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Making the best use of new technologies in the National Diet and Nutrition Survey: a review

Final Report

Nutritional Epidemiology Group, University of Leeds

November 2014

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Social Research that works for society

Acknowledgements

This review benefitted from the advice of several colleagues, whose contributions were gratefully received: Professor Jeremy Wyatt, Leadership Chair in eHealth Research, whose suggestions ensured a comprehensive hand-search strategy and provided a framework for literature synthesis; Mr Dan Pullinger, at the University of Leeds library, gave helpful pointers in developing the database search strategy; and Dr Ged Hall, whose advice on social media was indispensable.

The authors would also like to acknowledge the Rank Prize Funds which supported a student research assistant, Sarah Matthews, to assist in literature screening.

This project was funded by the Department of Health Policy Research Programme.

This report is independent research commissioned and funded by the Department of Health Policy Research Programme (Making the best use of new technologies in the National Diet and Nutrition Survey: A Review, PR-R6-0113-12002).The views expressed in this publication are those of the author(s) and not necessarily those of the Department of Health.

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Executive summary

Background

Dietary assessment is of paramount importance for public health monitoring. Currently in the UK, the population's diets are examined by the National Diet and Nutrition Survey Rolling Programme (NDNS RP). In the survey, diet is assessed by a four-day paper-based dietary diary, with accompanying interviews, anthropometric measurements and blood and urine sampling. However, there is growing interest worldwide in the potential for new technologies to assist in data collection for assessment of dietary intake.

Published literature reviews have identified the potential of new technologies to improve accuracy, reduce costs, and reduce respondent and researcher burden by automating data capture and the nutritional coding process. However, this is a fast-moving field of research, with technologies developing at a rapid pace, and an updated review of the potential application of new technologies in dietary assessment is warranted. This review was commissioned to identify the new technologies employed in dietary assessment and critically appraise their strengths and limitations in order to recommend which technologies, if any, might be suitable to develop for use in the NDNS RP and other UK population surveys.

Objectives

The overall aim of the project was to inform the Department of Health of the range of new technologies currently available and in development internationally that have potential to improve, complement or replace the methods used in the NDNS RP. The specific aims were: to generate an itinerary of new and emerging technologies that may be suitable; to systematically review the literature and critically appraise new technologies; and to recommend which of these new technologies, if any, would be appropriate for future use in the NDNS RP. To meet these aims, the project comprised two main facets, a literature review and qualitative research.

Literature review data sources

The literature review incorporated an extensive search of peer-reviewed and grey literature. The following sources were searched: Cochrane Database of Systematic Reviews (CDSR), Database of Abstracts of Reviews of Effectiveness (DARE), Web of Science Core Collection, Ovid MEDLINE, Ovid MEDLINE In-Process, Embase, NHS EED (Economic Evaluation Database), National Cancer Institute (NCI) Dietary Assessment Calibration/Validation Register, OpenGrey, EPPI Centre (TRoPHI), conference proceedings (ICDAM 2012, ISBNPA 2013, IEEE Xplore, Nutrition Society Irish Section and Summer Meetings 2014), recent issues of journals (Journal of Medical Internet Research, International Journal of Medical Informatics), grants registries (ClinicalTrials.gov, BBSRC, report), national surveys, and mobile phone application stores. In addition, hand-searching of relevant citations was performed. The search also included solicitation of key authors in the field to enquire about

as-yet unpublished articles or reports, and a Bristol Online Survey publicised via social media, society newsletters and meetings.

Literature review eligibility criteria

Records were screened for eligibility using a three-stage process. Firstly, keyword searches identified obviously irrelevant titles. Secondly, titles and abstracts were screened against the eligibility criteria, following which full-text copies of papers were obtained and, in the third stage of screening, examined against the criteria. Two independent reviewers screened each record at each stage, with discrepancies referred to a third reviewer.

Eligibility criteria were pre-specified and agreed by the project Steering Group (Section 1.6). Eligible records included: studies involving technologies, new to the NDNS RP, which can be used to automate or assist the collection of food consumption data and the coding of foods and portion sizes, currently available or beta versions, public domain or commercial; studies that address the development, features, or evaluation of new technology; technologies appropriate for the requirements of the NDNS RP in terms of nutritional analysis, with capacity to collect quantifiable consumption data at the food level; primary sources of information on a particular technology; and journal articles published since the year 2000 or grey literature available from 2011 onwards. The literature search was not limited to English-language publications, which are included in the itinerary, although data were not extracted from non-English studies.

