Comparison study: INTAKE24 vs Interviewer led recall

Final report

October 2014

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Contents

1. Executive summary

INTAKE24 is an online dietary recall based on the multiple pass method. It was developed using an iterative cycle with 4 rounds of user testing and development. The system is web-based and designed to be intuitive, engaging and quick and simple to use. The portion size of the foods reported is estimated using a series of food photographs. These have been developed based on the portion sizes of foods reported in the UK National Diet and Nutrition Surveys and have been extensively validated in both a feeding study and a relative validation against 4-day weighed intakes. Foods within the system are linked to the NDNS Nutrient databank and all data are automatically coded and entered. A researcher interface allows the researcher to start, stop and suspend surveys, to upload user details and to download data. Nutrient data is output as an MS Excel file.

A relative validation of INTAKE24 against interviewer led 24hr recalls was conducted with 167 participants aged 11-24 years living in Scotland. Participants were asked to complete INTAKE24 and an interviewer-led 24hr recall on the same day on four non-consecutive days over the course of one month, including one weekend day. The interviewer-led 24hr recalls followed the interview protocol used in the Low Income Diet and Nutrition Survey. Portion size assessment in the interviewer-led recalls was assisted by use of a food portion size food atlas.

Agreement between INTAKE24 and the interviewer led recalls was very good with intakes of energy and macronutrients within 1% on average. The limits of agreement for energy were from an under-estimate of 48% to an over-estimate 82% for the 11-16 year olds and an underestimate of 50% to an over-estimate of 97% for the 17-24 year olds. Of the foods reported in INTAKE24 82% matched the food reported in the interviewer led recall, 11% were omitted and 7% were identified as intrusions.

The system compares favourably in terms of accuracy and precision with both computerised and face-to-face 24hr recalls. The fact that recalls can be conducted at a time and place convenient to the participant without the need for an in depth face-to-face interview may improve participation and completion rates. The average time to complete the online recall was under 12 minutes. INTAKE24 has the potential to collect dietary data of comparable quality to that of an interviewer led recall but at a fraction of the cost.

2. 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. Twenty-four hour recalls are a popular choice for dietary surveys as they are quick to administer, and are less burdensome to complete than many other dietary assessment methods.[1] This may in turn 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 day's food intake multiple times, giving them several opportunities to remember forgotten foods and provide detailed information on the foods reported.[2]

INTAKE24 uses the multiple pass recall method, which is a process whereby the user records everything consumed over the previous 24 hours. The system is self-completed and designed to guide the user through the recall process. Participants therefore do need some level of literacy, computer literacy and, as with all self-complete methods, food knowledge. 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.

An additional advantage of a web-based recall method is that it allows 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.

This report presents the findings from a survey comparing INTAKE24 with an interviewer led recall in 167 11-24 year olds living in Scotland and Newcastle that completed at least one 24 hr recall.

3. Background to the project

This was the second part of a 16 month project involving a multidisciplinary team from the fields of Nutrition, Human Computer Interaction and Medical Statistics. In part 1 of the study SCRAN24[3], a prototype computer based 24hr recall 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 1) and a full report on the development and user-testing of the system was submitted in November 2013 (see Appendix 2).

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 content of the system were also carried out during the initial development of the tool. These included improvements to portion size images, addition of regional foods and alcohol and the addition of further prompts such as 'Did you leave any of your food?', 'Did you have any sugar on your cereal?', 'Did you have any spread on your bread?' or 'Did you have any bread with your soup?' A same as before option was also added so that foods consumed several times in one day, such as tea or coffee, can easily be re-entered without needing to add the details of milk and sugar or estimate portion size.

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 and guided the development of the associated food prompts and reminders.

4. Methods

4.1 Objectives

The objective of the project was to undertake a comparison of INTAKE24 (the test method) with interviewer-led 24hr recalls (the reference method) in 180 people aged 11-24 years living in Scotland. This was not intended to be a full validation of the system which was beyond the scope of the project but aimed to provide a comparison of INTAKE24 against an established, validated and widely used method.

4.2 Recruitment

4.2.1 Ethics

Ethical approval for the study was granted by the Newcastle University Faculty of Medical Sciences Ethics Committee.

4.2.2 Sample size

Sample size calculations were based on standard deviations of energy intakes reported by participants in the NDNS for two age groups 11-16 years and 17-24 years and allowed for 20% attrition. For 11-16 year olds the sample size was calculated based on a standard deviation of 2725KJ to give an 80% power to detect a difference in mean energy intake reported by the two methods 47 participants are required. For 17-25 year olds the sample size was again calculated based on a standard deviation of 4124KJ to give an 80% power to detect a difference in mean energy intake reported by the two methods. The variation in energy intake in the older age group is greater than for the younger age group and therefore 101 participants were required. Allowing for 20% attrition the aim was to recruit 58 participants aged 11-16 years and 122 aged 17-24 years.

4.2.3 Recruitment methods

All 11-16 year olds were recruited by the research team through 2 high schools; 45 were recruited from a high school in Dundee and 20 from a high school in Newcastle upon Tyne. Researchers were based in the home economics department. Pupils who were interested in taking part were given an information sheet and consent form. Parental consent was obtained from all pupils taking part. High street vouchers to a value of £15 were offered as an incentive to take part in the study.

Table 1: 11-16 year old target recruitment quotas

Characteristic	Category	Quotas
Age	11-12 13-14 15-16	Minimum 15 Minimum 15 Minimum 15
Gender	Male Female	Minimum 25 Minimum 25
SIMD	SIMD 1 SIMD 2 SIMD 3 SIMD 4 SIMD 5	Minimum 8 Minimum 8 Minimum 8 Minimum 8 Minimum 8
Ethnicity	White Non-white	47-50 8-11

Recruitment of 17-24 year olds was conducted by IPSOS-Mori. Participants were recruited via on-street recruiters and offered high street vouchers to the value of £30 as an incentive to take part. Completed consent forms were passed to Newcastle University. University researchers contacted consenting participants to arrange the first dietary recall day.

Table 2: 18-24 year old target recruitment quotas

Characteristic	Category	Quotas
Age	17-18 19-21 22-24	Minimum 35 Minimum 35 Minimum 35
Gender	Male Female	Minimum 52 Minimum 52
Economic status (can't use SIMD when recruiting on-street/door to door so economic status was used and we recruited from mix of areas)	HE/FE Working Unemployed At school Looking after home/family	Maximum 40 Minimum 40 Minimum 15 Minimum 12 Minimum 8
Ethnicity	White Non-white	Minimum 100 Minimum 15

Recruitment quotas were established to try to ensure a nationally representative sample of participants were recruited; this included age, gender, ethnicity, Scottish Index of Multiple Deprivation (SIMD[1]) for the 11-16 year age group and economic status for the 17-24 year age group). Due to a very low response rate from the participants recruited via the on street recruiters an additional 66 17-24 year olds were recruited by Newcastle University research staff. To boost the number of participants whose economic status was 'working', messages were uploaded onto the staff intranet at Newcastle and Dundee universities and FSAS. Colleagues within the desired age group were also approached at the university. To fulfil the quotas for participants 'looking after family' and 'unemployed', posters were displayed in local Sure Start centres, libraries and leisure centres.

4.3 Data collection

Participants were asked to complete INTAKE24 and an interviewer-led 24hr recall on the same day on four non-consecutive days over the course of one month. The first interview

[1] (SIMD is based on postcodes which are converted into datazones including their associated ranks, quintiles, deciles, vigintiles and geographies. For this report we have used quintiles, 5 stands for least deprived 1 for most deprived. SIMD takes into account income, access to services, education, housing, crime, employment and health.)

was conducted face-to-face; the researcher met the participants either at home, in school, at university or at an out of home food or drink outlet depending on the participant's preference. The researcher carried out height and weight measurements unless the participant was uncomfortable being measured. The four days included at least one weekend day and the days of the week were equally represented across the study sample. A weighted randomisation was used with 75% of participants completing INTAKE24 first and 25% completing the interviewer-led recall first. The rationale for this was that testing the online recall tool after having completed an interviewer led 24hr recall would be testing the system in a way in which it would never be used in practice. It also ensures the best possible quality of interviewer-led 24hr recall (a recall enhanced by having completed the online recall first). Having a subsample of both the younger and older age group completing the interviewer led recall first acts as a methodological check to enable us to estimate the impact of completing one method on the apparent accuracy of the other.

4.3.1 Face-to-face dietary recalls with 11-16 year olds – in school

For the 11-16 year olds, both the online and the interviewer-led recalls were conducted at school. Researchers were based in school for a total of 21 days. Each participant was given a unique username and password for INTAKE24. Once they had completed the online survey (unassisted), they completed a recall with a researcher (vice-versa for those completing the interviewer-led recall first). The interviewer-led 24hr recalls followed the interview protocol used in LIDNS. [(4)] Portion size assessment in the interviewer-led recalls was assisted by use of a food portion size food atlas. [(5)]

Participants height and weight were measured during the first appointment. Once they had completed four recall days they were given £15 high street vouchers as a thank you for taking part.

4.3.2 Face-to-face dietary recalls with 17-24 year olds

Appointments were made to visit participants at home or a location convenient for them (e.g. school, university, café, Sure Start Centre) for the first dietary recall (A visit protocol is included as Appendix 3). Participants were grouped in terms of their location, and effort was made to arrange these appointments consecutively where possible, to keep travel costs to a minimum (see Appendix 4). An example of a completed 24 hr interviewer led recall is shown in Appendix 5.

For participants who completed INTAKE24 first, an email was sent the day before the appointment with a link and login details for the online system. It was stressed that they were

to complete the online recall the next day before the researcher's visit. A text message was also sent the morning of the appointment reminding participants to complete INTAKE24.

