# Development of a web-based 24-hour dietary recall tool for use by 11-24 year olds: INTAKE24

## Final report

November 2013


## Contents

# 1 Introduction

INTAKE24 is an online 24-hour dietary recall tool which has been developed for use in future Scottish food and nutrition surveys and is easily adaptable to have a wider application across the UK and beyond. Twenty-four hour recalls are a popular choice for dietary surveys as they are quick to administer, do not require the participant to be literate[1] and are less burdensome to complete compared to other dietary assessment methods.[2] This in turn can improve response rates which is vital for achieving a representative participant sample. The Multiple Pass 24hr recall Method (AMPM) has been the method of dietary assessment used in the National Health and Nutrition Examination Survey (NHANES) conducted by the US Department of Health and Human Services and US Department of Agriculture (USDA) since 2001. AMPM is an interviewer administered 24hr recall where the volunteer is guided through a recall of the previous days food intake multiple times, giving them several opportunities to remember forgotten foods and provide detailed information on the foods reported.[3]

An additional advantage of the recall method is that it can be web-based, allowing the user to complete the recall at a time and place convenient for them. This reduces the cost of running the survey, as researchers are not required in the field. This method also ensures consistency of coding. Several countries have developed their own versions of computerised or web-based 24 hour recall systems. In the US, ASA24 (automated self-administered 24 hour recall), was developed to be a system which is easy to use and low cost.[2] The tool is for use with adults and is based on the United States Department of Agriculture (USDA) Automated Multiple Pass Method. It is planned that ASA24 will be the new method of dietary data collection in the NHANES surveys. Similarly in Europe Vereecken et al. (2005) developed YANA-C a computerised 24hr recall for use with adolescents aged 11 to 14 years.[4] The system has since been modified for use the in the IDEFICS study (Identification and prevention of dietary and lifestyle induced health effects in children and infants) and is known as SACINA (Self-Administered Children and Infants Nutrition Assessment).[5]

INTAKE24 uses the multiple pass recall method, which is a process whereby the user records everything consumed over the previous 24 hours. The user firstly lists all food and drinks consumed. This is followed by probing questions about quantities consumed and further information on the foods and drinks inputted. Finally the user reviews all the foods and drinks they have entered and is given the opportunity to add any forgotten items.

INTAKE24 was iteratively developed from an original system called SCRAN24.[6] SCRAN24 was a prototype developed in just 9 months on a very limited budget. It was based on a

previous system known as IPSAS (Interactive Portion Size Assessment Software) which was the UKs only validated computer based tool for use in assessing the portion size of foods consumed by children. The foods and portion sizes depicted in the tool were based on the foods and portion sizes recorded by children taking part in the National Diet and Nutrition Surveys carried out in Great Britain. SCRAN24 provided the basis of an excellent 24 hour dietary recall system and feedback from both students and teachers who had used the system was positive. However there were a number of key system developments, which it was felt could improve both usability of the system and the accuracy of the data collected.

This report describes these key areas of development and the new features introduced into the INTAKE24 system.

## 2 Project overview

This was a 16 month project involving a multidisciplinary team from the fields of Nutrition, Human Computer Interaction and Medical Statistics. The original SCRAN24 system was adapted to include key system developments to improve usability and to adapt the system for use with 11-24 year olds living in Scotland. One of the key system design changes was to make the tool web-based. Since the tool would be used without researcher supervision, special attention was given to the design of the interface to ensure the system was clear and intuitive. This was achieved by 'flattening' the interface; this means there is a consistent look and behaviour to the system, minimising confusion. The initial system design considerations can be found in the design document which was submitted to the FSAS in June 2012 (see Appendix…).

A researcher interface was also developed to provide a simple method of managing surveys and of outputting data, and a database tool was developed so that updates such as the addition of new foods and portion size images can be quickly and easily implemented.

Changes to the nutrition side of the system were also carried out. These included improvements to portion size images, addition of regional foods and alcohol and the addition of further prompts.

The system was developed and tested using an iterative process of four cycles of user testing; the first round used the initial SCRAN24 system and subsequent rounds used prototypes developed based on the feedback received. Interviewer led-24 hour recalls were conducted at each round of user-testing following completion of the online recall. These helped to identify foods which were forgotten during the online recall but that the researcher

was able to elicit during the interview. This guided the development of the associated food prompts and reminders.

## 3 System Developments

The user interface of the new web-based SCRAN24 system is loosely based on the previous design, but has undergone a number of significant changes. Some of these changes had to be introduced in order to make the new system compatible with modern web technologies: the previous system was designed as a stand-alone desktop application, and the presentation and user interface technologies available in a desktop environment are vastly different from those available in a web browser.

However, most of the changes made to the user interface were directly influenced by the user feedback and observations gathered during the user testing. In this section we will give a list of the major changes and explain the reasoning behind them.

### 3.1 The “flat” user interface design

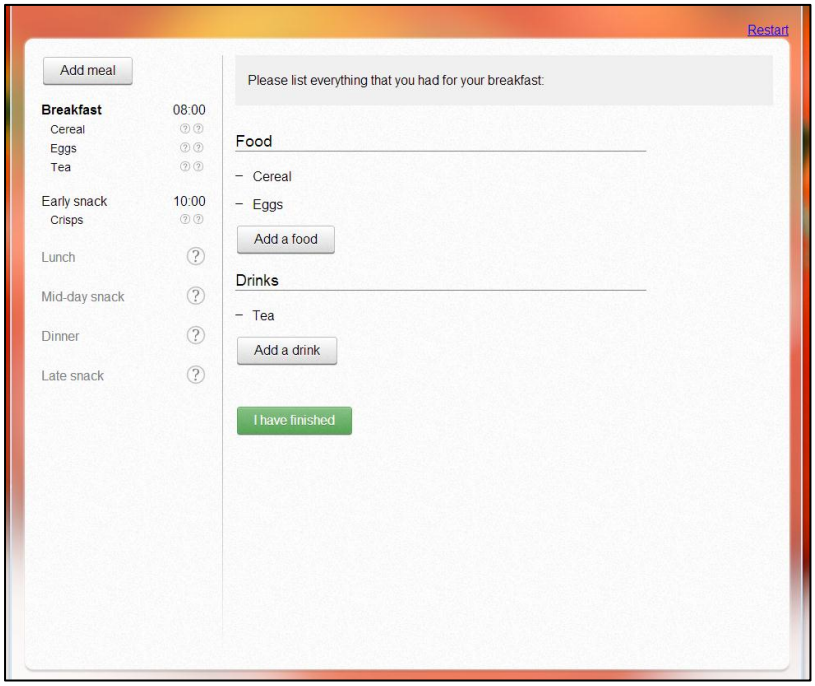


**Figure 1: The "flat" user interface**

One of the recurrent problems with the initial system was the inconsistency in the design of different stages in the survey. The system used a number of “screens” with significantly different functionality, each tailored for a specific activity and sharing very few user interface (UI) elements with other parts of the system.

