in the words of the women. Women were interviewed at a time and location of their choice. All were interviewed by telephone with interviews lasting on average 35 minutes (range 20-54).

2.5 Data Analysis

2.5.1 Statistical analyses

Using data from the health records of the study population, along with additional data from the user questionnaire the aim was to identify specific factors that may influence the acceptability and usability of myfood24 such as demographics; other participant characteristics including online literacy; and features of the tool.

Analyses were performed using Stata IC14 statistical software. Descriptive statistics were used to define the sample characteristics. Comparisons were made using chi-squared test for categorical data and independent t-test for continuous data. For all inferential statistics the significance level was two-sided and set at 0.05.

2.5.2 Analysis of interviews

Interviews were audio-recorded and transcribed verbatim in an anonymous format. Data were analysed using thematic analysis, using the principles outlined by Braun and Clarke [27] familiarising self with the data, generating initial codes, searching for potential themes, reviewing themes, defining and naming themes, producing the report.

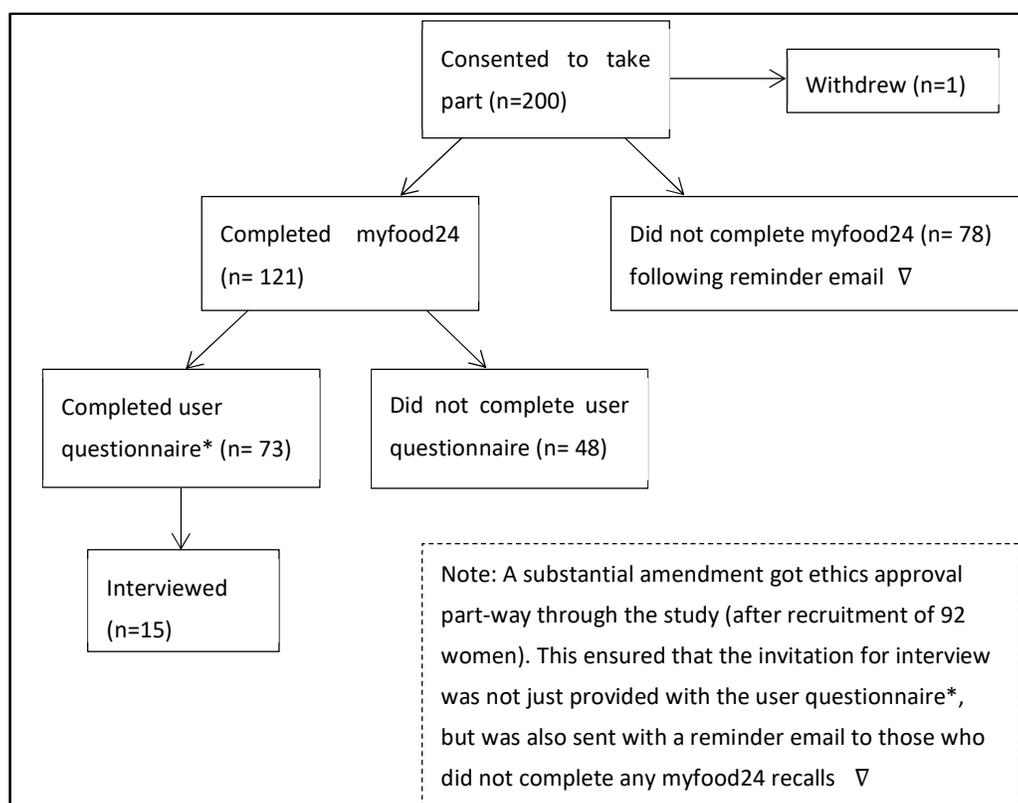


Figure 1. Study flow chart

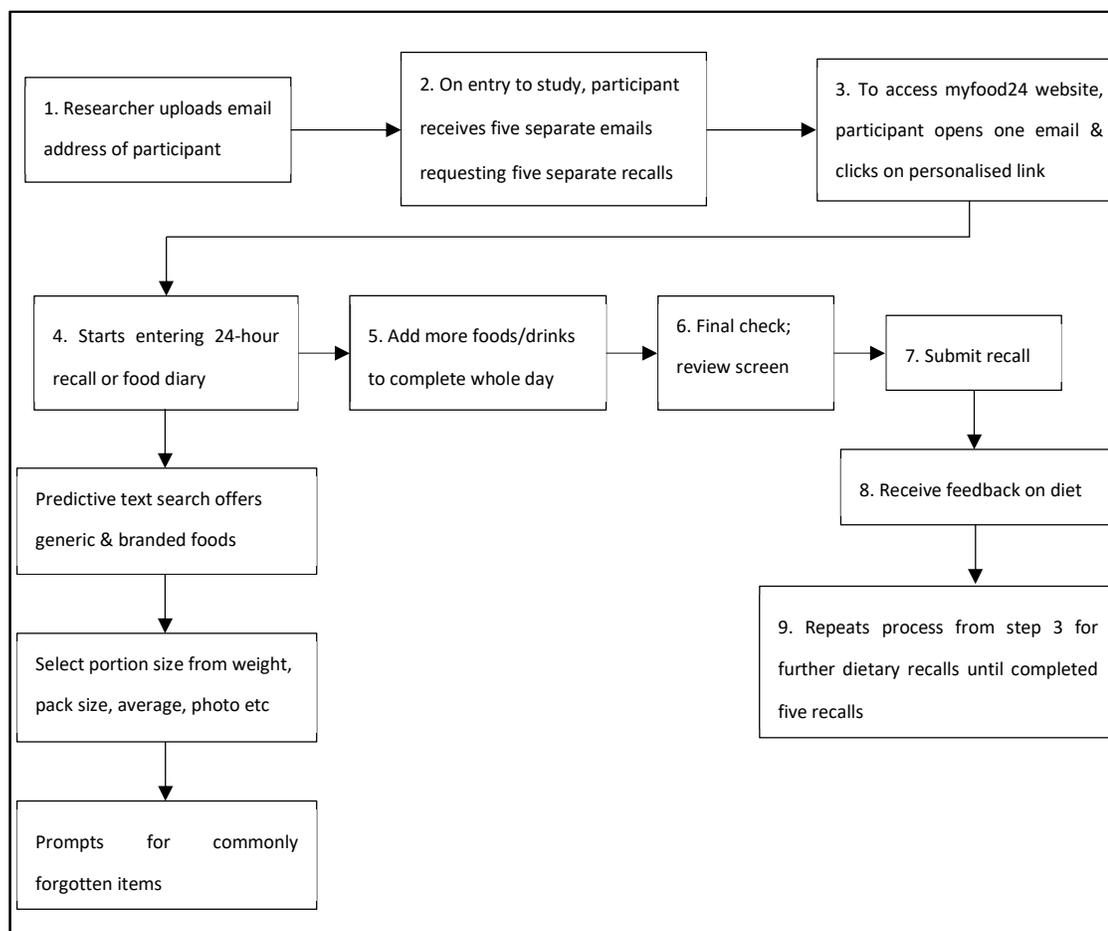


Figure 2: Process of accessing and completing an online myfood24 dietary recall

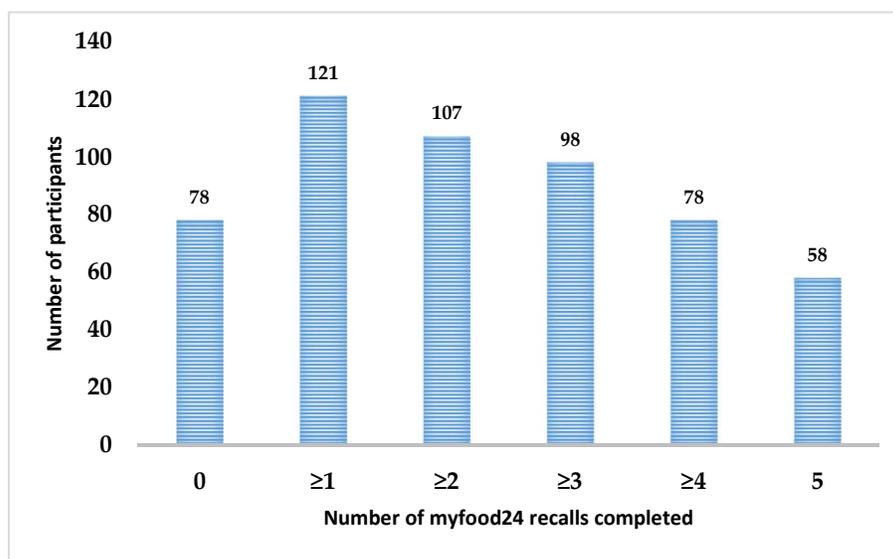
3. Results

3.1. Characteristics of participants

Two hundred women consented to the study and one of these withdrew. The mean age was 33.3 years (SD 5.0). According to health records, 76% of the women were overweight or obese at booking (first formal antenatal appointment) and the mean BMI was 29.7kg/m² (SD 6.5). The majority of women were White (57%) and one-third (33%) were Asian, and 36% women were primiparous.