For participants who completed the interviewer-led recall first, the link for INTAKE24 was sent, via email, to the participant once they had completed the interview. It was stressed that the online recall had to be completed later that day. When possible, researchers logged onto the researcher site to check completion, and if no survey had been submitted later that day, a reminder text message was sent.

On completion of the interviewer-led recall, the researcher explained that the remaining interviewer-led recalls would be completed over the phone. A portion size food atlas was left with the participant, along with a stamped addressed envelope to return the book once they had finished the study. They were advised that they would receive £30 high street vouchers as a thank you for taking part once the food atlas was returned. Height and weight measurements were taken for participants who had agreed to this aspect of the study.

4.3.3 Dietary recalls over the phone with 17-24 year olds

Following the protocol for the LIDNS the first interview with the 17-24 year olds was conducted face-to-face and subsequent recalls were conducted over the phone. The procedure above was followed but instead of visiting the participant at home, a researcher called the participant at the agreed time. During the interview the participant was directed to the appropriate page of the food atlas to make an estimate of portion size for each item consumed.

4.4 Data entry

Participants were asked to enter foods and drinks consumed the previous day into INTAKE24. If they could not find a specific food type or it was missing in INTAKE24 the system asks them to select the closest match. Interrogation of the INTAKE24 database identified 77 food search terms (1% of the total) which had resulted in a selection of a 'closest match' and these foods were subsequently added to the database. Examples include 'protein shake' coded as milk shake made with powder, 'almond milk' coded as semi skimmed milk and 'chicken curry pie' coded as chicken curry ready meal. INTAKE24 automatically codes the recalls. The database of foods within INTAKE24 is linked to the NDNS Nutrient Databank data set and the portion size images are linked to a database of weights. The system outputs the data in an MS Excel file. Manual coding and data entry was required for the interviewer-led recalls. A purpose built MS Access database was used to input interviewer-led recalls. Each food was coded using Year 4 Databank food codes. The

two datasets were then merged and corresponding recalls were identified. Items recorded using INTAKE24 were coded as Matches, Omissions or Intrusions.
An exact 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.

4.5 Statistical analyses

For the purposes of analysis the sample was split into two age groups, 11-16 years and 17-24 years. No additional division of gender was made as the sample size was too small. Mean intakes were analysed for all participants completing any number of days, i.e. at least one INTAKE24 and one interview-led recall on the same day. Unmatched recalls, where the participant had completed only INTAKE24 or the interviewer-led recall for that day, were not included in the analysis.

The impact of errors in reported nutrient intakes was investigated by calculating the ratio of an individual's mean energy and nutrient intakes based on the recall using INTAKE24 compared to their mean daily energy and nutrient intakes reported in the corresponding Interviewer led recall. The method of Bland and Altman[(6)] was used to look at the limits of agreement of the two methods. Limits of agreement are applied so that 95% of the differences will lie between the limits, this is calculated by:

$d \pm 2s$ (where d=mean difference, s=standard deviation of the differences)

As the data were not normally distributed the analyses were performed on the logged weights of the foods and nutrients. The log of the ratio of the weights is equal to the difference between the log of the weights (i.e. log of (fat(g) by INTAKE24: fat(g) by Interviewer led recall) is the same as (log of fat(g) by INTAKE24) minus (log of fat(g) by Interviewer led recall)). The values presented are the geometric mean ratio (that is the antilog of the mean of the log ratio).

In order to assess the ability of INTAKE24 to rank individuals, tertiles of intake as measured by each method were calculated. The percentage classified into the same, adjacent and

opposite tertile by both methods was calculated and kappa statistic was used to assess the level of agreement over and above that which would be expected by chance.

4.6 The above analyses were also conducted for selected food groups.Identifying energy under-reporters

128 participants agreed to have body weight measurements taken. Schofield equations[7] were used to calculate BMR for individuals where body weight was available and the ratio of energy intake to basal metabolic rate was calculated (EI:BMR). For the older age group (17-24 years) the percentage of individuals with an EI:BMR below 1.0 x BMR, 1.2 x BMR, 1.4 x BMR and 1.6 x BMR was calculated for comparison with the levels seen in the NDNS survey of British Adults aged 19-64 years.[8] For the younger age group the Torun cut-off[9] was used to identify under-reporters for comparison with the levels of under-reporting seen in the NDNS survey of young people aged 4 to 16 years[10].

5. Results

5.7 Recruitment and response

A Recruitment company was involved in the study due to the need to obtain a representative sample and to recruit participants to specific quotas. Details of the number of people recruited within each category, the method of recruitment and the percentage completing all 4 pairs of recalls are given in Tables 1 and 2.

5.7.1 Numbers recruited by Recruitment Company and numbers recruited by Research Team

Table 3: Details of recruitment quotas, method of recruitment and percentage completion – 11-16 year olds

	Category	Suggested quotas	Number Recruited	Location†		Recruited by		Completed (%)	
				NE	Scot	IPSOS	HNRC	IPSOS	HNRC
Age	11-12	Min 15	18	6	12	3	15	0.0	83
	13-14	Min 15	26	5	21	2	24	0.0	54
	15-16	Min 15	30	7	23	4	26	0.0	53
Gender	Male	Min 25	44	1	43	2	42	0.0	36
	Female	Min 25	30	17	13	7	23	0.0	97

Ethnicity	White	47-50	68	15	53	9	59	0.0	63
	Non-white	8-11	6	3	3	0	6	0.0	50

† **NE= Newcastle upon Tyne; Scot= Scotland**

The Newcastle research team recruited one school in Scotland with the aim of recruiting the majority of the younger age group through the school. This was agreed with IPSOS-MORI as it would make data collection more time and cost-efficient. IPSOS-MORI were asked to recruit the remainder of participants to complete the quotas for children from rural areas, SIMD, ethnic minority groups etc. A further 9 participants were recruited by the recruitment company however, as we were not provided with copies of the consent forms with parental consent we were not able to get in contact with them. As a result the Newcastle team recruited one further school, in Newcastle, to recruit additional participants.

Table 4: Details of recruitment quotas, method of recruitment and percentage completion – 17-24 year olds

	Category	**Suggested quotas**	**Number Recruited**	**Location†**		**Recruited by**		**Completed (%)**	
				NE	**SCOT**	**IPSOS**	**HNRC**	**IPSOS**	**HNRC**
Age	17-18	Min 35	61	7	54	46	15	22	100
	19-21	Min 35	81	11	70	64	17	25	77
	22-24	Min 35	73	32	41	40	33	30	97
	Missing		2	1	1	1	1	0.0	0.0
Gender	Male	Min 52	103	20	83	75	28	35	89
	Female	Min 52	114	31	83	76	38	20	92
Economic status	HE/FE	Max 40	78	0	78	69	9	42	89
	Working	Min 40	81	39	42	42	39	19	95
	Unemployed	Min 15	24	5	19	19	5	21	80
	At school	Min 12	10	5	5	0	10	0	100
	Looking after home/family	Min 8	10	2	8	8	2	0	50
	Missing		14	0	14	13	1	0.0	0.0
Ethnicity	White	Min 100	202	51	151	137	65	26	91
	Non-white	Min 15	15	0	15	14	1	36	100

† **NE= Newcastle upon Tyne; Scot= Scotland**

Of 148 17-24 year old contacts supplied by the recruitment company we were successful in arranging to visit just 58 people, 19 dropped out when initial contact was made by phone or email and the remainder (n=71) did not respond to telephone calls, emails or texts. This might be due to the method of recruitment, as potential participants were stopped on the street and asked to participate. People may find it difficult to refuse a request face-to-face but be more comfortable ignoring contact via phone, email and text. Of the participants who dropped out at initial contact it seemed many were not fully aware of what involvement in the study would entail.

The Newcastle team recruited an additional 39 participants aged 17-24 years through posters, asking participants to encourage others to take part and email advertisements for the study in order to boost numbers in specific quotas.

5.7.2 Demographics of participants

Table 5: Demographics of study participants – 11-16 year olds

Characteristic	Category	Suggested quotas	Number Recruited	Numbers completing 3+ matching recalls		Numbers completing 4 matching recalls	
				n	%	N	%
Age	11-12	Min 15	18	15	83	15	83
	13-14	Min 15	26	15	58	14	54
	15-16	Min 15	30	18	60	16	53
Gender	Male	Min 25	44	18	41	16	36
	Female	Min 25	30	30	100	29	97
Ethnicity	White	47-50	68	45	66	43	63
	Non-white	8-11	6	3	50	3	50
SIMD*	SIMD 1	Min 8	25	23	92	23	92
	SIMD 2	Min 8	9	9	100	9	100
	SIMD 3	Min 8	7	6	86	5	71
	SIMD 4	Min 8	5	5	100	5	100
	SIMD 5	Min 8	7	7	100	7	100
Total			74	48	65	45	61

*For a number of participants SIMD was not available. This was due to participants living in new housing or Newcastle.

The aim was to recruit 58 pupils aged 11-16 years and for 47 to complete the study (based on a drop-out rate of 20%). A higher dropout rate than anticipated (around 35%) was seen and so in order to achieve 47 completing the study we needed to recruit 74 participants. Of the 48 students who completed 4 face-to-face recalls and 4 recalls using INTAKE24 3 completed INTAKE24 on the wrong day. We therefore had 45 participants who completed 4 matching recalls both using INTAKE24 and face-to-face. Pupils were recruited at school and, with the exception of a small number of recalls conducted on Saturday or Sunday they completed both the interviewer led recall and INTAKE24 (un-aided) at school during school time. This is reflected in the higher completion rate when compared with the older age group. Interestingly in this age group we recruited more males than females however the difference in the completion rates between the two genders is striking with only 36% of male participants completing 4 matching sets of recalls compared with 97% of the female. participants. This gender difference has been seen in other studies. Martin et al (2009), in a feeding study to validate digital photography as a method of assessing food intake, found a higher completion rate for women than for men in both the main study (54% vs 46%) and pilot study (79% vs 21%). In a study comparing a paper based pain diary with an e-diary Palermo *et al.*(2004) also found girls demonstrated higher diary completion rates than boys[11] and in a study looking at outpatient compliance with a stress reduction programme females were found to be more than twice as likely to complete the programme than males[12].