During the user testing we have observed that unless the user had read instructions very carefully before proceeding to the next activity (something that very few people had actually

been doing), they were often confused and needed help. This was especially obvious with the “to-do list” screen.

In order to make the user interface simpler, and the next action expected from the user more obvious, we introduced a “flat” interface (Figure 1), which uses only a single interface screen shared between all of the various activities (e.g. free text entry, looking up foods in the database, portion size estimation).

As shown in the figure, the left hand side (called the *navigation panel*) always shows the current state of the survey – that is the list of meals and foods currently entered by the user, and whether they have looked up a particular food in the database and completed the portion size estimation. This makes it easy to see the overall progress, and also allows focusing on any element (a meal or a food) at any time, which was not easily done in the initial system.

The right hand side of the interface (called the *prompt panel*) always shows a contextual prompt – a simple question or a short explanation of the current activity with a corresponding user interface block, for example asking the user to enter the foods and drinks consumed for a particular meal or snack. When the user has answered the current question, the system will show the next prompt relevant to the currently selected item, for example matching the food to a specific food type in the database or selecting the portion size. If there are no more questions regarding the current selection, the system will automatically choose the next element to focus on. The user is able to manually focus on an element by using the left hand side of the interface at any time.

### 3.2 Dealing with unclear instructions

In the initial system there was a problem with unclear instructions and instructions that were confusing because they looked like parts of the user interface, for example instructions which included buttons that looked like they should be clickable but were included just as an example. This has been addressed by making the prompts as simple as possible, such that the user’s attention is always focused on just one straightforward question. This allows the system to skip showing the instructions for each step unless the user specifically requests help.

### 3.3 Improved free entry interface

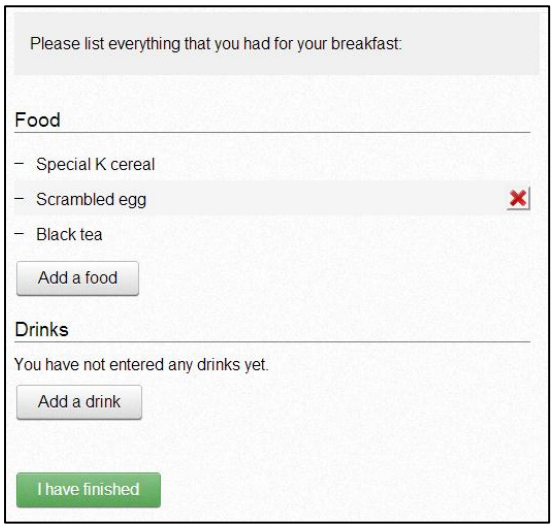


**Figure 2: Free entry interface**

The major issues with the free entry interface observed during the user testing were:

- Unclear scrolling interface that did not make obvious the full list of meals that the user could fill in;
- Difficulty deleting foods – having to use the "backspace" key often lead to unintentional deletion of foods other than the one that was meant to be deleted;
- Drinks were often forgotten.

To avoid these problems in the new system, we have made the following changes to the user interface. The list of meals is no longer fixed; instead, the navigation panel (Figure 1) initially contains a list of suggested meals and snacks that are usually consumed during the day. For each suggested meal or snack the system will show a confirmation prompt that asks the user either to confirm that they have had that meal or snack by providing the time, or to remove it from the list by telling the system that they did not have that meal or snack. This way, the user's attention will be brought to each eating occasion and it is very unlikely they will miss some of them. Additionally, the user is able to add any additional meals or snacks required by using the "Add meal/snack" button.

To avoid excessive scrolling, the food lists for individual meals are shown as separate prompts. This approach also makes it easier to design a richer free entry interface – such as adding a dedicated deletion button to provide a reliable mechanism for deletion of unwanted entries, and separate sections for food and drinks to lessen the probability of forgotten drinks (Figure 2).

## 3.4 Improved navigation

INTAKE24 supports the standard navigation controls present in web browsers, i.e. the “back” and “forward” buttons that act similar to “undo” and “redo” commands in traditional desktop software. This functionality is not limited to deletion – it is possible to undo any change, such as, for instance, portion size estimation in order to do it again.

## 3.5 Improved search functionality

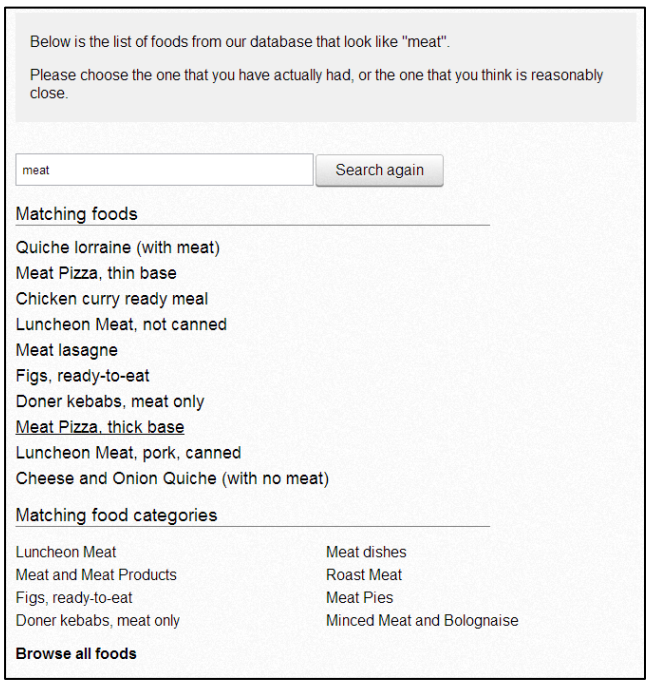


**Figure 3: Improved search interface**

In order to improve the food lookup system, the following features have been added to the food lookup system:

- Misspelled words are automatically recognised without further user input using two independent correction algorithms;
- A large number of combinations of word interpretations is analysed (including various combinations of synonyms);
- The word ordering and the inter-word distance are taken into account to show the foods whose descriptions are most similar to the user input;
- The limitations on the number of possible combinations, number of possible word interpretations, etc. are not fixed and can be changed to fine-tune the performance of the system.

As a result, the lookup system is more tolerant to queries that contain irrelevant information (e.g. “a plate of chips” instead of just “chips”), misspelled words and synonyms including regional food names.

The food lookup interface has been reworked (Figure 3) to support category browsing in addition to search. It is now possible to simply browse all foods that are in the system by category, which makes it easier to find something which is an approximate match to the food that the user has eaten when the specific item is not in the database.