3.2. Indicator of acceptability: Completion of myfood24 recalls

Women were asked to complete five recalls over a two-week period. For the full sample (n=199), the mean number of days completed was 2.3 (SD 2.2) days, however only 61% (121/199) completed myfood24 at least once. In the 121 women who completed myfood24 at least once, the mean number days completed was 3.8 (SD 1.4); 98 (81%) completed it at least 3 times and 58 (48%) completed it all five times. Further details are shown in Figure 3.

Figure 3: Number of myfood24 dietary recall completed by participants (n=199)

There were statistically significant demographic differences between those who did (121/199; 61%) and did not (78/199; 39%) complete myfood24 at least once, as shown in Table 1. Women who completed myfood24 were statistically more likely to have lower fasting blood glucose levels ($p=0.008$), be of White ethnicity ($p=0.001$) and primiparous ($p=0.02$).

Table 1: Comparison of characteristics between women who completed myfood24 at least once (n=121) and those who did not (n=78)

	Completed myfood24 (n=121)		Not completed myfood24 (n=78)		p value
	n	Mean	n	Mean	
Maternal age, years (SD)	121	33.5 (4.6)	78	33.2 (5.6)	0.7
Booking BMI, kg/m² (SD)	119	29.5 (6.2)	77	30.0 (7.0)	0.7
Fasting blood glucose, mmol/l (SD)	115	4.9 (0.6)	61	5.2 (0.8)	0.008
Ethnicity					
White (%)	79	65.3	35	44.9	0.001
Asian (%)	31	25.6	23	29.5	
Other (%)	11	9.1	20	25.6	
Parity					
Primiparous (%)	52	43.0	21	26.9	0.02

Multiparous (%)	69	57.0	57	73.1
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Within the women who completed myfood24, no statistically significant differences in demographic characteristics were found according to the number of times it was completed; comparing women completing one to two times (n=23) versus three times or more (n=98).

3.3 User questionnaire

User questionnaires were completed by 73 of the 121 women who used myfood24. Comparisons were made between these women (n=73) and those who did not complete it (n=48), as shown in Table 2. Statistically significant differences in demographics were found; completers were older ($P=0.01$) and had lower BMI at booking ($P=0.008$). The mean number of recalls completed was significantly higher ($p<0.001$) in those who completed the questionnaire.

The user questionnaire provided further demographic details on this subgroup. Of these 73 women, 47% were employed in managerial or professional occupations and 58% were educated to degree level or above. The majority of women (90%) described themselves as being confident with using technology, with good access and ability to use the internet (97%). Previous use of technology to record food intake was reported by 45%.

Usability was measured using the System Usability Scale (SUS) [24]. The mean SUS score for myfood24 used by women with GDM was considered good at 70.9 (95%CI 67.1,74.6) however this was completed by only 73/199 (37%) of participants.

Table 2 Characteristics of women who completed the user questionnaire (n=73) and those who did not (n=48) following completion of myfood24

	Completed		Did not complete		<i>p</i> value
	User Q		User Q		
	n	Mean	n	Mean	
Age, years (SD)	73	34.3 (4.3)	48	32.2 (4.7)	0.01
Pre-pregnancy BMI, kg/m² (SD)	72	28.3 (5.0)	47	31.4 (7.5)	0.008
Fasting blood glucose, mmol/l (SD)	72	4.9 (0.7)	43	5.0 (0.5)	0.5
Ethnicity					
White (%)	52	71.2	27	56.3	0.4
Asian (%)	15	20.6	16	33.3	