The aim was to recruit equal numbers across the quintiles of SIMD. In practice we over recruited those from a more deprived area. A small number (n=13) of 11-16 year olds were recruited through a school in Newcastle and therefore SIMD was unavailable, Heaton Manor school was selected which is a large school covering both affluent and deprived areas of Newcastle. In addition, SIMD information was not available from participants living in new housing (n=8).

Table 6: Demographics of study participants – 17-24 year olds

Characteristic	Category	Suggested quotas	Actual Recruitment	Numbers completing 3+ matching recalls		Numbers completing 4 matching recalls	
				n	%	n	%
Age	17-18	Min 35	61	25	41	22	36
	19-21	Min 35	81	34	42	28	35
	22-24	Min 35	73	42	58	34	47
	missing		2				
Gender	Male	Min 52	103	51	50	40	39
	Female	Min 52	114	50	44	44	39
Economic	HE/FE	Max 40	78	37	47	30	38
status	Working	Min 40	81	45	56	35	43
	Unemployed	Min 15	24	8	33	8	33
	At school	Min 12	10	10	100	10	100
	Looking after home/family	Min 8	10	1	10	1	10
	missing		14				
Ethnicity	White	Min 100	202	95	47	80	40
	Non-white	Min 15	15	6	40	4	27
Total			217	101	47	84	39

The aim was to recruit 122 17-24 year olds in order for 101 to complete the study. A vastly higher dropout rate was seen than originally anticipated with only 25% of the subjects recruited completing the study. This is likely to be due to the difficulties in contacting many of the recruits. More than half of the recruits did not answer phone calls, text messages or emails or hung up the phone or refused to participate when we called them to arrange a meeting for the first interview. In addition some of the contact details supplied were invalid. In order to achieve the target of 101 participants completing the study it was necessary to recruit 337 participants, more than double the number estimated. A number of participants dropped out on initial contact complaining that the £30 incentive wasn't enough. This highlights the balance between the cost of offering a significant incentive against the increased time and effort in recruiting and retaining a representative study sample. The unemployed and looking after family demographic proved the hardest to recruit and retain,

as evidenced by the low completion rate in these two groups. 17 individuals completed INTAKE24 for the wrong day on one or more occasion. These individuals completed a recall using INTAKE24 at least 4 times (indeed some participants completed INTAKE24 7 times) but one or more days recalled did not match the day recalled in the telephone interview.

5.8 Matches, Omissions and Intrusions

Table 7: Matches, omissions and intrusions of all foods in INTAKE24 compared with Interviewer led recall.

	All Participants	11-16 year olds	17-24 year olds
Exact Matches %	80.9	79.2	82.6
Approximate Matches %	1.3	1.5	1.1
Intrusions %	7.1	6.7	7.5
Omissions %	10.7	12.5	9.0

Of all foods participants reported using INTAKE24 81% were an exact match to the food reported in the Interviewer led recall and a further 1.3% were an approximate match, giving an over-all match rate of 82%. Of the foods reported in the Interviewer led recall 11% were not reported using INTAKE24 and so were classified as omissions. The intrusion rate of less than 7% was relatively low. The level of matches, omissions and intrusions were similar for the two age groups.

Table 8: Type of omissions from INTAKE24

Food type	Percentage of omitted Foods All participants	Percentage of omitted foods 11-16 year olds	Percentage of omitted foods 17-24 year olds
Bread/ cereal	14.9	10.6	19.8
Drinks	14.9	16.7	12.8
Vegetables	13.4	17.3	9.1
Meat/meat dishes	9.1	8.3	9.9
Sauces	9.1	11.3	6.8
Dairy	8.8	7.3	10.5
Sweets	7.5	5.8	9.3
Spread	6.6	5.2	8
Fruit	5.6	6.2	4.9
Chips/ crisps	3.3	2.1	4.5
Sugar	2.3	3	1.4
Alcohol	1.9	3.2	0.6
Fish	1.2	1.7	0.6
Legumes	0.5	0.4	0.6
Soup	0.5	0.6	0.4
Nuts	0.5	0.7	0.2
Egg	0.1	0.1	0
Herbs	0.1	0.1	0.2

There was no clear pattern to the types of foods commonly omitted, which included drinks (15% of omissions), bread/cereal (15% of omissions), vegetables (13% of omissions), meat/meat dishes (9% of omissions) and sauces (9% of omissions). The large percentage of omissions for bread/cereals was unexpected and stood out early on in data collection. This was identified as being due to a search for ‘cereal’ returning ‘milk on cereal’ as one of the food items. Participants who selected this often failed to go back and add in the cereal itself.

The search function on the system was refined as soon as the problem was identified (in the middle of data collection) so that 'milk on cereal' was returned only when the word 'milk' was included in the search term.

5.9 Accuracy and precision of reported nutrient intakes

Table 9: Accuracy and Precision of nutrient intakes – All Participants (completing any number of days n=167)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Energy (kJ)	7695.7	7777.7	0.99	0.51	1.92
Carbohydrate (g)	247.5	249.1	1.00	0.51	1.95
NSP (g)	11.9	11.8	1.00	0.46	2.18
Fat (g)	68.3	68.2	0.97	0.43	2.20
Fat (%)	31.9	32.6	0.98	0.60	1.61
Saturated Fat (g)	25.4	25.5	0.97	0.38	2.48
Protein (g)	65.5	64.5	1.01	0.43	2.37
NMES (g)	85.6	88.0	0.89	0.21	3.80
NMES (%)	19.0	18.2	1.02	0.25	4.12
Alcohol (g)	3.3	6.0	1.00	0.12	8.20
Vitamin C (mg)	112.5	105.8	1.04	0.23	4.74
Iron (mg)	9.6	9.7	0.98	0.44	2.20
Calcium (mg)	813.7	796.2	1.02	0.43	2.41

Mean intakes reported using INTAKE24 were very close to the intakes reported during the Interviewer led recall for energy and the macronutrients, with the exception of alcohol. Interrogation of the data found that this difference was in large part due to one individual who consumed a large amount of whiskey which was reported in the Interviewer led recall but omitted from INTAKE24. This individual was not excluded from the analysis.

The mean ratio is the intake of the nutrient reported using INTAKE24 divided by the intake of that nutrient reported during the Interviewer led recall, therefore a value of 1 would indicate an exact match. Limits of agreement indicate the lower and upper limits within which 95% of the differences will lie. Considering both age groups together INTAKE24 was found to under-

estimate energy intake by just 1% on average with the limits of agreement ranging from an under-estimate of 49% to an over-estimate of 92% compared with the Interviewer led recall. Mean intakes of all macronutrients and micronutrients were within 4% of the Interviewer led recall with the exception of NMES which was under-estimated by 11% using INTAKE24 compared with the Interviewer led recall. Our study sample consumed a large amount of high sugar drinks and these were one of the most commonly omitted items. In addition, initially the search option of 'cereal' would return 'milk on cereal'. So participants often added the milk they had on cereal, but forgot to add their breakfast cereal. This was corrected part way through data collection and is likely to have led to the under-estimation of NMES.

Table 10: Accuracy and Precision of nutrient intakes – 11-16 year olds (completing any number of days n=52)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Energy (kJ)	7023.7	7152.5	0.97	0.52	1.82
Carbohydrate (g)	249.1	248.9	0.99	0.52	1.88
NSP (g)	9.8	10.2	0.94	0.45	1.98
Fat (g)	56.4	59.1	0.92	0.43	1.96
Fat (%)	30.0	31.2	0.95	0.63	1.42
Saturated Fat (g)	21.8	23.0	0.92	0.39	2.17
Protein (g)	55.6	55.8	0.99	0.47	2.11
NMES (g)	102.9	96.3	0.95	0.25	3.61
NMES (%)	23.9	21.9	1.10	0.32	3.75
Alcohol (g)	0.2	1.2	1.07	0.33	3.48
Vitamin C (mg)	132.3	121.8	1.09	0.44	2.71
Iron (mg)	8.8	8.8	0.98	0.45	2.11
Calcium (mg)	802.4	785.9	1.00	0.46	2.18

For the younger age group there was a slight tendency to under-estimate intake of energy and macronutrients on average compared with the Interviewer led recall. Energy intake was under-estimated by 3%, carbohydrate by 1%, fat and saturated fat by 8% and protein by 1% on average. Intakes of alcohol and vitamin C were slightly overestimated on average by 7% and 9% respectively. The limits of agreement for energy were from an under-estimate of 48% to an over-estimate of 82%. The widest limits of agreement for this age group were for

NMES which ranged from an under-estimate of 75% to an over-estimate of 261% (compared with the interviewer led recall), this is likely to be related to the omissions from INTAKE24 (food/ drink that was recorded in the interviewer led recall but omitted in INTAKE24) of sugary drinks, breakfast cereals and sweets. Our sample were high consumers of these foods with the 11-16 year old group collectively reporting having 84kg of sugary drinks (just under 430ml per person per day, on average), 11kg of sweets, chocolate and biscuits and 1.8kg of high sugar breakfast cereals using INTAKE24 over a total of 196 recording days.