The following features are also integrated into INTAKE24:

- Automatic splitting of phrases that look like multiple foods (e.g. for “fish and chips” the system will suggest two separate dishes: fish and chips, rather than suggesting only one (fish or chips).
- Sorting of look up results based on popularity of individual foods rather than their alphabetical ordering. This results in the more popular foods always being towards the top of the search result list.

### 3.6 Same as before

The “Same as before” feature was developed to speed up the entry procedure for foods that are consumed several times in one day, such as hot drinks. This feature can optionally be used with any food in order to allow the respondent to quickly reuse the portion size information they have entered before for that particular food without going through the portion size estimation prompts again. This option is especially useful for foods that trigger a series of “associated food” prompts, in which case it also allows the user to copy the answers given to those prompts before, namely the list of associated foods and their portion sizes. See Figure 4: Same as before optionfor an example: a user who has entered a coffee is prompted to use the same information as they have entered for coffee earlier, including the portion size and the additional foods such as sugar and milk.

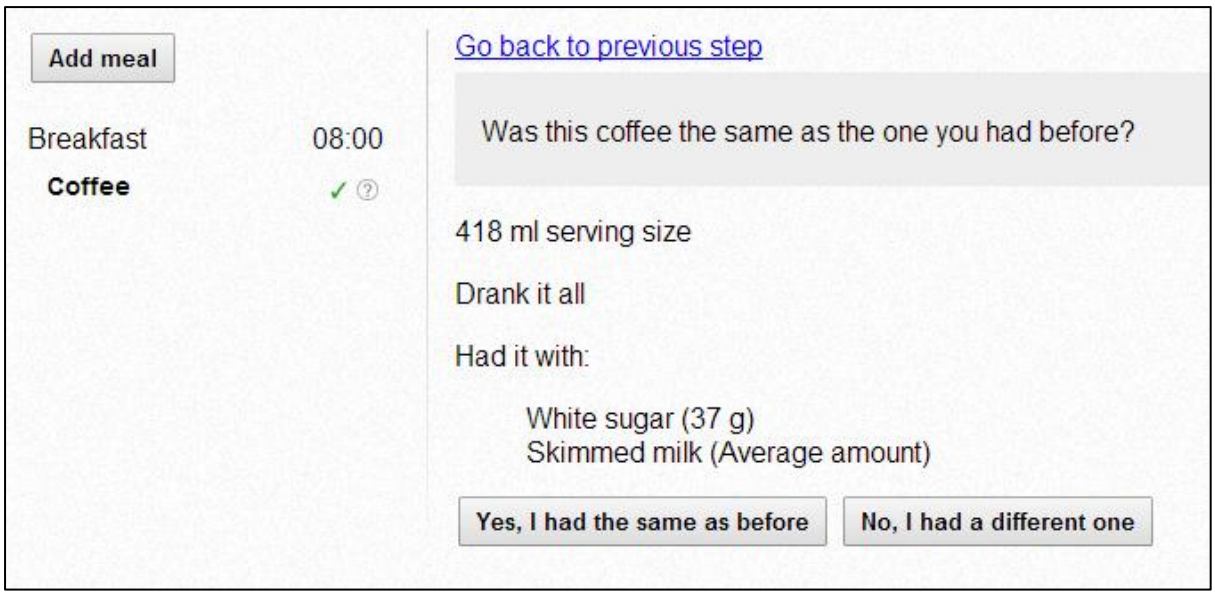


**Figure 4: Same as before option**

## 3.7 Improvements to portion size estimation

The original SCRAN24 system included over 2000 photographs of over 100 foods for portion size estimation taken from the development of the Young Person's Food Atlas (YPFA).[7] The portion sizes depicted were based on the amount of foods served to children taking part in the National Diet and Nutrition Survey.[8]

Although the YPFA has previously been tested and validated, large discrepancies in estimated intakes were still found for a small number of foods. A study was carried out to investigate whether different methods of presentation of foods in the food photographs could improve the accuracy of portion size estimations. It was hypothesised that by presenting foods in a similar way to how they would be served in a day-to-day setting, accuracy of estimations would be improved; for example having the option of crisps in a bag but also in a bowl, whole pizzas and slices of pizza, takeaway cups, and takeaway chips in containers.

The accuracy of the newly developed photographs was compared to those already used in the YPFA. A brief description of the methods and findings are given below, however the full report is included as Appendix 1

### 3.7.1 Data collection method for portion size study

Using data from the National Diet and Nutrition Survey[8] and the validation of the YPFA,[7] foods with the largest contribution to energy intakes and the poorest portion size estimation value (more than 10% under- or over-estimation) were selected. Alternative presentation

methods were discussed for these foods, and new portion photos were taken. The foods and drinks selected were breakfast cereals, milk on cereal, butter/margarine, chocolate bars, crisps, pizza, chips (including takeaway chips), cheese, pasta, bananas, apples, Yorkshire pudding, gravy, hot drinks (cups/mugs), and soft drinks (glasses). For example, for butter/margarine the range of photographs were extended from butter on bread only to also include images of portions of butter on a bread roll, a scone and also on a knife.

Sixty participants were recruited from a local secondary school and Newcastle University; 30 were aged 11-17 and 30 aged 18-24. The protocol for the study included a food-in-front (FIF) interview. Previous research has shown no difference between the accuracy of estimation of portion size in either a 24hr recall of consumed food, a 'just after eating' setting or a FIF setting.[9]

All foods were prepared and presented to the participants as they would be served if they were consumed i.e. in a bowl, on a plate, in a mug, in a glass. Weights of the foods and drinks were recorded; these were chosen to represent a range of the portions usually consumed and did not exactly match any of the portion photographs (with the exception of the chocolate bars and the packet of crisps). The participants were asked to estimate the portion size using the YPFA photos and the new photos in a randomised order.

### 3.7.2 Results of portion size study

The accuracy and precision of both estimations were calculated. The accuracy of the estimation refers to the mean of the estimate compared to the actual value. This was calculated by dividing the estimated weight by the actual weight. Precision refers to the range of the estimates provided; the smaller the range, the more precise the estimates are. Precision was calculated as the mean ratio +/- 2 times the standard deviation.

The new photos were found to be more accurate and more precise compared to the YPFA photos for the following foods; apple, banana, butter, cereal, chocolate bars, crisps, pasta, and pizza. For glasses, the YPFA portion photos were found to be both more accurate and more precise. The new photos were more accurate than the YPFA photos but less precise for cheese, takeaway chips, gravy, and Yorkshire pudding. This indicates that the new photos for these foods worked well at group level only. For chips, milk on cereal, and mugs, the new photos were less accurate but more precise than the YPFA photos.

Further analysis was carried out to determine which foods required new photos to be taken. Scatter plots of the differences in estimates were plotted to assess the visual spread of

estimates for the new photos and the YPFA photos. (See Short Report on Improvements made to Portion Estimation for full analysis, Appendix 1).