Literature synthesis and appraisal

New technologies were categorised into eleven types of technology, and an itinerary was generated of tools falling under each category type. Due to the volume of eligible studies identified by the literature searches, data extraction was limited to the literature focussing on selected exemplar tools of five technology categories (web-based diet diary, web-based 24-hour recall, handheld devices (personal digital assistants and mobile phones), non-automated cameras to complement traditional methods, and non-automated cameras to replace traditional methods). For each category, at least two exemplars were chosen, and all studies involving the exemplar were included in data extraction and synthesis. Exemplars were selected on the basis of breadth of evidence available, using pre-specified criteria agreed by the Steering Group.

Data were extracted by a single reviewer and an evidence summary collated for each exemplar. A quality appraisal checklist was developed to assess the quality of validation studies. The checklist was piloted and applied by two independent reviewers. Studies were not excluded on the basis of quality, but study quality was taken into account when judging the strength of evidence. Due to the heterogeneity of the literature, meta-analyses were not performed.

References were managed and screened using the EPPI Reviewer 4 systematic review software. EPPI Reviewer was also used to extract data.

Literature review results

4,977 records were identified by the database searches and 61 records were identified through other sources. Following de-duplication, 3,840 records were screened. Full-text records were obtained for 723 records. After full-text screening, 291 records were judged eligible for inclusion, seven of which were non-English. The 291 records contained data on 148 different tools. This was then reduced to 223 records in five exemplar categories, representing 126 tools. Twelve exemplar tools were selected from these, for which there were 66 records – each exemplar having a number of associated records.

The exemplars chosen to represent the five included technology categories were: 2 web-based diaries (The Biggest Loser, MXS-Epidemio); 3 web-based 24-hour recalls (ASA-24, INTAKE24, Nutrinet-Sante); 2 handheld devices (BalanceLog for PDA, My Meal Mate (MMM) for smartphone); 2 non-automated cameras to complement traditional dietary assessment (NANA, Long et al, 2013); and 3 non-automated cameras to replace traditional methods (Remote Food Photography Method (RFPM), mobile phone food record (mpFR), Nutricam).

Findings from each of the 66 included records are shown in Appendix H. Below is a summary of the literature review synthesis. A more detailed textual summary of the evidence surrounding each technology type, which includes important points for interpretation such as sample sizes and limits of agreement, is presented in Section 2.2.4. Study findings were synthesised for each of the five technology categories:

Web-based diary

- Four records related to the exemplars in this category: 3 articles presented data on the validity of web-based diaries, and one article presented the results of an adherence study.
- Evidence of exemplar use in a population applicable to the NDNS RP was not available.
- Studies reported that using an online diary gave an estimated mean energy intake (EI) that was:
    - about 2800kJ (660kcal) lower relative to indirect calorimetry,
    - 2301kJ (550kcal) lower relative to double labelled water (DLW), and
    - 50kJ (12kcal) lower relative to paper-based diary.
- Two of the validation studies were rated as poor quality, and 1 moderate quality.
- When offered a choice, 77% of a French survey sample selected to use the web-based diary over a paper-based version, indicating a majority preference.
- There was no evidence relating to participant burden of web-based diaries, such as completion times.
- There was no evidence of resource or cost implications.

Web-based 24-hour recall

- Thirteen records related to the exemplars in this category: 11 studies offered data on the validity of web-based recalls, 4 records presented results of usability studies, and 1 feasibility study reported adherence findings.
- Web-based 24-hour recalls had been applied in a variety of populations, some of which were partially applicable to the NDNS RP: INTAKE24 was used in UK

adolescents and young adults, Nutrinet-Sante involved a French population survey and ASA24 has been applied extensively in the US.

- Studies in adults reported that using a web-based 24-hour recall gave an estimated mean EI that was:
    - between 4kJ and 1099kJ (1kcal and 263kcal) higher than directly observed intakes,
    - between 79kJ and 439kJ (19kcal and 105kcal) lower relative to paper-based diary,
    - 25kJ (6kcal) higher relative to interviewer-led recall,
    - amongst men, 145kJ (35kcal) lower than interviewer-led recall,
    - amongst women, 23kJ (5kcal) higher than interviewer-led recall,
    - amongst older adults, 439kJ (105kcal) lower than interviewer-led recall, and
    - amongst young UK adults, 60kJ (14kcal) lower than interviewer-led recall.
- Studies in UK adolescents reported that using a web-based 24-hour recall gave an estimated mean EI that was:
    - 20% lower than parent records,
    - 130kJ (31kcal) lower than interviewer-led recall, and
    - along with young adults (11-24 year-olds), 638kJ and 82kJ (153kcal and 20kcal respectively) lower than interviewer-led recall.
- The majority of validation studies were rated as moderate quality, whilst a few were rated as poor quality.
- Evidence of participant burden associated with web-based recalls indicated mean completion times of 13 minutes and 31 minutes.
- One study reported a greater preference for web-based recalls compared to interviewer-led recalls amongst adults, whereas another study found almost half of older adults preferred interviewer-led.
- Completion rates of studies varied according to the sample characteristics; a poor response rate was reported for a study amongst older adults.
- A set-up cost of €150,000 was reported for Nutrinet-Sante, over 9 months, with no additional costs associated with each web-based 24-hour recall.