Table 11: Accuracy and Precision of nutrient intakes – 17-24 year olds (completing any number of days n=115)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Energy (kJ)	8014.6	8074.4	0.99	0.50	1.97
Carbohydrate (g)	246.8	249.1	1.01	0.51	1.99
NSP (g)	12.9	12.6	1.02	0.46	2.27
Fat (g)	73.9	72.5	0.99	0.43	2.31
Fat (%)	32.8	33.3	1.00	0.58	1.70
Saturated Fat (g)	27.1	26.7	0.99	0.38	2.62
Protein (g)	70.2	68.6	1.02	0.42	2.50
NMES[2] (g)	77.4	84.1	0.86	0.19	3.87
NMES (%)	16.7	16.5	0.98	0.23	4.25
Alcohol (g)	4.8	8.3	0.97	0.09	10.91
Vitamin C (mg)	103.2	98.2	1.02	0.18	5.75
Iron (mg)	10.0	10.1	0.99	0.43	2.24
Calcium (mg)	819.1	801.1	1.03	0.42	2.53

For the older age group there was no clear tendency toward under-estimation or over-estimation. Mean intakes reported using INTAKE24 were very close to those reported during the interviewer led recall for all nutrients except for alcohol and NMES which were both slightly higher in the Interviewer led recall. Examining the mean ratios energy intake was found to be under-estimated by just 1%, fat by 1%, NMES by 14% (again this is likely to reflect the high consumption and high omission rate for sugary drinks), alcohol by 3% and iron by 1%. Intakes of carbohydrate, protein, vitamin C and calcium were slightly over-estimated by 1%, 2%, 2% and 3% respectively. The limits of agreement for energy were

from an under-estimate of 50% to an over-estimate of 97%. The widest limits of agreement for this age group were for alcohol which was in large part due to one individual who reported consuming a large amount of whiskey in the Interviewer led recall but not when completing INTAKE24. The limits of agreement for fat were also relatively wide. One participant added 90ml olive oil and 90gr coconut oil to his cup of tea in the morning, so he ‘drank ‘ olive oil and coconut oil and reported the amount consumed to be much greater using INTAKE24 than he did during the interviewer led recall. However, as this is not usual practice, it is not possible to estimate the portion size of olive oil and coconut oil as a drink in INTAKE24, instead spoonfuls are used. This might have contributed to these wide limits of agreement. The 17-24 year olds collectively reported having 121kg of sugary drinks (just under 300ml per person per day, on average), 25kg of sweets, chocolate and biscuits and 3.4kg of high sugar breakfast cereals using INTAKE24 over a total of 413 recording days.

5.10 Accuracy and precision of reported intakes by food group

Table 12: Accuracy and Precision of intakes by food group – All Participants (completing any number of days n=167)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Cereals and cereal products	101.1	112.5	0.82	0.18	3.69
Starchy Carbohydrates	176.2	162.9	1.06	0.27	4.12
Milk and milk products	203.7	184.9	1.04	0.11	9.92
Eggs and egg dishes	9.3	11.6	0.95	0.20	4.53
Fat spreads	5.5	7.2	0.74	0.05	11.13
Meat and meat products	118.0	110.7	0.99	0.22	4.40
Fish (non-oily) and fish dishes	14.6	14.2	1.01	0.10	10.01
Oily fish	2.6	2.5	1.01	0.83	1.22
Vegetables, excluding potatoes	69.6	68.0	0.87	0.04	17.59
Savoury snacks	17.4	18.7	0.87	0.14	5.35
Nuts and seeds	5.0	5.8	0.98	0.35	2.76
Fruit	208.8	205.6	0.82	0.04	18.81
Cakes, biscuits, Pastries, Sugar preserves and confectionery	63.6	65.6	1.01	0.23	4.42
Non-alcoholic beverages	1227.7	1160.9	1.00	0.24	4.20
Alcoholic beverages	64.5	93.4	0.79	0.06	9.99
Miscellaneous	42.6	43.5	0.91	0.03	32.82

Table 13: Accuracy and Precision of intakes by food group – 11-16 year olds (completing any number of days n=52)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Cereals and cereal products	94.4	114.7	0.71	0.10	5.27
Starchy Carbohydrates	158.8	143.5	1.12	0.42	3.00
Milk and milk products	252.5	198.2	1.22	0.42	3.52
Eggs and egg dishes	4.3	4.6	0.91	0.24	3.47
Fat spreads	3.8	5.7	0.70	0.10	4.73
Meat and meat products	103.4	101.6	0.89	0.09	9.02
Fish (non-oily) and fish dishes	12.1	12.6	0.97	0.10	9.67
Oily fish	0.0	0.0	1.00	1.00	1.00
Vegetables, excluding potatoes	34.0	39.5	0.68	0.01	30.63
Savoury snacks	22.5	26.5	0.79	0.15	4.18
Nuts and seeds	0.2	0.2	0.99	0.24	4.09
Fruit	257.9	234.9	0.76	0.01	45.17
Cakes, biscuits, Pastries, Sugar preserves and confectionery	60.7	64.6	0.81	0.19	3.44
Non-alcoholic beverages	963.6	810.4	0.99	0.09	11.25
Alcoholic beverages	0.5	8.7	0.83	0.09	8.01
Miscellaneous	22.2	24.4	0.84	0.01	58.55

Table 14: Accuracy and Precision of intakes by food group – 17-24 year olds (completing any number of days n=115)

	INTAKE24 Mean	Interview Mean	Mean Ratio	Limits of Agreement	
				Lower	Upper
Cereals and cereal products	104.2	111.6	0.88	0.27	2.91
Starchy Carbohydrates	184.0	171.7	1.04	0.23	4.61
Milk and milk products	181.8	178.9	0.97	0.07	13.18
Eggs and egg dishes	11.5	14.7	0.97	0.19	5.08
Fat spreads	6.3	7.9	0.76	0.04	15.36
Meat and meat products	124.6	114.8	1.04	0.42	2.58
Fish (non-oily) and fish dishes	15.7	14.9	1.03	0.10	10.25
Oily fish	3.7	3.5	1.01	0.81	1.27
Vegetables, excluding potatoes	85.6	80.8	0.97	0.07	12.53
Savoury snacks	15.0	15.2	0.90	0.14	5.95
Nuts and seeds	7.2	8.3	0.98	0.43	2.21
Fruit	186.8	192.4	0.86	0.06	11.57
Cakes, biscuits, Pastries, Sugar preserves and confectionery	64.9	66.1	1.11	0.26	4.77
Non-alcoholic beverages	1346.1	1318.0	1.00	0.54	1.86
Alcoholic beverages	93.2	131.3	0.78	0.05	11.02
Miscellaneous	51.8	52.0	0.95	0.04	24.66

The results of the comparison study in terms of food groups are disappointing with accuracy for some food groups being poor and wide limits of agreement indicating poor precision for almost all food groups. There is a tendency for intakes of cereal to be under-estimated which may, in part, reflect the issues with cereal on milk. The log transformed data show there was a tendency for participants to under-estimate their intake of fruit on average, however the raw gram weights reported are very similar indicating the values are skewed by a small number of individuals greatly over-estimating their intake. Intakes of fat spreads also tended to be under-estimated. This may be due to individuals forgetting or being unclear how to multiply the amount of fat spread on bread by the number of slices. Something the trained

interviewer would pick up on in the in person interview. Alcohol also tended to be under-estimated. Intakes of alcohol pose a particular difficulty due to the effects of alcohol on memory. It may be that verbalising their intake to the interviewer aids memory of the number of drinks consumed. Starchy carbohydrates and milk were the only food groups which showed a tendency toward over-estimation, particularly by the younger age group. This may be related to the difference in the way chips are estimated in INTAKE24 compared with the food atlas. A wider range of different types of chips including takeaway chips were added to the online system but do not feature in the food atlas.

The foods groups Meat and meat products, Fish and fish dishes, Oily fish, Nuts and seeds, Cakes, biscuits, pastries, sugar, preserves and confectionery and Non-alcoholic beverages were reported with reasonable accuracy however the limits of agreement were still wide.

The poor accuracy and precision for food groups is likely to reflect the level of omissions and intrusions. On average 11% of foods reported in the Interviewer led recall were omitted from the INTAKE24 recall and 7% of the foods reported in INTAKE24 were classified as intrusions. These errors will have a greater impact on the food group data compared with the nutrient data. Five people had a large number of both omissions and intrusions accounting for more than 50% of the foods reported. For one individual intrusions and omissions accounted for 76% of the foods reported. This results in the very wide limits of agreement. These people appeared to have reported completely different foods for at least one meal in INTAKE24 compared with the interviewer led recall. It is possible that they were recalling a meal from a different day. It may be that completing INTAKE24 during the day as a record rather than a recall overcomes some of these issues.

5.11 Agreement on ranking of nutrient intakes by INTAKE24 and interviewer-led recalls

Table 15: Agreement on ranking of nutrient intakes into tertiles of intake – All participants n=167

Nutrient	Same	Adjacent	Extreme	Kappa	Agreement	p
Energy	68%	29%	3%	0.515	Moderate	<0.001
Protein	64%	32%	5%	0.453	Moderate	<0.001
Fat	65%	33%	3%	0.470	Moderate	<0.001
Carbohydrate	69%	29%	2%	0.539	Moderate	<0.001
NMES	76%	23%	1%	0.638	Good	<0.001
Alcohol	98%	2%	0%	0.915	Very Good	<0.001
Vitamin C	79%	20%	1%	0.682	Good	<0.001
Calcium	66%	31%	3%	0.493	Moderate	<0.001
Iron	68%	28%	3%	0.522	Moderate	<0.001

The percentage agreement between the two methods was good with percentage classified into the same tertile ranging from 64% for protein to 98% for alcohol. The percentage classified into opposite tertiles was low, ranging from 5% for protein to 0% for alcohol. The strength of agreement using kappa ranges from poor to very good (<0.20 = poor, 02.1-0.40 = fair, 0.41-0.60 = moderate, 0.61-0.80 = good and 0.81-1.00 = very good). Agreement was rated as moderate or above for all nutrients.