## 3.8 New portion photographs

The accuracy and precision was improved for 12 out of the 15 foods tested; these are listed in Table 1 below. New photos were taken for these foods and also for mugs and glasses. A larger range of different sized mugs and glasses was taken; these included wine glasses and pint glasses.

**Table 1: Foods for which accuracy and precision of portion photos were improved**

| **New photos taken by professional photographer and added to INTAKE24** | |
|---|---|
| Apple | Pasta |
| Banana | Pizza |
| Butter/margarine | Yorkshire pudding |
| Breakfast cereals | Chips |
| Milk on cereal | Cheese (in a sandwich) |
| Chocolate bars | Crisps |

There was also a selection of portion photos from the YPFA which needed re-taking for the online tool. For some foods, different preparation styles of the same weight of food were shown on one plate. For researcher-led interviews, this can be explained to the participant by the researcher; however it was felt that this may cause confusion when using the online tool. These photos were re-taken, with the different preparation styles separated out, see Figure 5. This was completed for raw and cooked carrot, cheese, and cucumber.

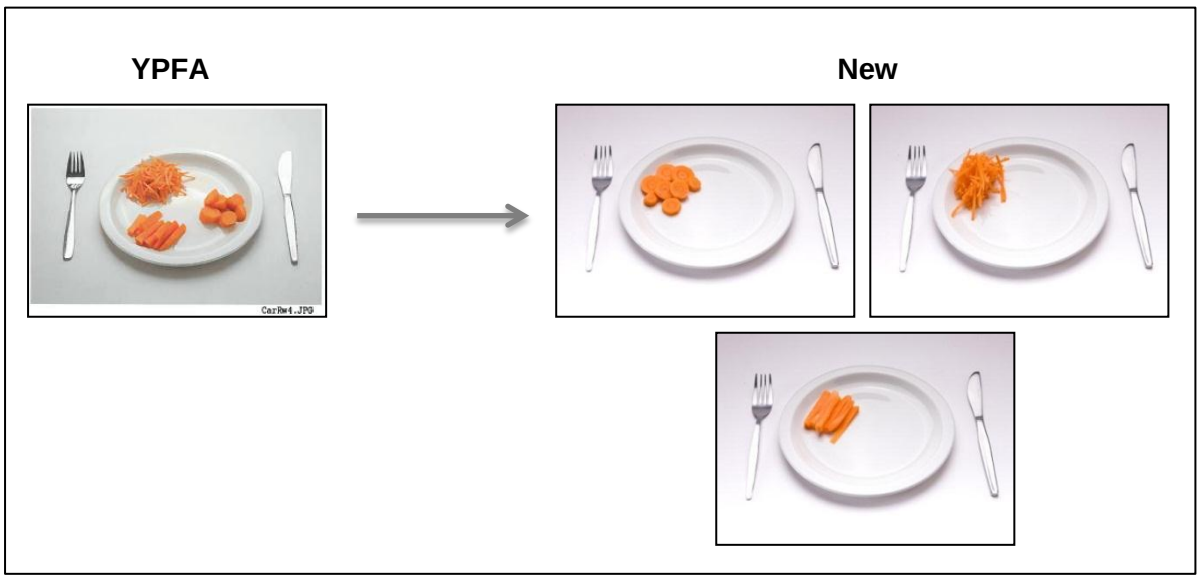


**Figure 5: Changes to portion photo of raw carrot**

Photos of a range of canned foods were taken; these allow estimations based on can size and/or proportion of can consumed. These were presented all together and by food type e.g. meat, fish, vegetables and fruit. We ensured that a comprehensive range of can sizes available was presented in the photos. Finally takeaway cups for hot and cold drinks in all available sizes were collected from high street cafes, such as Costa and Starbucks, and professional photos were taken of these, see Figure 6. More than 700 new photos have been added to INTAKE24.


**Figure 6: Guide photos for takeaway drinks**

## 3.9 New foods and drinks added to the system

The 1255 foods included in the SCRAN24 system were based on McCance and Widdowson food codes. For use in a Scottish National survey regionally specific foods needed to be added. Data from the NDNS Scottish sample[8, 10, 11] (from the most recent weighed intake survey) was used to identify foods and drinks which were frequently consumed and were major contributors to intake of energy and key nutrients among 11-24 year olds in Scotland. However, there were no additional foods identified to be added.

In addition to NDNS data, regional foods and terms were identified through contact with friends and colleagues in Scotland and via internet searches. In total, 37 regional food and drinks were added to the system, see

Table 2).

As the original SCRAN24 system was developed for 11-16 year olds, alcoholic drinks had to be included. These were taken from the NDNS databank, and 38 drinks were added, see Table 3.

In total approximately 400 new foods and drinks have been added to INTAKE24. These include the regional foods and alcoholic drinks, and also common foods which were missing from the system. These were compiled from searches of supermarket websites and included foods such as chorizo, roast duck, soya alternatives to dairy products, and a larger range of breakfast cereals.

Some terminology of the foods in INTAKE24 was based on McCance and Widdowson food codes. To make searching for foods easier, some of the foods and food categories were re-named to be more user-friendly. For example, 'Short sweet biscuits, e.g. Shortcake biscuit, Lincoln' was re-named 'Shortcake biscuit'. For some foods, however, examples were added to the food description as it was felt that this would help users to identify them; for example 'Dry cider' and 'Sweet/medium cider' were re-named 'Dry cider e.g. Strongbow' and 'Sweet/medium cider e.g. Woodpecker'.

**Table 2: Regional foods and drinks added to INTAKE24**

| **Regional foods and drinks added to INTAKE24** | |
|---|---|
| **Meat and meat dishes** | |
| Black pudding | Haggis |
| Red pudding | Stovies |
| Mock chop | Potted hough |
| Lorne sausage | Scotch egg |
| Smoked sausage e.g. Mattessons | |
| **Fish** | |
| Smoked haddock | Arbroath Smokies |
| **Soups** | |
| Cock-a-leekie soup | Cullen skink |
| Scotch broth | |
| **Vegetables** | |
| Clapshot | Colcannon |
| Kail/kale | Neeps |
| Tatties | |
| **Confectionery/desserts** | |
| Cranachan | Clootie dumpling |
| Tablet | |
| **Bakery items** | |
| Pan loaf | Macaroni pie |
| Dundee cake | Bolognese pie |
| Bridie | Scotch pie |
| Fatty cutties | Girdle scones |
| Butteries/rowies | Bannock scones |
| **Biscuits** | |
| Abernethy biscuits | Shortbread |
| **Others** | |
| Skirlie | Mealy pudding |
| Whisky Mac | |