Handheld technologies

- Seven records related the exemplars in this category: 2 studies presented data on the validity of mobile phones and PDAs, and 4 studies addressed elements of user acceptability.
- Studies reported that using a handheld technology gave an estimated mean EI that was:
    - 1154kJ (276kcal) lower relative to DLW, and
    - between 68kJ and 441kJ (16kcal and 106kcal respectively) lower than interviewer-led 24-hour recalls.
- Evidence of participant burden associated with handheld technologies indicated a mean daily completion time of 16 minutes, compared to 19 minutes for a web-based diary and 15 minutes for a paper-based diary.
- Acceptability findings indicated that handheld technologies tended to be rated more positively than other methods.
- Non-completers may have withdrawn from studies because they did not like the handheld equipment.

- There was no evidence of resource or cost implications of handheld technologies.

Non-automated cameras to complement diary or recall

- Three articles related to the exemplars in this category: 2 validation studies and 1 usability study.
- Exemplars had been used in samples of US adults and in UK older adults.
- One study (using NANA) reported that using non-automated cameras to complement diet diaries or recalls gave an estimated EI that was 287kJ (67kcal) lower than a paper-based diary.
- NANA was found to be reproducible.
- The acceptability study reported the method to be acceptable and helpful for memory, with a minority of users finding it awkward.
- There was no evidence relating to participant burden of non-automated cameras used to complement diaries or recalls.
- There was no evidence of resource or cost implications.

Non-automated cameras to replace traditional methods

- Fifteen records related to the exemplars in this category: 8 validation studies were described and 9 usability or feasibility studies.
- Exemplars had not been used in the UK or in a survey setting applicable to the NDNS RP.
- Studies reported that using a non-automated camera gave an estimated EI that was:
    - 600kJ (144kcal) lower relative to DLW,
    - 368kJ (88kcal) lower relative to direct observation in a laboratory setting,
    - 151kJ (36kcal) lower relative to directly observed lunch, 406kJ (97kcal) lower for dinner, and
    - 1454kJ (348kcal) lower than expected energy requirements.
- Inter-rater reliability of dietitians classifying foods from photographs was high.
- Automated classification of images could be up to 97% accurate for test images, but significant differences in energy estimates were reported.
- 75%-98% users found it easy to carry the extra equipment.
- Time to complete a day's intake was less than a paper diary for 60% participants.
- Issues reported in feasibility studies included problems with memory and lighting.
- Between 70% and 100% participants were reported to prefer photography methods to paper diaries.
- Reported ease of use varied depending on the sample characteristics.
- There was no evidence of resource or cost implications.

A total of 25 validation studies, reported in 24 references, were appraised in terms of quality. Of these, 1 study was agreed to be of good quality, 17 of moderate quality, and 7 of poor quality.

Qualitative research

NatCen was sub-contracted to conduct a small qualitative study with recent NDNS RP participants and members of the public to explore their perspectives on the potential use of new technologies in the survey. Twelve in-depth interviews were carried out by telephone with recent NDNS RP participants (2013/2014), and 4 focus groups took place with members of the public aged 19 and over who had never taken part in the NDNS RP.

Participants in the telephone interviews were men and women living in all four nations of the United Kingdom, mainly in small towns and rural areas. Their ages ranged from 21 to 86. Interviews were recorded and transcribed with the participants' consent. A copy of the topic guide can be found in Appendix K.

The focus groups took place in London and Manchester (2 in each city), with 6-8 participants in each group. One of the groups in each city was with people who identified themselves as smartphone or tablet users. The other two groups were with people who used neither device. Discussion followed a pre-approved topic guide (Appendix K), and interviews were recorded and transcribed with the participants' consent.

Thematic analysis was conducted with the interview and focus group scripts. The study found a divide between the views of people who already used mobile devices and those who did not. The former group wanted to be able to complete the survey using a smartphone app. The latter group had a strong preference for the existing paper diary.

The following conclusions came out of the qualitative research:

- The paper diary is currently still needed
- Mobile device users wanted to be able to complete the survey using a smartphone app, because they carried their smartphones with them all the time
- Participants felt a smartphone app would capture more accurate information
- Tablet apps and websites currently have less appeal than a smartphone app
- Cameras for recording images of foods and drinks consumed should be optional and integrated into a mobile app.

Limitations of the evidence base

The review highlighted a number of limitations with the evidence base. Perhaps most conspicuous was the lack of evidence around the cost implications of new technologies used for dietary assessment. Despite frequent assertions of cost savings by authors, only 1 study described costs.