Other (%)	6	8.2	5	10.4	
Parity					
Primiparous (%)	31	42.5	21	43.8	0.9
Multiparous (%)	42	57.5	27	56.2	
Number of days completed myfood24 (SD)	73	4.2 (1.1)	48	3.2 (1.6)	<0.001
SUS score (95% CI)	73	70.9 (67.1,74.6)	-	-	-
Occupation	68				
Managerial & professionals (%)	32	47.0			
Intermediate & lower supervisory	17	25.0	-	-	-
Semi routine & routine (%)	4	6.0			
Not employed (%)	15	22.0			
Education level	70				
Degree or above (%)	42	58.3	-	-	-
No degree (%)	30	41.7			
Had previously filled in food diary (%)	26	35.6	-	-	-
Previously used technology to record food (%)	33	45.2	-	-	-
Internet ability good to excellent (%)	71	97.3	-	-	-
Access to internet (%)	72	98.6	-	-	-
Use internet daily (%)	69	94.5	-	-	-
Confident in using technology (%)	66	90.4	-	-	-

3.4 Interviews

3.4.1 Characteristics of interviewees

Of those who chose not to complete myfood24, there were no expressions of interest to be interviewed. Sixteen women who had completed myfood24, expressed interest, resulting in 15 interviews with one declining due to time commitments. Characteristics of those interviewed were similar to the other participants who completed myfood24. The mean age was 35.1 years (SD 4.5); five were primiparous. The majority of women were White (13 White, 2 Asian). The mean BMI at booking was 28.3 (SD 4.7). All had completed myfood24 at least once and 10 had completed it five times. The mean SUS score was 74.0 (SD 23.0).

Most women reported completing the dietary recalls at the end of the day in the evenings, with a number of them using paper records as an aid to recall.

3.4.2 Themes

Thematic analysis relating to usability and acceptability of myfood24 identified the following themes: 1) ease of use; 2) impact on food choices; 3) comparisons with paper diaries; and 4) future developments.

(i) *Getting acquainted: Ease of Use*

Many of the women had used similar technologies before to record their diet and reported finding myfood24 to be comparable once they had become acquainted with the technology. Most found myfood24 'straightforward' and that inputting data became faster with practice, initially taking approximately 20 minutes.

'I found it quite easy... I mean, you just typed in a word and it would bring what you wanted up and then you chose from the list' (interview 3).

Several features were reported that helped or hindered the ease of use of myfood24. Features of the tool most commonly identified as being useful for input were the food photographs to help with portion estimation, and the use of reminder prompts. Some also used the recipe function and favourites list; most reported that they would use these functions on a longer-term basis. The food database received mixed feedback. Some found the food database too restrictive whereas others found the choice overwhelming. Some reported finding food entry burdensome when cooking from raw ingredients and the process too time consuming to be feasible.

'Obviously you don't weigh your food... it was nice to see actually a portion size' (interview 6)

'I didn't have to go back and correct anything really because it reminded me' (interview 3)

'For something that was quite simple, it would take actually a long time to find it' (interview 4)

'It was quite time consuming having to kind of search for things and put everything in its own, you know, like all the different components that made up a meal' (interview 11).

One reported disadvantage was the perceived need to record for the 24-hour period in total, rather than being able to add details after each meal, finding this less easy to use than paper diaries. Most women reported completing the dietary recalls at the end of the day in the evenings, with a number of them using paper records as an aid to recall. Interviews identified that accessibility was hindered by problematic initial access to the myfood24 website, offering insight into the completion rates observed. As shown in Figure 1, myfood24 uses a web link accessed from the participant's email account with each recall requiring a separate email. Women reported that the process had been confusing and it was difficult to keep track of the multiple emails, all of which were sent on the day of entry to the study and without any indication as to which of the five days they referred to. It should be noted however that this was a feature of the research procedures and not how myfood24 would be intended for use.

(ii) *Feedback: Impact on food choices and behaviours*

On completion of a 24-hour dietary recall, myfood24 provides an instant summary of its nutritional composition, including energy, protein, fat, carbohydrate, fibre, salt and micronutrients. This is compared to a dietary reference value.