**Table 3: Alcoholic drinks added to INTAKE24**

| Alcoholic drinks added to INTAKE24 | |
|---|---|
| **Beers, lager & cider** | |
| Best bitter, e.g. Boddingtons | Non-premium lager, e.g. Carlsberg |
| Real ales & strong bitters | Premium lager e.g. Amstel |
| Pale ale & mild ale e.g. IPA | Lager, special strong brew |
| Beer | Dry cider e.g. Strongbow |
| Stout not canned, e.g. Guinness | Sweet/medium cider e.g. Woodpecker |
| Stout in a can, e.g. Guinness | Home brew (homemade beer) |
| Continental lager, e.g. Grolsch | |
| Low calorie lager, e.g. Pils | |
| **Wine** | |
| Red wine | Champagne & Prosecco |
| Rose wine | White wine, low alcohol |
| Dry white wine | Homemade wine, any type |
| Medium white wine | Buckfast wine |
| Sparkling white wine | Mulled wine |
| Sweet white wine | |
| **Spirits & liqueurs** | |
| Spirits e.g. whisky, gin, brandy, rum, vodka, Bacardi, Malibu | |
| Medium liqueurs e.g. Tia Maria, Crème de menthe | |
| Strong liqueurs e.g. Pernod, Drambuie, Cointreau, Grand Marnier | |
| Cream liqueurs e.g. Baileys | |
| Aperitifs e.g. Martini, Cinzano, | |
| Dubonnet | |
| Pimms | |
| Sherry | |
| Port | |
| Diet alcopop e.g. Diet Bacardi Breezer | |
| Alcopop spirit based e.g. Bacardi Breezer, Smirnoff Ice | |
| Alcopop not spirit based e.g. Hooch | |
| Whisky Mac | |

## 3.10 Linking foods to NDNS databank codes

In the original SCRAN24 system, foods and drinks were linked to McCance and Widdowson food codes to allow for nutrient analysis. To maintain consistency with previous national food and nutrition surveys, the foods within the system were linked to the Nutrient Databank

food codes. These are the food codes which are used in the UK National Diet and Nutrition Surveys.

The Year 3 Databank food codes were provided by Public Health England. The foods contained within INTAKE24 were linked to the databank codes. Two researchers worked independently assigning codes to all the foods contained within the system. Once complete the spreadsheet was checked for matches (same databank code assigned to same food) and discrepancies (different codes assigned to same food). Discrepancies were discussed by the team, and the most appropriate code was assigned. A steering group member from Public Health England also checked the re-coding to ensure consistency with NDNS coding, and to advise on the most appropriate codes to use.

The foods have since been updated with Year 4 Databank food codes.

## 3.11 Features included in INTAKE24

Several features have been incorporated into INTAKE24 to improve the accuracy of recalls. The main objective of these features was to reduce the likelihood of foods and drinks being forgotten.

### 3.11.1 Associated food prompts

To ensure that the user enters everything consumed, prompts have been included in the system which mimic the type of questions which would be asked by a researcher in an interviewer-led recall. It is common for some foods to be forgotten, therefore associated foods have been linked to foods within the INTAKE24 system. The system recognises the food entered, for example ‘bread’ and asks the question “Did you have any butter or margarine on your bread?” The user can select either “No I did not”, “Yes I had some” or “I have already entered it”; this is if the food has been entered by the user but not yet linked to a food in the database. Commonly forgotten foods include butter/margarine, ketchup and other sauces, milk on cereal, added sugar in tea/coffee.

In addition to prompts for associated foods, if the user has not entered any drinks together with a meal, the system will ask if they are sure that they have not had any drinks with that meal. The system will also ask about long time gaps where no foods are reported.

### 3.11.2 Sandwich wizard and salad wizard

A special feature was created for sandwiches and salads. This was developed in response to the findings from the early rounds of user testing; items which were part of a sandwich, such as butter/margarine, salad items, and sauces, were often forgotten. Due to the vast number of different sandwich fillings and combinations it was unfeasible to include every variation within the system and keep it up to date. Therefore a 'build my sandwich' wizard method was created.

The system recognises the term 'sandwich' and synonyms, such as 'roll', 'butty', or wrap, entered by the user. The system returns "Build my sandwich" at the top of the food list and selecting it initiates the sandwich wizard. The user is asked a series of questions regarding the components of the sandwich, as follows:

1. *What kind of bread did you have in your sandwich?*
2. *What kind of spread did you have in your sandwich?*
3. *What kind of meat or fish did you have in your sandwich?*
4. *What kind of cheese or dairy product did you have in your sandwich?*
5. *What kind of extra filling did you have in your sandwich?*
6. *What kind of sauce or dressing did you have in your sandwich?*

For all the questions above there are relevant categories listed below for the user to select the exact food. For questions 2-6 they have the option to say '*I didn't have any*'. The user is asked question 5 repeatedly to ensure all components of the sandwich are captured. Once all fillings are entered, they can click '*I did not have any other fillings*' (see

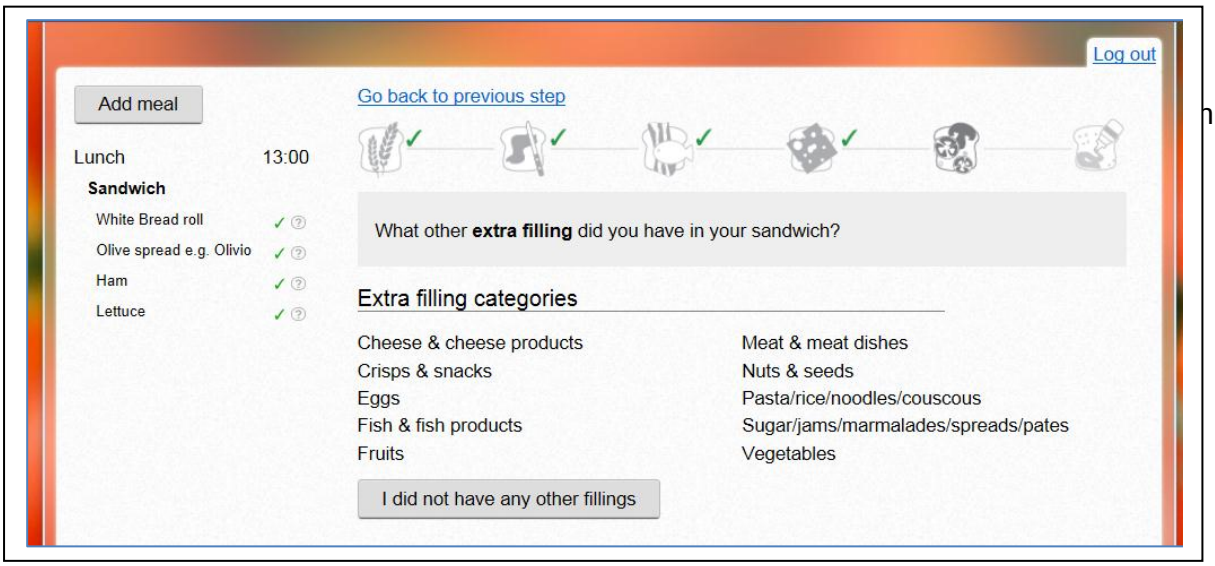

**Figure 7: Example of one of the questions in the sandwich wizard**

The salad wizard works in the same way. The system recognises that 'salad' has been entered by the user, and asks '*What items did you have in your salad?*'. The user can select as many foods as they consumed and then click '*I did not have any more*'. The user is finally asked '*Did you have any sauces or dressings on your salad?*' The user is then guided through the portion estimate stage.