Another limitation of the evidence base is that only a minority of the tools had been developed for or applied in a population dietary survey setting. Frequently, new technologies featured dietary recording as a self-monitoring component of interventions, or tools were developed for specific population groups only. As a result, much of the evidence in the literature has limited applicability to the NDNS RP.

In addition, the review presents for the first time an appraisal of the quality of new technology validation studies, identifying an important lack of good-quality validation studies. Results of poor-quality studies must be interpreted with caution.

Finally, an obvious and important limitation of this review was the necessity to extract data from only a proportion of the literature. Conclusions about the advantages, disadvantages and suitability of a technology category were based upon exemplars, with an assumption that tools within each category share similarities. Information about non-exemplar tools can be found in the sources listed in the accompanying bibliography.

Recommendations

On the basis of the current evidence, a recommendation to fully replace current methods in the NDNS RP with new technologies cannot be made. It is strongly recommended that investment is made into good-quality feasibility, cost-effectiveness and validation studies, in order to fill the evidence gap. The following key points were raised:

1. **There was not enough evidence to indicate either an improved or inferior validity as compared to traditional dietary assessment methods.**
   Both the quantity and quality of validation studies were found to be lacking. More research in a setting similar to the NDNS RP would be necessary (see Recommendation 4).
2. **There was a critical lack of evidence regarding the costs of new technologies for a dietary survey.**
   Research into the costs, both direct and indirect, and cost comparisons with traditional methods, is recommended (see Recommendation 6).
3. **Camera methods are unsuitable for use in the NDNS RP at this moment in time.**
   Qualitative research indicated resistance to the additional burden. Furthermore, processing of images for nutritional analysis needs further refinement.
4. **Piloting the feasibility of adopting a new technology in the context of the NDNS RP is crucial.**
   A direct evaluation of potentially useful tools, in a setting similar to the NDNS RP, would be necessary. A feasibility study should include measurements of response rates, compliance rates, validity or relative validity and costs.
5. **If implemented in the short-term, new technologies for dietary assessment should only be considered as an adjunct or alternative option in the NDNS RP.**
   Acceptability of new technologies was low amongst some people. In order to preserve the representativeness of the NDNS RP sample, it would currently not be possible to use a new technology without offering a traditional alternative. In order to adopt this approach with confidence, further research is needed into its impact on response rates, completion rates, validity or relative validity and costs (see Recommendation 6). Rates of acceptability may change with time.
6. **Future research should focus on the implications of employing multiple methods of dietary assessment within a survey.**
   Qualitative research indicates that there are individual differences in preference for different types of technology or traditional methods. Offering a choice of tools to participants could improve acceptability and therefore response and completion

rates. Evidence is needed to confirm this, as well as to identify the impact on validity and costs of using mixed dietary assessment methods within a survey, mixing traditional and technology-based tools, or the same tool across different technology platforms. Pilot or feasibility studies are recommended, with reference to current NDNS RP methods.

7. **Monitoring of future developments in new technologies and in the evidence is recommended.**
   Given the pace of development in this field, it is recommended that efforts are made to revisit the evidence at regular intervals. Consideration should be given to monitor the evidence of selected tools or technologies at yearly intervals, with efforts to revisit the wider literature (such as every 5 years) in order to log the emergence of new tools or technologies.

Conclusion

This review presented evidence from a literature review and supporting qualitative study. Despite identifying many more records than previously published reviews, a lack of good-quality, appropriate evidence was clear. The main perceived advantages of incorporating a new technology in dietary assessment – for example, saving costs in data processing, or improving compliance – appear to be anticipated, rather than demonstrated. As a result, there is not enough evidence available with which to predict the impact these technologies would have on accuracy, response rates, compliance and costs. In addition, both the literature review and the qualitative research suggested that new technologies are not acceptable to some people, with likely consequences for a representative sample. Therefore, at present, it seems premature to fully implement new technologies alone to assess diet in the NDNS RP without further investment in their development, validation and assessment of feasibility.

In the future, the adoption of multiple tools, or different versions of the same tool, may be desirable and improve response rates within the NDNS RP. However, good-quality research is needed to demonstrate such tools will enhance compliance without adversely affecting the validity and comparability of dietary data. As technology use becomes more prevalent across the population in the UK, acceptability of new technologies is likely to increase, and further research could demonstrate its usefulness. At the same time, disregarding new technologies may become detrimental to the survey, as traditional paper-based tools possibly become less acceptable to respondents. In this fast-paced field of development, it is recommended that progress in technology development, validity and acceptability is monitored.

1. Introduction

1.1 Background

Accurate and timely information about dietary practices and nutrient intakes of the UK population is required by government to monitor dietary quality, to track dietary changes over time and to develop policy. Using representative samples of the population, the National Diet and Nutrition Survey Rolling Programme (NDNS RP) is designed to assess what and how much people are eating in the UK. The methods used to capture dietary practices have evolved since its inception in the late 1980s.