Table 16: Agreement of ranking of intakes of key food groups into tertiles of intake – All participants n=167

Food Group	Same	Adjacent	Furthest	Kappa	Agreement	p
Cereals and cereal products	67%	32%	1%	0.500	Moderate	<0.001
Starchy Carbohydrates	71%	25%	4%	0.571	Moderate	<0.001
Milk and milk products	77%	21%	2%	0.652	Good	<0.001
Eggs and egg dishes	98%	2%	0%	0.953	Very Good	<0.001
Fat spreads	70%	27%	3%	0.545	Moderate	<0.001
Meat and meat products	74%	25%	1%	0.616	Good	<0.001
Fish (non-oily) and fish dishes	92%	5%	3%	0.844	Very Good	<0.001
Oily fish	100%	0%	0%	1.000	Very Good	<0.001
Vegetables, excluding potatoes	76%	23%	1%	0.643	Good	<0.001
Savoury snacks	83%	17%	1%	0.741	Good	<0.001
Nuts and seeds	99%	1%	0%	0.953	Very Good	<0.001
Fruit	83%	15%	2%	0.741	Good	<0.001
Cakes, biscuits, pastries, sugar preserves and confectionery	73%	26%	1%	0.589	Moderate	<0.001
Non-alcoholic beverages	65%	32%	2%	0.482	Moderate	<0.001
Alcoholic beverages	98%	2%	0%	0.938		<0.001
Miscellaneous	72%	24%	4%	0.580	Moderate	<0.001

For food groups the percentage classified into the same tertile by INTAKE24 and the interviewer-led recall was high ranging from 65% for non-alcoholic beverages to 100% for oily fish. A higher percentage agreement tended to be seen for those foods which are less commonly consumed, such as oily fish, eggs and nuts and seeds. Interestingly alcohol also showed a very high level of agreement with 98% being classified in the same tertile of intake. These 4 food groups all achieved a very good' level of agreement as assessed by the kappa statistic. Again agreement was rated as moderate or above for all food groups.

No differences in the ability of INTAKE24 to rank intakes was seen by age of respondent (See Appendix 6).

5.12 Daily energy intake (mean of 4 days) compared with NDNS

Table 17: Average daily intake of energy and macronutrients reported using INTAKE24 compared with National Diet and Nutrition Survey values

	NDNS[13] 11-18yrs	INTAKE24 11-16yr	Ratio (INTAKE24/ NDNS)	NDNS[13] 19-64yr	INTAKE24 17-24yr	Ratio (INTAKE24/ NDNS)
MALES						
Energy Kcal						
Mean	2007	1788.6	0.89	2200	2117.5	0.96
SD	508	609.9		706	734.3	
Carbohydrate g						
Mean	268	268.3	1.00	255	259.2	1.02
SD	70	101.3		81	89.6	
NSP (g)						
Mean	12.7	14.5	1.14	14.9	14.7	0.99
SD	4.2	5.8		5.6	7.9	
Fat g						
Mean	75.6	57.8	0.77	80.8	86.2	1.07
SD	23.0	22.1		30.5	57.1	
Fat (%)						
Mean	33.7	29.1	0.86	33.0	35.2	1.07
SD	4.7	5.3		7.1	9.5	
Saturated Fat g						
Mean	28.3	23.8	0.84	29.6	30.7	1.04
SD	9.9	11.6		12.8	16.2	
Protein g						
Mean	73.7	65.2	0.89	88.1	81.2	0.92
SD	20.7	21.9		35.7	33.6	
NMES g						
Mean	85.6	100.4	1.17	71.8	77.3	1.08
SD	41.0	55.5		44.4	49.1	
NMES (%)						
Mean	15.8	21.6	1.37	11.9	14.8	1.24
SD	6.0	7.3		5.6	8.3	
Alcohol g						
Mean	3.5	0.0	N/A	23.7	6.2	0.26
SD	13.7	0.0		42.5	11.0	
FEMALES						
Energy Kcal						
Mean	1637	1599.8	0.98	1638	1698.8	1.04
SD	413	569.6		477	514.4	

Carbohydrate g						
Mean	220.0	237.6	1.08	200.0	235.1	1.18
SD	58.0	80.5		63	75.7	
NSP (g)						
Mean	10.9	14.0	1.28	12.8	17.3	1.35
SD	3.5	4.6		4.5	9.3	
Fat g						
Mean	63.1	55.9	0.89	61.0	61.9	1.02
SD	19.4	27.8		24.0	27.2	
Fat (%)						
Mean	34.3	30.8	0.90	32.9	32.0	0.97
SD	5.1	4.8		6.8	6.5	
Saturated Fat g						
Mean	22.9	21.2	0.93	22.4	23.3	1.04
SD	7.8	11.2		10.0	11.6	
Protein g						
Mean	57.3	50.9	0.89	65.4	60.4	0.92
SD	14.9	16.7		18.1	13.5	
NMES g						
Mean	67.1	101.3	1.51	52.4	77.5	1.48
SD	35.9	44.9		38.6	43.3	
NMES (%)						
Mean	15.1	24.9	1.65	11.6	17.9	1.54
SD	6.3	6.6		6.5	7.5	
Alcohol g						
Mean	2.2	0.3	0.14	10.9	2.6	0.24
SD	8.3	1.4		16.3	5.7	

For all participants who completed 4 recalls using INTAKE24 the mean daily intake of energy, macronutrients and key micronutrients were calculated. A comparison of the mean intakes with those reported in the National Diet and Nutrition Survey Rolling programme year 1, 2 and 3 headline results[13]. The NDNS rolling programme uses a 4-day estimated weight food diary with an interview mid-way through the diary period as well as at the end with the participant (on day 5) to collect any missing information on the foods. A small number of food photographs are included in the diary to aid portion size estimation and for all other foods participants are asked to record the amount consumed using household measures and weights from labels. The younger age group reported comparable intakes of carbohydrate, comparable intakes of energy for the females but lower intakes of energy for the males. Reported intakes of fat, protein and alcohol were low compared with the national data and intakes of NMES and NSP were high. For the older males reported intakes of energy, carbohydrate, fat, protein and NSP were all similar to levels reported in the national survey, reported intakes of NMES were slightly higher and alcohol slightly lower. For the females

reported intakes of energy and fat were similar but intakes of carbohydrate, NMES and NSP were higher and intakes of protein and alcohol slightly lower.

Table 18: Average daily intake of micronutrients reported using INTAKE24 compared with National Diet and Nutrition Survey values

	NDNS[13] 11-18yr	INTAKE24 11-16yr	Ratio (INTAKE24 /NDNS)	NDNS[13] 19-64yr	INTAKE24 17-24yr	Ratio (INTAKE24 /NDNS)
MALES						
Vitamin C (mg)						
Mean	89.7	131.7	1.47	91.4	101.5	1.11
SD	65.1	124.4		71.5	66.8	
Iron (mg)						
Mean	10.8	9.9	0.92	12.0	10.3	0.86
SD	3.3	3.6		4.4	4.4	
Calcium (mg)						
Mean	869.0	1020.7	1.18	921.0	920.8	1.00
SD	317 .0	468.8		347.0	365.5	
FEMALES						
Vitamin C (mg)						
Mean	79.0	136.8	1.73	87.6	110.4	1.26
SD	52.2	83.7		66.7	72.3	
Iron (mg)						
Mean	8.6	8.3	0.97	9.8	9.6	0.98
SD	2.7	3.1		3.0	3.5	
Calcium (mg)						
Mean	696.0	690.7	0.99	740.0	739.0	1.00
SD	248.0	284.1		254.0	222.4	

Reported intakes of vitamin C by participants in this study were high in comparison with the NDNS values. This may reflect the tendency for participants to report a higher intake of starchy carbohydrates using INTAKE24, the main contributors to this group were chips and potatoes of which 26kg were consumed. Reported Intakes of Iron and Calcium were very similar to the values reported in the rolling programme with the exception of calcium intake in the 11 to 16 year olds. This may be due to slight differences in the age group or could be due to differences in the way portion size for milk on cereal is reported in each survey (although this would be expected to impact on all groups). Estimation in INTAKE24 is using an image of a bowl with increments for the respondent to indicate the fill level, this may tend to over-estimate the amount of milk slightly as no allowance is made for the volume taken up

by the cereal in the bowl. In the rolling programme participants are asked to indicate the amount of milk on their cereal by saying whether it was damp, normal or drowned.

5.13 Energy under-reporting

Body weight was available for 30 of the 11-16 year olds and 60 of the 17-24 year olds who completed 4 recalls using INTAKE24. Schofield equations[7] were used to calculate BMR for these individuals and the ratio of energy intake to basal metabolic rate was calculated (EI:BMR) the results are shown in tables 12 and 13.

Table 19: Energy intake to BMR ratios for 17-24 year olds – A comparison of low energy reporting using INTAKE24 with NDNS data.

	NDNS[8]		INTAKE24	
EI:BMR	**Men 16-64 years**	**Women 16-64 years**	**Males 17-24 years**	**Females 17-24 years**
	cum %	cum %	cum %	cum %
Less than 1.0	13	26	35	36
Less than 1.2	30	47	50	53
Less than 1.4	51	71	68	81
Less than 1.6	73	87	88	92
Mean	1.39	1.22	1.19	1.19
SEM	0.01	0.01	0.08	0.06

For the older age group the percentage of individuals with an EI:BMR below 1.0 x BMR, 1.2 x BMR, 1.4 x BMR and 1.6 x BMR was calculated for comparison with the levels seen in the NDNS survey of British Adults[8] (as the report on under-reporting in the NDNS rolling programme has not yet been published). A higher proportion of low energy reporters was seen using INTAKE24. This was particularly evident in the males (n=29) where the mean EI:BMR was lower.