### 3.11.3 Pizzas

The accuracy of portion estimations of pizzas was improved by including a larger variety of different sizes of pizza. The user is also asked for more information on thickness and size of slice.

In total, nine pizzas were included in the guide photo. Pizza thicknesses were measured using a round cutter and the weight of 10 pieces averaged. This was completed for pizzas which clearly differed in thickness; five in total. Conversion factors for thickness were calculated and applied to the weight of slice or whole pizza selected by the user, see Appendix 7.1 for an example.

## 3.12 Method of adding/deleting foods and portion estimation methods in INTAKE24: The db tool

Amending the foods list in INTAKE24 is a simple process. It uses a companion program which runs in Java™, called db tool. Figure 8 highlights the key features of the tool. The development of the db tool was important as it allows the food list and portion estimation to be easily updated. The variety of foods available to purchase is ever growing, as is the number of new foods appearing on the supermarket shelves. The db tool ensures that all these foods can be added to INTAKE24 easily to keep the system up-to-date. Updates to the NDNS databank can also be added via the tool. If it is necessary to change the method of portion estimation for a particular food or group of foods; again this can be done easily using the tool.

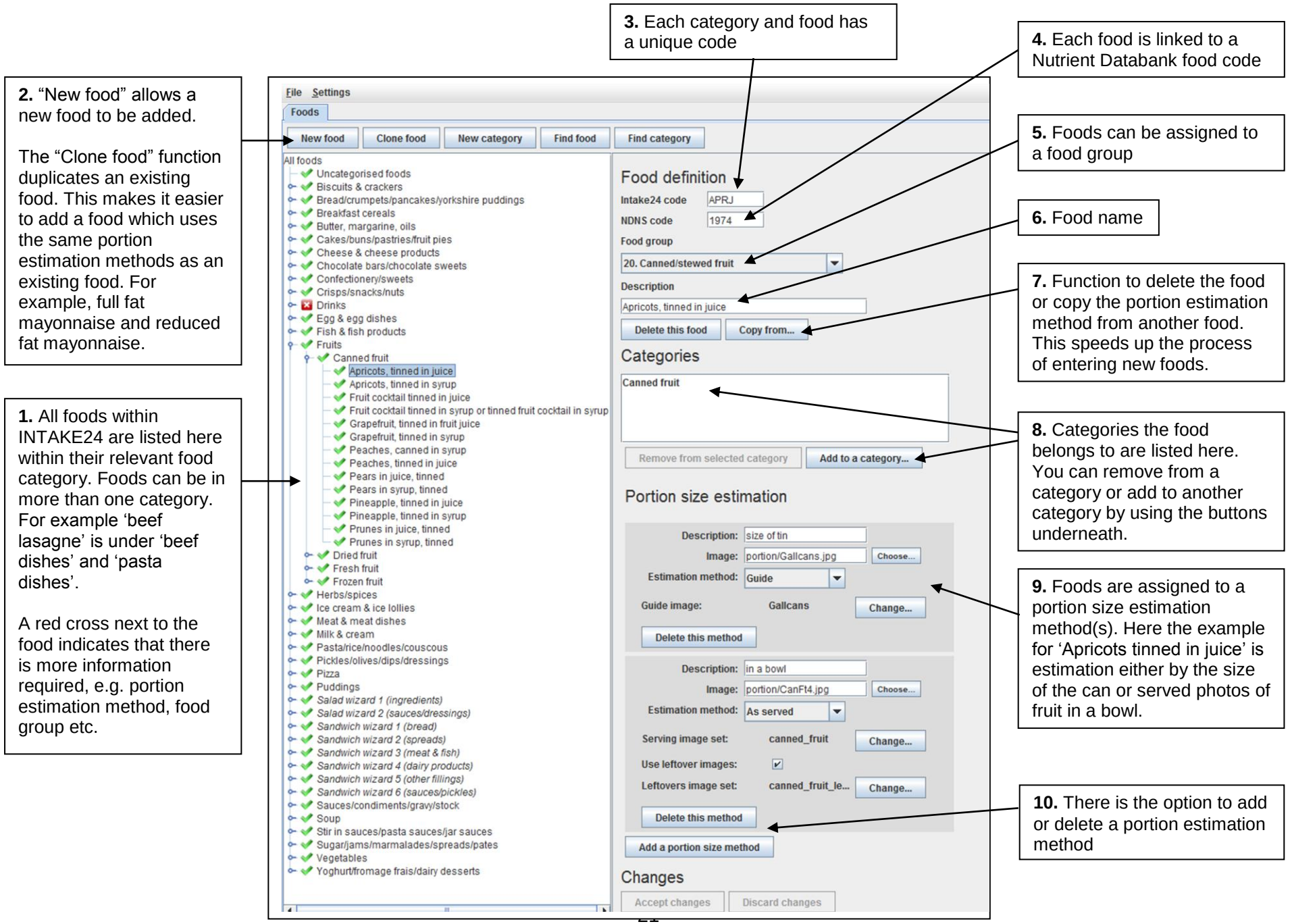


**Figure 8: Screen shot of the db tool and its key features**

### 3.13 Researcher interface

Researchers can log onto the INTAKE24 system using a staff username and password; see Figure 5. This directs them to the researcher interface where they are able to carry out five main functions:

- Start, suspend or end a survey
- Download the survey data
- Download an activity report. This informs the researcher of the number of recall submissions, the mean, minimum and maximum completion times, and the submission dates for each participant.
- Upload usernames and passwords for participants
- Update the survey schedule (start and end dates)