The ability to accurately assess diet is of paramount importance in establishing nutrition related disease risks and evaluating the effectiveness of public health interventions. Established methods of dietary assessment such as weighed food records, 24-hour recalls and food frequency questionnaires (FFQs) present a challenge to researchers due to their inherent limitations. Retrospective methods suffer from reliance on respondent memory, potential recall bias and mis-reporting and prospective methods can place a high burden on the respondent and risk an alteration of habitual intake. Nutritional coding of the data collected by these traditional methods requires a trained individual and can be extremely time consuming and expensive. These limitations have been well described previously in the MRC Diet and Physical Activity measurements toolkit [1].

Currently, the NDNS RP involves an interview, a four-day un-weighed dietary diary and blood and urine sampling, and annually collects information from at least 1000 individuals (500 adults and 500 children) aged 1.5 years and above. As described above, traditional methods for estimating dietary intake are subject to a number of limitations. It is important to evaluate the robustness of existing methods against new and emerging approaches to ensure the best approaches to dietary assessment are employed in the NDNS RP.

New technologies are becoming an increasingly prominent feature of everyday life in the UK. A recent report [2] has shown that 93% of adults personally use a mobile phone, with 61% of adults now owning a smartphone, and 57% using a smartphone for internet access. Smartphone ownership amongst adults has increased from 51% in 2013. The number of households that reported owning tablet computers has almost doubled in a year, to 44%. As well as increasing ownership, media consumption is also on the increase. New technologies increasingly feature in healthcare and research settings, such as for health promotion [3-5] or patient self-monitoring [6, 7].

There is now also growing interest in employing new technologies to assist in the process of dietary data collection. Such technologies include, but are not restricted to, the use of camera and mobile telephone technology to capture food and meal images, interactive computer-based methods and handheld personal digital assistants. Automated systems have the potential to improve the accuracy of data collected, reduce costs, provide immediate feedback and reduce respondent and researcher burden by automating the data capture and nutritional coding process [8-10]. It has also been suggested that new technologies

are viewed more favourably and are often preferred by participants [11], especially amongst children and young adults [12].

New and emerging technologies may be employed in different ways - to replace, improve, or complement traditional methods of dietary assessment. Replacement methods include new tools that stand alone from traditional methods. Alternatively, the new technology may be employed as a means to improve response rates or to complement existing pen and paper-based methods. These may include for example, techniques that improve or facilitate quantification of amounts consumed.

Several literature reviews have been published that describe the use of new technologies for dietary assessment, reflecting a growing interest. However, many of these provide a limited depiction of the field, either through the use of non-systematic methods [13-15], or by confining searches to particular technology types [10, 16] or the assessment of particular foods only [17]. In addition, some reviews focus on presenting an overview of technologies in the absence of critical analysis [11, 18]. Two systematic reviews investigate and critically appraise the literature on a broad range of technologies used for dietary assessment [8, 19]. The earliest of these, Ngo et al. (2009)[8], concluded that whilst new technologies have the potential to accurately measure dietary intakes further work is necessary for improving and evaluating established and new tools. Illner and colleagues [19] were somewhat less positive, but concluded that whilst the critical limitation of individual bias remains, innovative technologies show promise in terms of being more cost- and time-effective.

Since this is a fast-moving field of research, an updated review of the potential application of new technologies in dietary assessment is warranted. To facilitate the decision-making process of the Department of Health with regard to the inclusion of technologies in the NDNS RP, this project was set up to identify and categorise new technologies in dietary assessment and critically appraise their strengths and limitations. In addition to the evidence already available in the literature, the second facet of the project elicited the views of potential users (members of the public and previous NDNS RP participants) using qualitative research methods. The findings of the literature review and the qualitative research both contributed to the appraisal of new technologies.

This report is divided into two main sections, in which the methods and findings from each facet of the project – the literature review and the qualitative research – are presented. A final section (the Discussion) draws together the findings from both investigations and presents a discussion of the findings in context and recommendations to the Department of Health.

1.2 Objectives

The overall aim of the project was to inform the Department of Health of the range of new technologies currently available and in development internationally, that have potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme (NDNS RP). The specific aims were:

- To generate an itinerary of new and emerging technologies that may be suitable for use in the NDNS RP in the future.
- Through systematic review of the literature and qualitative research, to critically appraise these technologies in terms of meeting requirements of the NDNS RP and other relevant population surveys by exploring their limitations, relative validity, cost-effectiveness and current and future potential.
- To recommend which of these new technologies, if any, would be appropriate for future use in the NDNS RP and/or complementary surveys, with an indication of the degree to which they fit the survey requirements and the degree to which current technologies may need adapting, as well as a description of the perceived benefits and limitations.