Table 20: Proportion of participants aged 11-16 identified as under-reporting energy intake using the Torun cut off – comparison with NDNS data

	NDNS[10]				INTAKE24	
	Males		Females		Males	Females
	11-14	15-18	11-14	15-18	11-16	11-16
% Under-reporters	54%	64%	52%	74%	83%	66%

For the younger age group the Torun cut-off[9] was used to identify under-reporters for comparison with the levels of under-reporting seen in the NDNS survey of young people aged 4 to 16 years. The Torun cut off was developed for 6 to 18 year olds and is based on a large number of studies on total energy expenditure, growth and habitual activity pattern of children and adolescents using either doubly-labelled water or heart-rate monitoring.

A high proportion of under-reporters were identified using the Torun cut off for intakes collected using INTAKE24 in comparison with the NDNS data. This is disappointing as it was hoped that the lower burden of the online 24hr recall with estimated portion size compared with the 7 day weighed intake method used in the NDNS study would result in lower levels of under-reporting and higher completion and participation rates. It should be noted that mean energy intake reported during the interviewer led recall was only slightly higher meaning the participants under-reported intake in the interviewer led recall to a similar extent.

6. Discussion

6.1 Accuracy and precision of INTAKE24 compared with other established methods of assessing dietary intake of adults and children

Table 21 – Accuracy and precision of dietary assessment methods with adults

Reference	Method of assessment	Study population	Method of validation	Accuracy / precision*
Conway et al. (2004) [14]	USDA MP24hr recall	Adult males n=45	Subjects fed known amounts of food	Energy over-estimated by 7% on average. Limits of agreement from -10% to +27% (width 37)
Carter et al. (2013)[15]	7 day recorded intake MyMealMate	Adults n=50	Nutritionist conducted 24hr recall	Energy under-estimated by 2% on average. Limits of agreement from 29% to + 24% (width 53)
Martin et al. (2009) [16]	Digital photography of foods portion size estimates made by researchers	Adults n=52	Feeding study volunteers provided with pre-weighed portions. Researchers weighed leftovers.	Energy under-estimated by 7% on average. Limits of agreement from -53% to +17.5% (width 71)
Blanton et al. (2006) [17]	USDA AMPM MP24hr recall	'Highly motivated women' (Adults) n=20	Doubly Labelled Water	Energy estimates within 4% of actual Limits of agreement from -39% to +45% (width 84)
Present study	INTAKE24	Adults aged 17-24 years n=115	Nutritionist conducted 24hr recall later the same day	Energy intake under-estimated on average by 1%. Limits of agreement from -50% to +97% (width 147)
Beasley et al. (2005)[18]	3 day PDA-based food record DietMatePro	Adults n=39	Nutritionist conducted 24hr recall	Energy under-estimated by 3% on average. Limits of agreement from – 77% to + 92% (width 169)

Table 22 – Accuracy and precision of dietary assessment methods with children

Reference	Method of assessment	Study population	Method of validation	Accuracy / precision*
Vereecken et al. 2008 [19]	YANA-C computerised 24hr recall	Children aged 11-14 years n=236	Dietitian conducted 24hr recall later the same day	Energy under-estimated by 3% on average Limits of agreement from -46% to +41% (width 87)
Present study	INTAKE24	Children aged 11-16 years n=52	Nutritionist conducted 24hr recall later the same day	Energy intake under-estimated on average by 3%. Limits of agreement from -48% to +82% (width 130)
Lietz et al. (2002) [20]	EPIC FFQ	Children aged 12 years. n= 37	7-day weighed intake	EPIC over-estimated energy intake by 30% on average. Limits of agreement from 46% to +92% (width 138)
Vereecken et al. (2005) [21]	YANA-C computerised 24hr recall	Children aged 11-14 n=237	1-day estimated weight food record.	Energy over-estimated by 13% on average. Limits of agreement from -60% to +87%.(width 147)

* Limits of agreement have been calculated from mean difference and SD or mean ratio and SD or have been taken from the limits of agreement presented on a Bland-Altman plot so may not be exact.

Table 21 and Table 22 show the accuracy and precision of INTAKE24 and how this compares with other established methods of assessing dietary intake with both adults and children. The tables are ordered by the width of the limits of agreement (precision) of the method.

INTAKE24 was found to under-estimate energy intake by just 1% on average compared with the Interviewer led recall in the 17-24 year old group. The limits of agreement for energy intake ranged from an under-estimate of 50% of energy intake to an over-estimate of 92%. For the younger age group (11-16 year olds) energy intake was under-estimated by 3% on average with limits of agreement from -48% to +82%. The accuracy of INTAKE24 compares favourably with other methods of dietary assessment in both adults and children although the precision of the system is slightly lower, particularly for adult participants, as seen by the relatively wide limits of agreement.

Of the studies quoted here only Lietz et al. (2002) excluded low-energy reporters from their data.

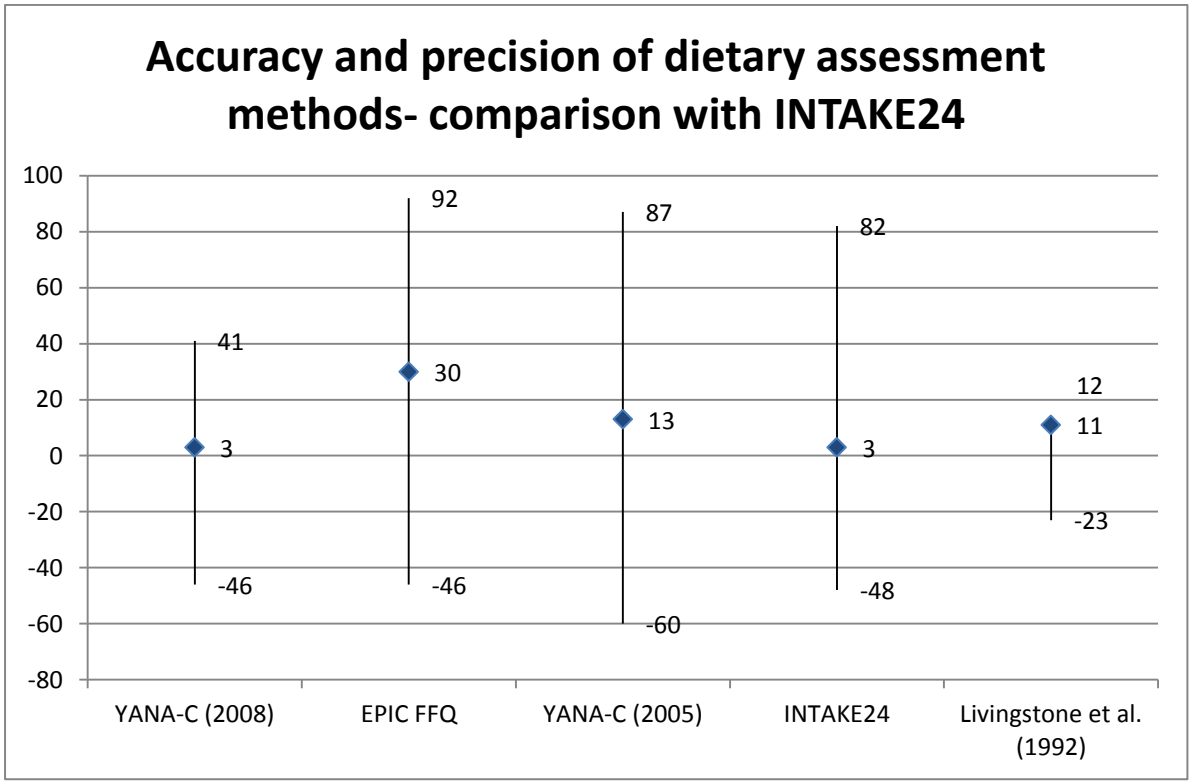

Figure 1: Accuracy and Precision of dietary assessment methods with children

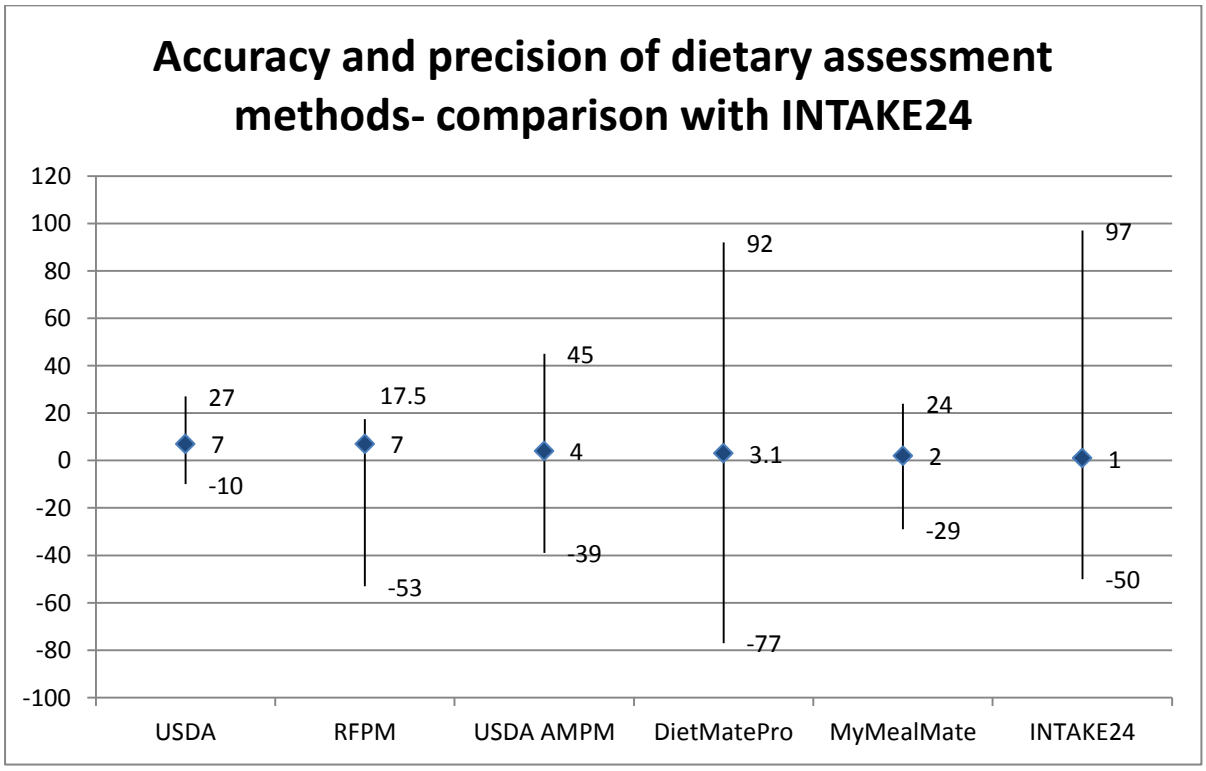

Figure 2: Accuracy and Precision of dietary assessment methods with adults

Table 23 – Matches, Omissions and Intrusions a comparison of other studies conducting 24hr recalls with results from INTAKE24