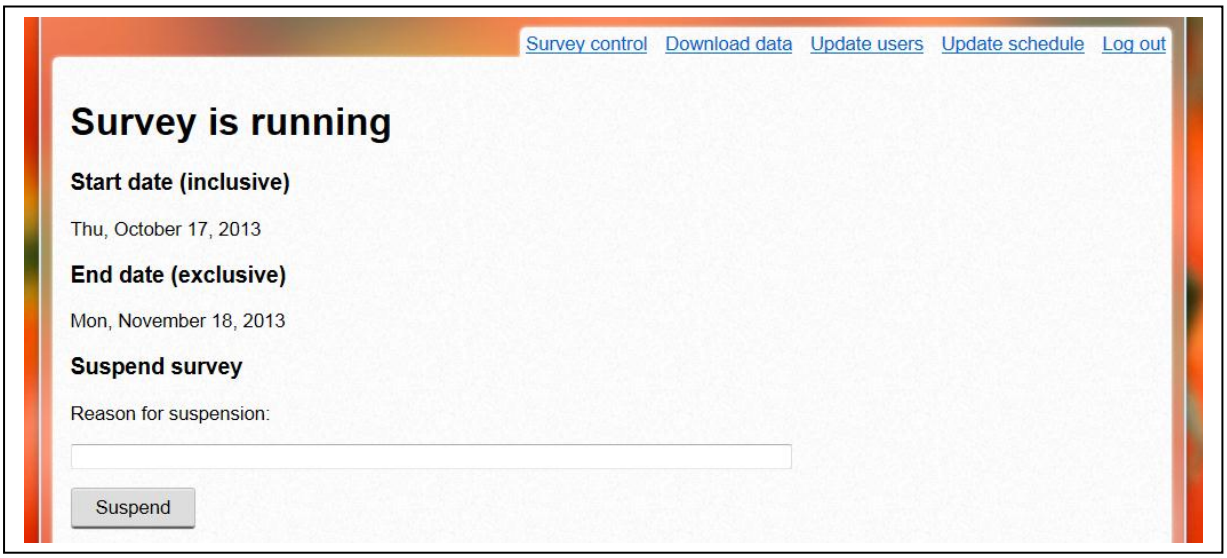


**Figure 9: Screen shot of researcher interface**

# 4 Usability testing

User evaluation of the system was a fundamental part of the design process. Evaluation focused mainly on the usability of the system (e.g. how easy it is to learn and use) and on the users experience while interacting with the system (e.g. how satisfying, enjoyable and motivating the system is to use).[13] It is essential that the target age group intended to use the system (11-24 years) are used in the evaluation process. Integrating observation and post-completion interviews allows us to obtain maximum information to feed into the design process; amending and improving the system to have the best possible tool for use in the field.

## 4.1 Methodology

The development of INTAKE24 involved four rounds of user testing. Table 4 indicates the system that was tested during each round of testing. Twenty participants took part at each stage (10 x 11-16 year olds and 10 x 17-24 year olds). The younger age group were recruited from secondary schools and the older age group from university students.

**Table 4: The location and the type of system tested at each stage of user testing**

| User testing | Number of participants | Location | System tested | Other information |
|---|---|---|---|---|
| Round 1 | 9 x 11-16y<br>9 x 17-24y | Newcastle upon Tyne | SCRAN24 | Feedback on the original system was gathered |
| Round 2 | 7 x 11-16y<br>7 x 17-24y | Newcastle upon Tyne | First INTAKE24 prototype | Feedback from round 1 was fed into the development of the first INTAKE24 prototype |
| Round 3 | 10 x 11-16y<br>10 x 17-24y | Dundee | Second INTAKE24 prototype | Changes were made to prototype 1 and the system was tested with people living in Dundee |
| Round 4 | 10 x 11-16y<br>10 x 17-24y | Newcastle upon Tyne | Final INTAKE24 system | |

Each participant was asked to use INTAKE24 to recall the previous day's food and drink intake. They were encouraged to 'think aloud' while using the system, by giving a running commentary; for example what they liked/ didn't like, how easy it was to use, and what they thought the system was asking them to do. Two researchers were present to observe the participants, take notes and to re-establish the flow of dialogue when the participant lapsed into silence.

Once the participant had completed the online recall, the researchers carried out a semi-structured interview, tailored according to observations made, to collect feedback on the system. Each participant was also asked to complete a system usability scale questionnaire.

After completion of the questionnaire, each participant completed an interviewer-led 24-hour recall with one of the researchers. This followed the same protocol as used in the Low Income Diet and Nutrition Survey (LIDNS).[14] These helped to identify foods which were forgotten during the online recall but that the researcher was able to elicit during the interview. This guided the development of the systems prompts and reminders.

## 4.2 Results

The first part (section 4.2.1) describes the results from the final round of testing. Section 4.2.2 summarises the results from all rounds of testing.

### 4.2.1 Findings from final round of usability testing

Table 5 shows the mean nutrient intakes for INTAKE24 and the interviewer-led recall, and the differences in intakes between the two methods. With the exception of vitamin C and iron, nutrient intakes reported using INTAKE24 were below those reported from the interviewer-led recall. Energy intake, which was under-estimated by 8% using INTAKE24 ($p<0.05$) and fat intake, which was under-estimated by 13% ($p< 0.01$) were significantly different from the interviewer led values.

Although there was a significant underestimation of energy and fat intakes, overall the accuracy of the estimations improved from the first round to the final round of testing. Since the final round of testing was completed, refinement of the wizards and the addition of more foods were carried out; this may further improve the accuracy of estimations. The purpose of the testing phase was predominantly to identify missing foods and to refine key features. The aim of the second part of the study will be to compare intakes from both methods and if necessary to introduce further improvements to the system.

**Table 5: Mean nutrient intakes for final round of user testing for both methods (n=20)**

| | INTAKE24 Mean (SD) | Interview Mean (SD) | Difference (INTAKE24-Interview) | p-value[1] |
|---|---|---|---|---|
| Weight of food (g) | 2238.0 (975.7) | 2071.5 (704.3) | 166.5 | 0.252 |
| Energy (kJ) | 7075.4 (2926.5) | 7713.2 (2592.9) | -637.8 | 0.031 |
| Carbohydrate (g) | 224.0 (88.0) | 234.3 (81.6) | -10.3 | 0.323 |
| NMEs[2] (g) | 64.7 (41.9) | 67.5 (43.7) | -2.8 | 0.609 |
| Protein (g) | 64.5 (35.3) | 66.5 (36.6) | -2.0 | 0.522 |
| Fat (g) | 62.1 (35.1) | 71.6 (30.3) | -9.5 | 0.006 |
| Vitamin C (mg) | 120.1 (104.0) | 95.3 (66.0) | 24.8 | 0.157 |
| Iron (mg) | 11.0 (6.4) | 10.3 (5.6) | 0.7 | 0.485 |
| Calcium (mg) | 805.7 (358.5) | 860.2 (460.0) | -54.5 | 0.350 |

During the interview, the researcher was able to probe for more information about the foods and drinks consumed and prompt for forgotten foods. INTAKE24 and the interviewer led recall were compared against each other to determine matches, omissions and intrusions, see Table 6. A match was defined as exactly the same food being reported in INTAKE24 as was recorded in the interviewer led recall e.g. skimmed milk in INTAKE24 and skimmed milk in the interviewer led recall. An approximate match was defined as the same food but a slightly different variant of that food e.g. semi skimmed milk in INTAKE24 and skimmed milk in the interviewer led recall. An omission was a food recorded in the interviewer led recall but not in INTAKE24 and an intrusion was a food recorded in INTAKE24 but not recorded in the interviewer led recall. The percentage of exact matches was almost 82%, omissions and intrusions were 7% and 5% respectively. There were 25 omitted foods from INTAKE24 compared with the subsequent interviewer led recall. The types of omissions are shown in Table 7. Most omissions were for 'additions, e.g. sauces, oils etc.' and drinks, 24% and 20% respectively. To increase the likelihood of capturing forgotten drinks, the predefined 'snack' times in INTAKE24 were re-named 'snack/drinks'.