1.3 Research questions

The following research questions were proposed in order to direct the focus of the literature search:

1. What are the new and emerging technologies suitable for use in population dietary surveys?
2. Do new technologies improve accuracy or enhance validity in dietary assessment?
3. What is the relative validity of new technologies, when compared to traditional dietary assessment methods?
4. What impact do new technologies have on participant burden in dietary assessment?
5. What impact do new technologies have on researcher burden in dietary surveys?
6. How do new technologies rate in terms of acceptability amongst participants of dietary surveys?
7. What are the conclusions around feasibility of these new technologies?
8. Are new technologies cost-effective for population dietary surveys?
9. What recommendations can be made regarding the use of new technologies in the NDNS RP or other complementary national dietary surveys?

1.4 Definitions

Acceptability	For the purposes of this review, 'acceptability' evidence includes bothusability and feasibility evidence (see below), covering aspects of user experience such as participant burden, adherence, preferability, ease of use, or accessibility.
Exemplar	The best example of a type of technology, for which the broadest evidence is available, and which is therefore taken to represent the advantages and disadvantages of the technology category to which it can be classified.
Feasibility	For the purposes of this review, we define feasibility studies as any study which investigates the appropriateness of a tool for dietary assessment in a trial, study or survey setting. Outcomes reported may include (but are not limited to) adherence, usage and participant opinions.
New technology	For the purposes of this review, **'new technologies'** refers to new or novel ways of collecting (and processing) dietary data, including, but not limited to, devices (hard ware) and applications (software) such as cameras, mobile phones, sensors, audio-recording devices, optical readers, phone applications, hand-held digital technology, PC- and web-based programmes, which are new to the NDNS RP.
Record(s)	'Record' refers to a source of data, and applies to both traditional references or citations (such as would be collated in an indexed database) and any form of grey literature. The term 'reference' on the other hand, may not be considered to incorporate forms of grey literature which are not traditionally indexed.
Usability	For the purposes of this review, a usability study is defined as that which investigates features of user experience in a setting other than a trial, pilot study, or survey (these would be classed as feasibility studies) – for example, using focus groups.
Validity	Validity refers to the degree to which a tool measures what it was designed to measure. In this review, the term 'validation study' encompasses studies of comparability, calibration or relative validity. In the summary of findings, results of reliability of reproducibility studies are also included with validation studies. Validity studies may also report feasibility or acceptability outcomes.

1.5 Review team

The research was undertaken by a team based at the University of Leeds, and by sub-contractors at MRC Human Nutrition Research (HNR), and NatCen Social Research (NatCen).

The following team at the University of Leeds was primarily responsible for undertaking the systematic review of the literature:

- Victoria Burley (project lead)
- Janet Cade (co-applicant)
- Kate Timmins (post-doctoral research associate)
- Catherine Rycroft (research assistant)
- Chen Jing (research assistant)
- Sarah Matthews (research assistant)
- Neil Hancock (database management)
- Darren Greenwood (statistical advisor)
- Claire Hulme (health economics advisor)

The qualitative research element of the project was sub-contracted to researchers at NatCen. This work was led by:

- Fatima Husain
- Kim Vowden
- Valdeep Gill

1.6 Steering group

In addition to the Review Team, the project was guided by a Steering Group, comprising independent experts (Alison Lennox, University of Surrey; Bob Erens, London School of Hygiene and Tropical Medicine), observers from the funding body (Louise Knowles, Department of Health; Gillian Swan and Katharine Roberts, Public Health England), members of the NDNS RP consortium (Polly Page and Toni Steer, MRC HNR; Beverly Bates, NatCen) and lay members (George Clark and Diane Rees-Morris), alongside the Review Team. Minutes of the Steering Group meetings can be seen in Appendix A.

2. Literature review

One of the primary objectives of the review was to compile an itinerary of new technologies used for dietary assessment. Given the fast-paced developments in this field, it was necessary to consider both well-established as well as new and emerging examples. Therefore, the literature review took a broad and extensive approach, incorporating peer-reviewed and grey literature database searches, as well as exploring several other channels, such as social media.

2.1 Literature review methodology

A protocol for the literature review was developed and agreed by the Steering Group at the project start-up meeting, on 23rd April 2014 (see Appendix A), prior to beginning the literature search. The protocol, and subsequent revisions to protocol, may be seen in Appendix **B.**

2.1.1 Search strategy

2.1.1.1 Search for existing reviews

Existing reviews were found through searches of the following review databases during May 2014:

- Cochrane Database of Systematic Reviews (CDSR) 2005 to March 2014
- Database of Abstracts of Reviews of Effectiveness (DARE) 1st Quarter 2014

Reviews were also identified through the main database searching, citation searching or in contacting experts (see below).