All interviewees reported finding this feature useful as a way to get feedback on their food intake and associated eating behaviours, although a minority questioned the accuracy. Women described how this feedback increased their knowledge of their dietary intake, could provide reassurance, and enable women to consider what changes were required. Some women reported that the summaries were a motivating factor, influencing future choices about food types and portion sizes. 'I did find it frustrating, to be honest, in terms of just trying to find what matched what I was eating, I don't know how accurate it was for me' (interview 4)

'a week's worth of days in front of you it does make you think about what you're eating and how much' (interview 3)

'I was like ooh I shouldn't have eaten that or oh, I've had a really good day today.' (interview 12)

Most women focused on the data relating to total carbohydrates and sugars – key to management of GDM – but some also noted using the summaries to understand their fat and salt consumption. In addition, for some the summary information highlighted that they had actually been too restrictive with their diet, in response to their diagnosis.

'Once you can see it in numbers and can see the picture of it, it's harder just to shrug off and think I'm fine...I couldn't just go on with it' (interview 11).

(iii) *Comparing online self-monitoring to paper diaries, and the use of real-time tracking*

Comparing myfood24 with paper-based food diaries that women were required to complete as standard care, some felt myfood24 led to more accurate recording of food intake due to its use of reminders (for example prompting about snacks between meals, and the use of condiments) and recording of quantities, which had not been requested in their diaries used as part of their clinical care.

'I thought that [myfood24] made me remember things. It was more specific. I think it was easy to forget when you're writing it down. You know because it reminded you – have you remembered to put a drink down here, have you remembered to put a snack down there.' (interview 9)

Women felt that whilst myfood24 was more accurate than paper-based diaries, in its current format it was also less convenient than paper-based diaries, particularly given the need to record diet alongside tracking blood glucose levels and the paper-based diaries. Thus, although women valued the myfood24 summary information highly, the utility of myfood24 was limited by being

produced at the end of a 24-hour period and without any connection to blood glucose readings, limiting its ease of use.

(iv) Future developments: suggestions based on experience

A number of suggestions were made by women, the most common being to improve accessibility via an app so data could be conveniently logged throughout the day using a smart phone or tablet. Other suggestions for practical aspects relating to usability and improved input were a larger food database, option to scan bar codes, and easier retrieval of favourite foods. Women made several suggestions to adapt myfood24 to develop its accessibility but also its usefulness in promoting self-management and supporting behaviour change. Of greatest priority for this clinical population was the need to record blood glucose readings alongside dietary information, in order for the information to be meaningful and develop knowledge of their body's response to different types and quantities of food.

'I think a phone app would be a lot easier...you'd just keep updating it as the day went along... it'd make it more helpful like that' (interview 12)

'I don't know if there was an option where you could save that information, and maybe it was something that I missed, but I would have found that useful as an ongoing thing, if you could save it...' (interview 7)

'I thought what might be quite useful would be more like a graph ... that shows like you're here and this is what you really should be getting, aiming for.' (interview 2)

Women also emphasised the need for a diary format instead of 24-hour recall. This related both to aiding recall but also to the way in which women used feedback to guide future choices and behaviour. Some also identified the need for improved visual displays of the summary nutritional information, including the ability to track information across time and relative to individualised targets (rather than reference values) to support behaviour change.

4. Discussion

This study has demonstrated that introducing an online 24-hour dietary assessment tool in a clinical population is feasible. For it to be an effective tool when used in a clinical setting, myfood24 needs to perform well for acceptability and usability. Women who completed questionnaires and interviews, indicated that myfood24 had good usability regarding dietary *assessment* however for myfood24 to be have good acceptability for dietary *management* and support meaningful behaviour change, modifications are needed to enable real-time tracking and monitoring alongside blood glucose levels.

Acceptability

Acceptability considers users willingness to employ the tool for the task it is designed to support [28]. In this study 78/199 women (39%) did not use myfood24 even once. Reasons for this are not known and may extend beyond the acceptability of the tool. It is noted that statistically significant differences existed between those who did and did not complete myfood24, some of which may be indicative of levels of motivation and self-management; unfortunately, further comparisons were precluded by certain data only being available for those who completed myfood24 and went on to complete the user questionnaire.