**Table 6: Matches, omissions and intrusions of all foods in INTAKE24 when compared with Interviewer led recall for final round of testing**

| | Number of foods | Percentage of total foods recorded |
|---|---|---|
| Exact Match | 292 | 81.8 |
| Approximate Match | 22 | 6.2 |
| Omission | 25 | 7 |
| Intrusion | 18 | 5 |
| Total No. Foods recorded | 357 | 100% |

**Table 7: Type of omissions from INTAKE24 in round 4 of user testing**

| Food group | Number of foods | Percentage of total foods recorded |
|---|---|---|
| Butter/Spread | 1 | 4 |
| Fruit/Veg | 3 | 12 |
| Additions (Sauces, etc) | 6 | 24 |
| Drinks | 5 | 20 |
| Cheese | 1 | 4 |
| Bread | 2 | 8 |
| Meat | 1 | 4 |
| Biscuits/Cakes | 3 | 12 |
| Other | 3 | 12 |
| Total No. Foods recorded | 25 | 100% |

### 4.2.2 Summary of findings from all rounds of usability testing

The findings from all four rounds of user testing have been summarised in Tables 8 and 9.

The time taken to complete the computerised recall reduced from an average of 22 minutes per recall to 14 minutes. The maximum completion time reduced from 50 minutes to 21 minutes. The improvement that contributed most to the reduction in completion time was the 'flattened' interface. The SCRAN24 system included different interfaces for the different tasks, and unless the user had read instructions very carefully before proceeding to the next activity (something that very few people did), they were often confused and needed help, thus adding to the completion time. INTAKE24 uses only a single interface screen shared between all of the various activities (e.g. free text entry, looking up foods in the database, portion size estimation). This makes the usability of INTAKE24 more intuitive.

The average completion time for the second INTAKE24 prototype in round three of user testing was the quickest, however this was due to prompts for forgotten foods not being included in the system at that time.

**Table 8: Mean completion time (min) for INTAKE24 for the four rounds testing**

| | Round 1 (SCRAN24) | Round 2 | Round 3 | Round 4 |
|---|---|---|---|---|
| Mean completion time (min) | 22.26 | 16.51 | 09.25 | 13.41 |
| Min completion time (min) | 12.00 | 06.00 | 04.30 | 06.21 |
| Max completion time (min) | 50.00 | 39.00 | 17.00 | 20.30 |

**Table 9: Accuracy of estimates using INTAKE24 from all four stages of testing**

| | | User testing | | |
|---|---|---|---|---|
| | **Round 1 (SCRAN24)** | **Round 2** | **Round 3** | **Round 4** |
| Weight of food (g) | 0.90 | 0.73 | 0.87 | 1.05 |
| Energy (KJ) | 0.84 | 0.80 | 0.84 | 0.89 |
| Carbohydrate (g) | 0.92 | 0.88 | 0.85 | 0.94 |
| Protein (g) | 0.80 | 0.77 | 0.86 | 0.96 |
| Fat (g) | 0.78 | 0.52 | 0.81 | 0.81 |
| Vitamin C (mg) | 1.09 | 1.15 | 0.89 | 1.22 |
| Iron (mg) | 0.81 | 0.78 | 0.84 | 1.03 |

The accuracy of estimation of foods using INTAKE24 was calculated as a ratio for each individual's total nutrient intake, using the calculation below:

Ratio = estimated intake (INTAKE24) / estimated intake (interviewer-led)

Ratios of less than 1 indicate an under-estimation of intakes using INTAKE24 and above 1 represent an over-estimation.

Table 9 illustrates the changes in accuracy of the online tool through the four rounds of testing. The closer the value is to 1, the more accurate. For all nutrients (with the exception of vitamin C), the accuracy of estimates was improved using INTAKE24 compared with SCRAN24. Accuracy was also improved in each round of testing, from the INTAKE24 prototype tested in round 2 to the final version in round 4.

## 5 Summary and further work

The findings from the final round of user testing are positive. The introduction of associated food prompts has led to fewer omissions in INTAKE24. Additionally, the new flattened interface has almost halved the time taken to complete the online recall. These results indicate great promise for the future of INTAKE24 as an online recall for large scale diet and nutrition surveys.

The results from the first stage of the project are from a relatively small sample of participants, and although the accuracy of estimates was improved using INTAKE24, there were still significant underestimations of energy and fat intakes. The next stage of the study is to compare INTAKE24 with interviewer-led recalls in 180 11-24 year olds living in Scotland. Participants will access INTAKE24 at home/school or any other convenient location. This will test the system in a 'real-life' setting, i.e. how it will be used when deployed as a dietary assessment tool in nutrition surveys and compare how well the system performs against a standard interviewer-led 24 hour recall methodology.

In addition the system will be optimised for use on mobile devices such as smart phones and tablets.

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# 7 Appendices

## 7.1 Method of estimating portion size of pizzas

**Table 10: Densities of pizzas for use in portion estimation**

| Pizza number | Average cutter weight (g) | Pizzas included in thickness guide* |
|---|---|---|
| **1** | 14 | ✓ |
| **2** | 12 | ✓ |
| **3** | 22 | ✓ |
| **4** | 20 | ✓ |
| **5** | 10 | |
| **6** | 22 | |
| **7** | 13 | |
| **8** | 15 | ✓ |
| **9** | 12 | |

*Only pizzas that visibly differed in thickness were included in the thickness guide. The order of thickness (thinnest to thickest) were 2, 1, 8, 4, and 3

An example of a user's selection of portion size of pizza and the subsequent calculation is shown below.

| | Pizza | Thickness | Slice |
|---|---|---|---|
| **Participant selection** | 7 | 5 (pizza 3) | B |
| **Weight (g)** | 562 | | 140.5 |

Taking into account the choice of pizza, slice and thickness, estimated weight could then be calculated as follows:

Conversion factor = density for pizza 3 / density for pizza 7
= 22 / 13
= 1.7

The conversion factor above is then multiplied by the weight of the pizza slice chosen.

Weight of slice = 140.5 x 1.7
= 238.9g