2.1.1.2 Database searching

A search was conducted during May 2014 to locate papers published from 2000 onwards. The following databases were searched:

- Web of Science Core Collection, including conference proceedings
- Ovid MEDLINE 1996 to April Week 4 2014
- Ovid MEDLINE In-Process and Other Non-Indexed Citations May 06, 2014
- Embase 1996 to 2014 week 18
- NHS EED (Economic Evaluation Database) 2nd Quarter 2014
- National Cancer Institute (NCI) Dietary Assessment Calibration/Validation Register (available at http://appliedresearch.cancer.gov/cgi-bin/dacv/index.pl)

The databases were searched using a strategy compiled a priori (see Appendix B-1) in the Ovid interface, and adapted for each database.

2.1.1.3 Grey literature searching

Searches during May 2014 identified unpublished studies from 2011 onwards, within:

- OpenGrey
- EPPI Centre (TRoPHI)

2.1.1.4 Hand-searching

Hand-searches of other sources of information were completed during May-June 2014:

- Conferences
    - 8th International Conference on Diet and Activity Methods (ICDAM) 2012
    - International Society of Behavioral Nutrition and Physical Activity (ISBNPA) 2013
    - IEEE (Institute of Electrical and Electronics Engineers) Xplore
    - Nutrition Society Irish Section Meeting 2014
- Journals
    - Journal of Medical Internet Research (JMIR) (Apr-Jun 2014, vol 16, issue 4-6)
    - International Journal of Medical Informatics (Feb-Jul 2014, vol 83, issue 2-7)
- Grants registries
    - ClinicalTrials.gov
    - BBSRC grants database (http://www.bbsrc.ac.uk/PA/grants/Default.aspx)
    - rePORT (http://report.nih.gov/)
- National surveys for OECD member states and partners
- Mobile phone application stores
    - www.apple.com/uk
    - https://play.google.com/store/apps
    - www.amazon.co.uk/appstore

The top 20 mobile apps relating to diet on each store site were compiled (by relevance or popularity, depending on the website). Apps were assessed against the review criteria in terms of appropriateness for dietary assessment in the NDNS RP. Eligible apps were then used as search terms in Web of Science to identify any published articles associated with each app.

2.1.1.5 Citation searching

Reference lists of reviews and highly relevant papers were searched to identify any further relevant articles. A citation search was conducted using Web of Science by searching for citations of key articles.

During the screening process, articles which had used a new technology for dietary assessment but did not provide any new information about the technology were excluded. These articles were searched for citations to prior relevant studies to ensure they had been included.

New technologies employed in national dietary surveys were identified, and citations to the development or usage of the technology obtained.

2.1.1.6 Expert solicitations & social media

Key authors in the field were approached to enquire about as-yet unpublished articles or reports. In addition, social media relevant to academic research, including ResearchGate, was used to solicit information about new tools or studies that might be in development or in preparation, by posting direct information requests. A Bristol Online Survey was created for the purposes of soliciting similar information, and the link distributed via social media,

through society newsletters and websites (the Nutrition Society) and by leaflets distributed at the Nutrition Society Summer Meeting, July, 2014. Contacts and responses were logged.

2.1.2 Literature management

Bibliographic details of records returned by the database searches were imported into EPPI-Reviewer 4 [20]. References were de-duplicated using the in-built software algorithms, as well as being manually checked.

Following de-duplication, the records were screened for eligibility using a three-stage process:

1. Keyword searches in EPPI-Reviewer to identify obviously irrelevant titles;
2. Title/abstract screening, following which full-text copies of papers were obtained; and
3. Full paper screening.

During the first pass screening, titles of records identified by keyword searches (for example, “veterinary”, see Appendix C for a full list) were rapidly assessed by two independent reviewers and excluded if obviously ineligible. If the eligibility was unclear from the title, or there was a discrepancy between reviewers, the record was retained for second-pass screening.

In the second and third stages of screening, studies were screened against pre-specified eligibility criteria (see below) agreed by the Steering Group. Two independent reviewers screened each record at each stage. If the reviewers disagreed on a study’s eligibility, a third reviewer examined the record and made the decision on eligibility.

The number of records included or excluded at each stage was recorded, along with the reasons for exclusion, as advised by the PRISMA recommendations (Preferred Reporting Items for Systematic Review and Meta-Analyses [21]).

Potentially relevant records and projects found through the grey literature, grants database and citation searching, and other sources, were checked against the references held in the EPPI-Reviewer database to identify duplicates or linked publications. New records were incorporated into the review database and screened against the criteria as described above. Grants which appeared to meet the criteria for this review, but for which no existing articles could be identified, were collated separately in a table.

2.1.3 Eligibility criteria

The need for a broad approach was determined at the initial project steering meeting (24th April, 2014; Appendix A): as long as a new technology or tool had the potential to meet the requirements of the NDNS RP, it would be eligible. The NDNS RP requirements were confirmed during the steering meeting to include: that the dietary assessment be capable of capturing the whole diet, with sufficient detail of foods and drinks to allow full nutrient

analysis; and that the sample be drawn from a wide range of ages (1.5 years and upward).The following eligibility criteria were used to screen records for inclusion in the review.