Of those who completed the questionnaire (n= 73), 45% of participants had used technology previously to log food, so this indicates it is common for women in this group to have similar previous experiences, potentially influencing acceptability in this is population. After participants used myfood24 at least once, the majority went on to use it again, with almost half of women completing it the five times as requested, which would suggest a satisfactory level of acceptability. There did not appear to be any demographic differences regarding number of times completed, however a larger sample size may be needed to determine this. Findings from the interviews suggested that there was confusion experienced with the current email system for accessing myfood24 which could have impacted on acceptability. However, receiving the summaries of their nutritional intake immediately following the recall, made a valuable contribution to the acceptability of myfood24 and this is supported in other studies [13,16]. Future work should prioritise developing the summary information.

Women continued to have to complete paper-based food and blood glucose diaries as part of standard care. Some women found the paper diary more convenient due to the ease of access and having all the data in one place, enabling links to be made between food intake and blood glucose levels. However, having to undertake this dual recording of data both paper and online, could have also impacted on acceptability. Studies in populations with diabetes and renal disease support the suggestion that being able to input foods in real time via a phone app and adding other clinical data such as blood glucose levels can improve acceptability [13,14].

myfood24 also has the potential to promote user-provider/professional interactions as data is available to both user and provider. However, this feature was not utilised in this study. Significant benefits in diabetes outcomes have been found when patients were provided with analysis or

feedback from clinicians on their data [13]. Additionally, acceptability and effectiveness of a smartphone nutritional assessment tool for healthy pregnant women, was enhanced by using a similar feature [16].

Usability

Usability considers user experience, user friendliness and ease of use [26]. This was measured using the SUS and interview data. The SUS for myfood24 in this study was classed as good (SUS =70) and is comparable to the scores obtained in the general population in other myfood24 evaluations with adults (SUS = 80) and adolescents (SUS = 74) [18,19]. However, in this study, only 37% of the participants completed the SUS and it is therefore unlikely to be as high in the full sample. Usability may be therefore better measured by considering how many completed it, and for how long, as described earlier in Figure 3. This would indicate usability is satisfactory and the qualitative data supports this finding that the current tool is adequate to record diet but would require further refinement if it were to be used to promote and support changes in behaviour change and sustained self-management. Further refinement would additionally improve ease of use and facilitate familiarity.

A number of suggestions were made by interviewees regarding how to improve myfood24. Many of these are applicable to all dietary assessment tools/ food logging applications [6,15] and include improvements to speed up food data entry, extensions to the food database including ethnic foods; chain restaurant meals; popular homemade recipes and more support to estimate portion sizes. Specifically related to myfood24, women wished to undertake recalls whenever they wanted, and access previous recalls be able to utilise food lists and to also make comparisons. Recent developments in the visual displays of nutrient summary feedback for use in teaching situations, could be adapted for the healthcare setting. Further thought into how the website is accessed and the setup of personal accounts for clinical rather than research purposes, is crucial to achieving this. This would reduce the confusion experienced with the current email system and allow women to undertake dietary recalls as frequently as they choose to; furthermore, personal accounts could be used to promote self-monitoring during the pregnancy and beyond.

Continued development by the myfood24 consortium and website developers, taking into account suggestions for further improvements from this and other studies [6] will enhance the usability further. The findings highlight the importance of tailoring tools to the needs of population, illustrated here by the importance of real-time tracking for women with GDM and need for integration of dietary intake with other data; here, blood glucose but other conditions would benefit from recording other health information (e.g. weight, other blood test results, blood pressure, activity data).

Opportunities for use of myfood24 in a clinical setting

This study has established that introducing myfood24 in a GDM population is feasible and provides helpful insights into how to optimise its usability and acceptability in this population. There could be significant benefits of introducing myfood24 in this clinical setting. Women with

GDM require weekly to fortnightly follow up in lengthy multi-professional clinic appointments and via telephone and therefore health apps have been developed to enable remote monitoring of blood glucose levels and help prioritise health professional case-loads [29]. In the same way it could be advantageous to complete online dietary assessments between clinic visits for review by the user and health professional. Using self-administered dietary assessment technologies has been shown to be a more engaging and accurate way of capturing a diet history [5,14] and preferred to traditional methods in people with diabetes [30]. Women in our study commented that they began to consider changes in their food intake from performing the recalls and receiving the feedback; this has been observed in other populations [13,15] and has been shown to improve uptake of self-monitoring and lead to dietary changes [31]. Following initial education, women could continue to monitor their dietary intake and receive feedback from the website which could result in increased self-efficacy and self-management skills. Additionally, remote monitoring and feedback of the data from the health care professional could reduce workloads of staff in clinics and enhance the service by freeing up time for education and support as demonstrated in other studies [12,32]. In other chronic conditions, use of dietary assessment technologies in this way has had a beneficial effect on clinical outcomes. [14,33].