Reference	Method of assessment	Study population	Method of validation	Matches/ Omissions
Baxter et al. (1997) [22]	Dietitian conducted 24hr recall	Children aged 9-10 years n=260	Observation of school meals	84% matches, 16% omissions, 5% intrusions for reports of school meal collected within 90 mins of consumption. 68% matches, 32% omissions and 13% intrusions next day.
Baranowski et al. 2002 [23]	FIRSSt computerised 24hr recall	Children aged 9-10 years n=138	Dietitian administered 24hr recall	60% matches, 24% omissions, 15% intrusions.
Present study	INTAKE24	Participants aged 11-24 years n=149	Nutritionist conducted 24hr recall later the same day	82% matches, 11% omissions, 7% intrusions.
Subar [24]	ASA24	Participants aged 20-70 years n=81	Feeding study	79.5% matches, 20.5% omissions, 2.5% intrusions.

The level of matches (82%), omissions (11%) and intrusions (7%) observed in this study compare favourably with both dietitian-conducted 24hr recalls and other computerised 24hr recalls with children (Table 21). Only one other validation study attempted validation against a full 24 hr recall in children this validation of FIRSTt found 60% matches with a dietitian administered interview[23]. A recently completed relative validation of ASA24 in adults aged 20-70 during a feeding study found 80% of the foods reported were matches, 20.5% of foods were omitted and 2.5% of foods reported were intrusions.[23]

The agreement of ranking of intake as assessed by the percentage classified into the same tertile and kappa was good in comparison with that seen in other validity and repeatability studies. Masson *et al.* (2002) examined the agreement between an FFQ and 4-day weighed records and found the percentage of participants correctly classified into tertiles of nutrient intakes ranged from 39-78% and kappa values ranged from 0.23 to 0.66[25]. In testing the

reproducibility of an FFQ Navarro *et al.* (2001) found kappa varied from 0.51 to 0.74 for 2 repeated FFQs[26].

7. Conclusions

Dietary assessment methods which utilise technology may be more appealing and engaging than paper based methods, particularly for children and young adults. Web based methods of assessing intake which are easy to use and can be conducted at a time and place convenient to the participant, without the need for an in depth face-to-face interview may improve participation and completion rates. They also have the benefit of ensuring standardisation of methods, as the quality of the data collected and the accuracy of food coding and data entry do not vary with the experience and diligence of the dietitian or researcher. Nutrient output may be available as soon as the participant has completed their recall.

The results of the relative validation of INTAKE24 compare favourably, in terms of accuracy, with other validation studies of both computerised and face-to-face 24hr recalls. However, the precision is lower than that achieved with face-to-face interviews (USDA and USDA AMPM studies) or prospective methods (food diaries - Livingstone et al (1992), RFPM and MyMealMate). The system was very quick to complete with an average recall taking under 12 minutes, whereas an average interviewer led recall took around 20-25 minutes. The interviewer led recall required both the researcher and participant to identify the correct page in the Food Atlas in order to select the portion size consumed.

Under-reporting was evident in both INTAKE24 and the interviewer led recall. Asking individuals to report their intake as they go through-out the day as opposed to recalling intake the following day may reduce the number of omissions and intrusions and reduce the degree of under-reporting. The development of mobile internet allows users to access the internet 'on the go'. INTAKE24 is currently optimised for use on mobiles and tablets and we are aware that some participants used the system on these devices; however we did not record how the tool was accessed. Recent statistics show that 61% of adults use the internet 'on the go'; 53% use a mobile or smartphone and 32% use a laptop or tablet.[26] Therefore a tool which enables the user to record through the day is something which is worth exploring.

INTAKE24 has the potential to collect dietary data of comparable quality to that of an interviewer led recall but at a fraction of the cost. Further work will extend and validate the system for use in other populations.

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Appendix 3 - INTAKE24 COMPARISON STUDY – VISIT PROTOCOL

Must have with you for visits:

- Completed participant consent form
- Interviewer-led recall sheet
- Food atlas
- Return envelope
- Scales and height measure

Participants who are completing INTAKE24 first:

1. The first recall day is arranged with the participant.

2. The day before the appointment, an email is sent to the participants asking them to complete INTAKE24 tomorrow before the appointment. EMAIL SENT WITH INTAKE24 LOG-IN DETAILS.

3. On the day of the appointment, the researcher must text the participant to remind them of the time of the visit and ask them to complete INTAKE24 beforehand.

4. The researcher visits the participant at home (or other convenient location) and the INTERVIEWER-LED RECALL is carried out.

5. The food atlas is left with the participant and a brief description of how to use it is given (indicate served and leftover images. Researcher will say “please turn to page xx” during telephone interview). MAKE A NOTE OF ATLAS NUMBER ON CONSENT FORM.

6. The researcher will explain that there will be three more recalls carried out over the next three weeks over the phone. A time for the second recall can be arranged at this time. Ask whether any problems or questions.

Participants who are completing INTERVIEWER-LED RECALL first (n=45):

1. The first appointment is arranged with participant.

2. The researcher visits participant at home and the INTERVIEWER-LED RECALL is carried out. The participant is then advised to complete INTAKE24 later the same day. PROVIDE PARTICIPANT WITH LOG-IN DETAILS.

3. The food atlas is left with the participant and a brief description of how to use it is given (indicate served and leftover images. Researcher will say “please turn to page xx” during telephone interview). MAKE A NOTE OF ATLAS NUMBER ON CONSENT FORM.

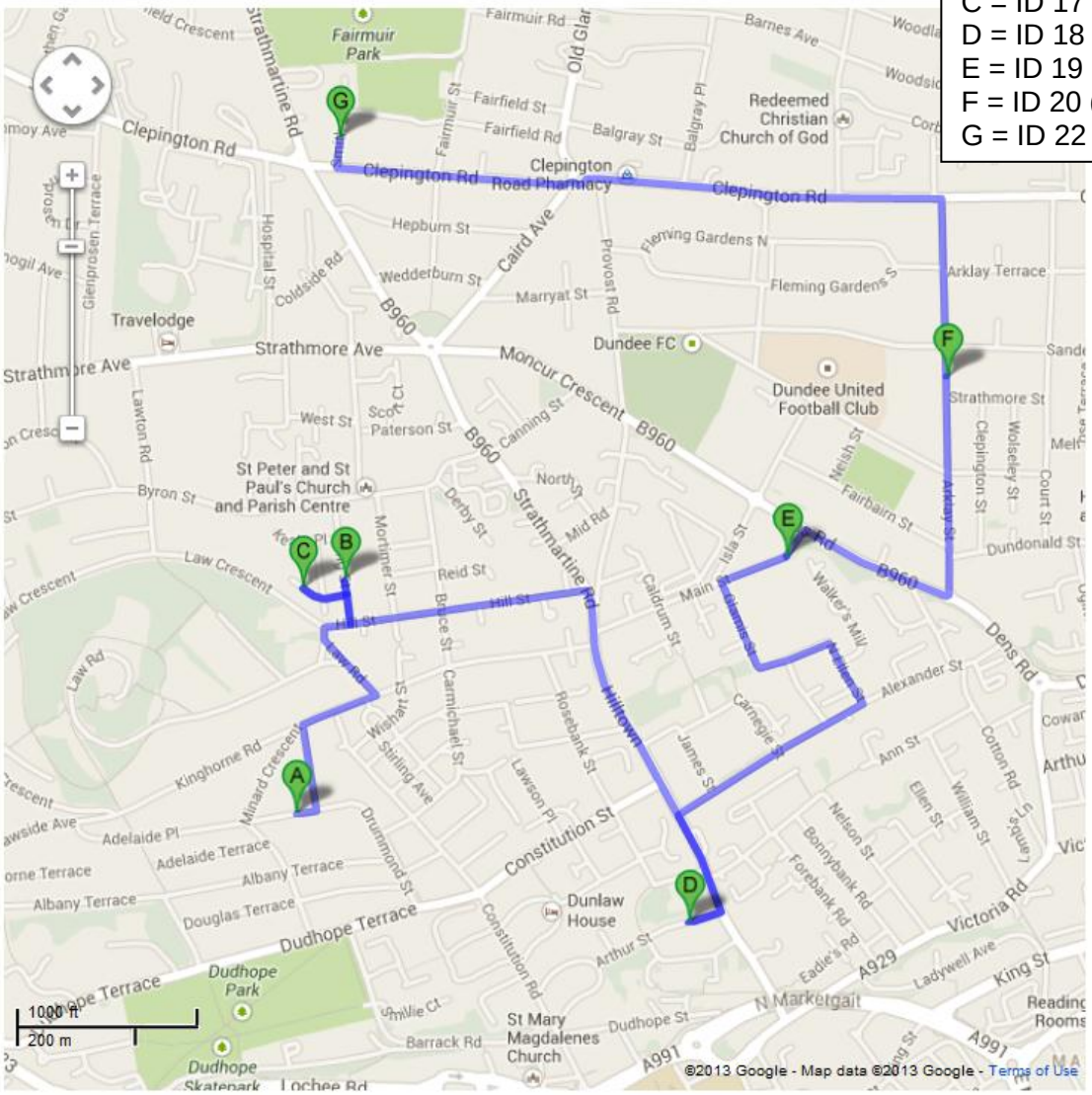
4. The researcher will explain that there will be three more recalls carried out over the next three weeks over the phone. A time for the second recall can be arranged at this time. Ask whether any problems or questions.

5. LOGIN TO RESEARCHER SITE INTAKE24 TO CHECK WHETHER THEY HAVE COMPLETED THAT DAY. IF NOT, SEND REMINDER TEXT

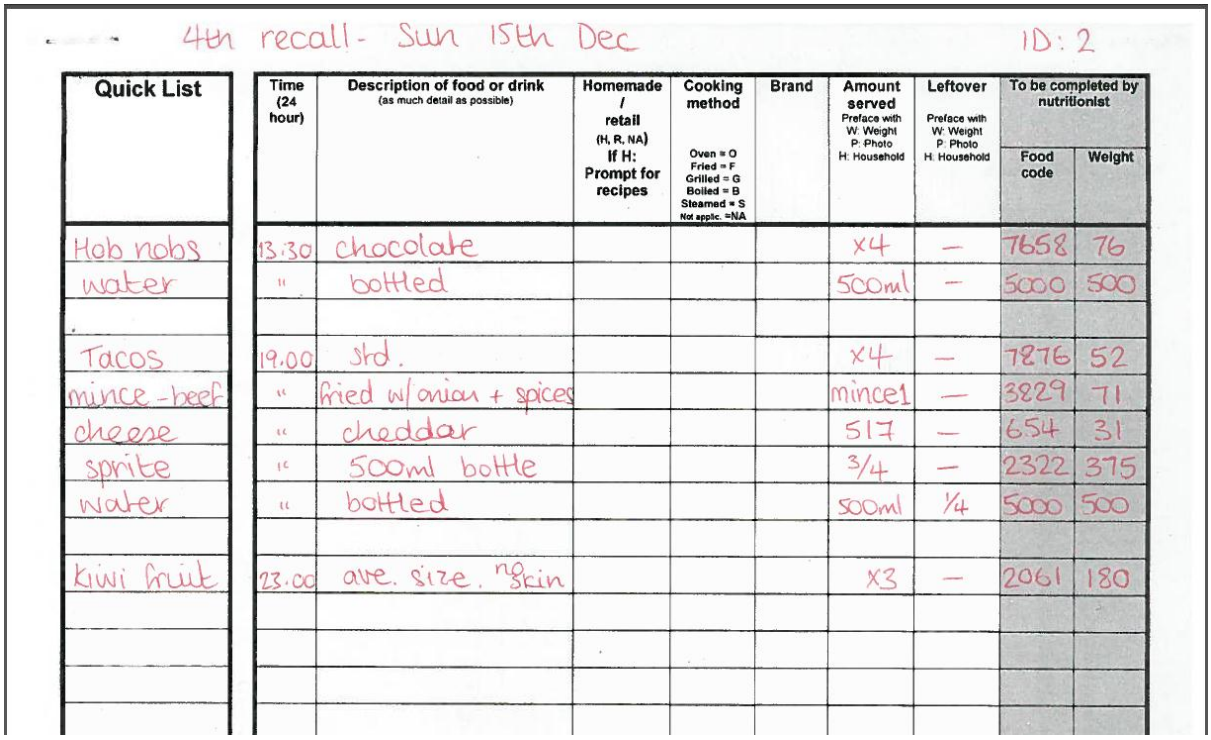
ID 015 - 022

A = ID 15 (2 mins)
B = ID 16 (1 mins)
C = ID 17 (4 mins)
D = ID 18 (3 mins)
E = ID 19 (2 mins)
F = ID 20 (3 mins)
G = ID 22

Appendix 4 – Map of participant addresses



Appendix 5 – Example of completed 24hr recall



4th recall - Sun 15th Dec ID: 2

Quick List	Time (24 hour)	Description of food or drink (as much detail as possible)	Homemade / retail (H, R, NA) If H: Prompt for recipes	Cooking method Oven = O Fried = F Grilled = G Boiled = B Steamed = S Not applic. =NA	Brand	Amount served Preface with W: Weight P: Photo H: Household	Leftover Preface with W: Weight P: Photo H: Household	To be completed by nutritionist: Food code	To be completed by nutritionist: Weight
Hob nobs	13:30	chocolate				x4	–	7658	76
water	"	bottled				500ml	–	5000	500
Tacos	19.00	std.				x4	–	7876	52
mince - beef	"	fried w/ onion + spices				mince1	–	3829	71
cheese	"	cheddar				517	–	654	31
sprite	"	500ml bottle				3/4	–	2322	375
water	"	bottled				500ml	1/4	5000	500
kiwi fruit	23.00	ave. size. no skin				x3	–	2061	180

Appendix 6 – Agreement on ranking of intake by age group

Table 24: Agreement on ranking of nutrient intakes into tertiles of intake – 11-16 year olds (completing any number of days n=52)

Nutrient	Same	Adjacent	Extreme	Kappa	Agreement	p
Energy	66%	33%	2%	.483	Moderate	<0.001
Protein	64%	32%	4%	.445	Moderate	<0.001
Fat	65%	33%	2%	.471	Moderate	<0.001
Carbohydrate	66%	32%	2%	.495	Moderate	<0.001
NMES	71%	28%	1%	.559	Moderate	<0.001
Alcohol	99%	1%	0%	.664	Good	<0.001
Vitamin C	81%	19%	0%	.706	Good	<0.001
Calcium	69%	27%	5%	.533	Moderate	<0.001
Iron	68%	26%	6%	.523	Moderate	<0.001

Table 25: Agreement on ranking of nutrient intakes into tertiles of intake – 17-24 year olds (completing any number of days n=115)

Nutrient	Same	Adjacent	Extreme	Kappa	Agreement	p
Energy	69%	28%	4%	.527	Moderate	<0.001
Protein	63%	31%	6%	.444	Moderate	<0.001
Fat	64%	32%	3%	.464	Moderate	<0.001
Carbohydrate	71%	27%	2%	.560	Moderate	<0.001
NMES	78%	20%	2%	.668	Good	<0.001
Alcohol	98%	2%	0%	.917	Very Good	<0.001
Vitamin C	78%	20%	2%	.669	Good	<0.001
Calcium	65%	32%	3%	.473	Moderate	<0.001
Iron	68%	30%	2%	.520	Moderate	<0.001

Table 26: Agreement of ranking of intakes of key food groups into tertiles of intake – 11-16 year olds (completing any number of days n=52)

Food Group	Same	Adjacent	Furthest	Kappa	Agreement	p
Cereals and cereal products	50%	46%	4%	.246	Fair	0.012
Starchy Carbohydrates	62%	31%	8%	.418	Moderate	<0.001
Milk and milk products	77%	21%	2%	.645	Good	<0.001
Eggs and egg dishes	98%	2%	0%	.936	Very Good	<0.001
Fat spreads	75%	23%	2%	.616	Good	<0.001
Meat and meat products	77%	23%	0%	.654	Good	<0.001
Fish (non-oily) and fish dishes	94%	2%	4%	.881	Very Good	<0.001
Oily fish	10000%	0%	0%	1.000	Very Good	<0.001
Vegetables, excluding potatoes	79%	21%	0%	.659	Good	<0.001
Savoury snacks	81%	19%	0%	.692	Good	<0.001
Nuts and seeds	96%	4%	0%	N/A*	N/A	N/A
Fruit	90%	8%	2%	.854	Very Good	<0.001
Cakes, biscuits, pastries, sugar preserves and confectionery	73%	25%	2%	.590	Moderate	<0.001
Non-alcoholic beverages	71%	25%	4%	.522	Moderate	<0.001
Alcoholic beverages	98%	2%	0%	.658	Good	<0.001
Miscellaneous	65%	31%	4%	.471	Moderate	<0.001

*Due to the low numbers eating nuts and fruits it was not possible to assess agreement for this group.

Table 27: Agreement of ranking of intakes of key food groups into tertiles of intake – 17-24 year olds (completing any number of days n=115)

Food Group	Same	Adjacent	Furthest	Kappa	Agreement	p
Cereals and cereal products	0.74	0.26	0.00	.612	Good	<0.001
Starchy Carbohydrates	0.76	0.22	0.02	.637	Good	<0.001
Milk and milk products	0.77	0.22	0.02	.649	Good	<0.001
Eggs and egg dishes	0.98	0.02	0.00	.958	Very Good	<0.001
Fat spreads	0.67	0.29	0.03	.507	Fair	<0.001
Meat and meat products	0.73	0.26	0.01	.599	Moderate	<0.001
Fish (non-oily) and fish dishes	0.91	0.07	0.03	.829	Very Good	<0.001
Oily fish	1.00	0.00	0.00	1.000	Very Good	<0.001
Vegetables, excluding potatoes	0.75	0.24	0.01	.620	Good	<0.001
Savoury snacks	0.84	0.16	0.01	.751	Good	<0.001
Nuts and seeds	1.00	0.00	0.00	1.000	Very Good	<0.001
Fruit	0.79	0.19	0.02	.689	Good	<0.001
Cakes, biscuits, pastries, sugar preserves and confectionery	0.72	0.27	0.01	.585	Moderate	<0.001
Non-alcoholic beverages	0.63	0.35	0.02	.433	Moderate	<0.001
Alcoholic beverages	0.97	0.03	0.00	.944	Very Good	<0.001
Miscellaneous	0.75	0.21	0.04	.624	Good	<0.001