The interviews highlighted emotional aspects of living with GDM and the breadth of behaviours women with GDM are tasked with managing (reported in full elsewhere; Darwin et al., in preparation) indicating that if myfood24 were to be optimised for mobile devices, there would likely be other beneficial components that may support women with GDM. Women diagnosed with GDM are expected to begin to make immediate changes to their lifestyle to meet the blood glucose target recommendations. However, there will be a wide range of levels of knowledge, skills and confidence around healthy eating. myfood24 has been shown here to have the potential to improve health literacy and eating behaviours of women with GDM. Reducing dependence on the health care professional to advise on dietary changes and increasing knowledge and skills has been shown to increase an individual's sense of control. Receiving prompts as cues for action and receiving feedback on their nutritional intake alongside biofeedback through blood glucose levels are recognised behaviour change techniques that can support healthy behaviours [34]. This increased level of control over their condition and perceived treatment efficacy may additionally help reduce the levels of distress experienced [35,36].

Strengths and Limitations of study

There are several strengths to this study. For a feasibility study, there was a large study population, with complete online data was collected on 73 women. The qualitative element of the study provided valuable insight into the usability and acceptability of the tool in everyday life, adding depth that has been reported as lacking in other studies of this type [6].

There are limitations to the assessment of the acceptability myfood24 in this population. A significant proportion of those recruited into the study never completed myfood24 and it appears that this may in part reflect the method for accessing myfood24 (i.e. through automated emails). It is additionally possible that some of these women attempted to use myfood24 and did not complete

their entry due to challenges with ease of use. No evaluation was built into the study to routinely establish the reasons for not completing myfood24 and to consider what strategies could have been used to increase participation for future interventions. Unfortunately, none of those who did not complete myfood24 volunteered to be interviewed. In addition, only 60% of women who used myfood24 completed the user questionnaire and the SUS for the remaining 40% are therefore unknown.

Another area of potential weakness was the limited ethnic diversity, which diminished with each stage of the research. A smaller proportion of women from black and minority ethnic groups completed the user questionnaire and took part in the interviews, limiting transferability of the study findings. As GDM is more prevalent in women from black and minority ethnic groups, this is not representative of a typical GDM population in the UK [37]. Over-represented in the group who completed the user questionnaire were women who were well educated and worked in professional jobs. Based on those completing the questionnaire, the study population appeared to be confident using technology and had good access to the internet, as well as previous experience with similar technologies.

Finally, once women had begun to use myfood24 they may have been willing to continue to use it throughout the pregnancy however the system did not allow them to continue to access myfood24 beyond their five recalls. The opportunity for continued use would have provided valuable insights into its usability and acceptability in participants with a health condition [14].

This study has generated a number of suggestions for the future development of myfood24 for clinical populations. Real-time data entry assisted by a phone app format, could improve acceptability and usability. Adding further features such as improving the presentation and content of the feedback, and tracking pertinent biomedical data alongside nutritional information, would increase its potential beyond dietary *assessment*, ready for testing in the context of self-management of health conditions. The feasibility of its application within the health service should be explored in a feasibility study which also captures the views of users and health professionals on its use as an alternative tool in dietetic care. Ultimately a definitive trial considering the clinical and cost-effectiveness of a refined myfood24 tool in clinical practice is recommended.

5. Conclusions

myfood24, an online 24-hour dietary recall tool was an acceptable way of recording dietary information in women with GDM. Usability and acceptability was reported to be satisfactory and this study identified a number of strategies to improve these further as planned developments of the tool are undertaken. Women were motivated to use the tool largely due to the feedback on their nutritional intake it provided, although being able to record food intake and input clinical data (blood glucose levels) in real time using mobile optimised technology was deemed necessary to be able to replace paper-based diaries. myfood24 has the potential in women with GDM to increase health literacy, improve eating behaviours and support self-management; and ultimately improve clinical outcomes.

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Conflicts of Interest: Prof J Cade is Director of Dietary Assessment Ltd, the company which runs myfood24, and Dr M Morris and Dr M Carter are shareholders. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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