2.1.3.1 Inclusion criteria:

- Studies involving technologies, new to the NDNS RP[1], which can be used to automate or assist the collection of food consumption data and the coding of foods and portion sizes. These technologies may be currently available or beta versions, public domain or commercial
- Studies that address the development, features, or evaluation of new technology
- Eligible technologies must be appropriate for the requirements of the NDNS RP in terms of nutritional analysis, with capacity to collect quantifiable consumption data at the food level
- Studies published since the year 2000
- Grey literature from 2011 onwards, which is considered a primary source of information on a new technology

2.1.3.2 Exclusion criteria:

- Studies that do not provide new information on the development, features, or evaluation of new technology for dietary assessment, such as intervention or observational studies that have utilised the technology for research purposes e.g. to describe diet-disease associations or dietary survey or change
- Tools used in nutrition education or e-learning, where food consumption is not measured and quantified and the tool is not appropriate for adapting to the purposes of the NDNS RP
- Tools that do not have the capability of capturing a sufficient level of detail for full nutritional analysis, for example, tools which measure specific foods or drink or a limited range of foods or drink, food frequency questionnaires, or tools in which consumption of foods and drink are not quantified
- Technologies which are not considered new to the NDNS RP
- Tools employed in recruiting, screening and tracking subject flow in dietary surveys
- Tools which measure purchasing of foods and drinks, in the absence of data on dietary consumption
- Second-hand references to new technologies, such as commentaries, reviews, editorials or other opinion articles
- Studies published before 2000

2.1.3.3 Date range

The database searches located references published from 2000 onwards. The searches for grey literature identified papers available from 2011 onwards.

[1] Technologies are considered ‘new’ if they are ways of dietary data collection that have not been used, previously or currently, in the NDNS RP or related surveys.

2.1.3.4 Language

The literature search was not limited to records written in English. However, literature published in languages other than English was logged only, and not included in the full review.

2.1.3.5 Additional exclusion criteria

In July, 2014, an interim meeting was held with the Department of Health and Public Health England (see Section 2.1.5 below). As a result of the volume of literature returned by the searches, the decision was taken to further refine the eligibility criteria. Additional criteria were set to exclude tools which were not considered capable of capturing the whole diet, and tools which would have to be aimed at only a small subset of the population, neither of which would meet the requirements of the NDNS RP. Full-text records were re-screened in light of the following exclusion criteria:

- Tools which used a diet history method to gauge usual intake
- Tools which were setting-based (e.g. to use in cafeterias only)
- Photography methods which focussed on behavioural indicators of under-reporting
- Tools designed exclusively for use in young children (primary school age, 11 years old and below)
- Papers using the Oxford WebQ (this tool was identified as a form of FFQ)
- Unstructured tools with free-text entry, such as Twitter or text messaging.

2.1.4 Compiling the itinerary

Following screening, a list of the new technologies found in the literature was compiled along with a bibliography of eligible studies. The new technologies were organised into categories that reflected shared similarities across tools. Prior to data extraction, the literature review team met with Department of Health and Public Health England representatives to discuss the search findings and the desired scope of the critical appraisal.

2.1.5 Selection of Exemplars

During the literature screening process, it became evident that the volume of eligible studies was much greater than anticipated during the preliminary scoping search, and too great to allow for a complete data extraction and synthesis in the project timeframe. Therefore, the decision was agreed with the steering group, funding body (Department of Health and Public Health England) and the review team at the University of Leeds to limit data extraction, synthesis and presentation to the literature focussing on selected exemplars of new technologies. The following sections describe the methodology employed to select the most appropriate exemplar tools.

Eleven categories of new technology were described and chosen as relevant for the review (see Appendix D). On discussion with the Steering Group (Appendix A), it was decided to take forward only five categories, as detailed below, to be critically reviewed. The categories excluded at this stage were: interviewer-led computerized direct-entry 24-hour recalls; self-

administered computerized recalls (non-web based); automated cameras; and barcode scanners. Primary reasons for exclusion were: introduction would be likely to depart too widely from current NDNS RP methods (automated cameras, barcode scanners); and non-web based tools would be impractical for the NDNS RP (self-administered and interviewer-led computerized recall). In addition, the decision was taken to merge handheld digital computers (PDAs) and mobile phone apps to create a single category of handheld devices, rather than exclude handheld digital computers, which were mostly considered obsolete technologies. This was because experience of using older handheld technologies may be relevant to the newer technology, mobile phones.

Exemplars were selected to represent each of these categories:

1. **Self-administered online diet diary**
   Web-based sites which allow participants to log in and record their dietary intake prospectively. There is a requirement for internet connectivity. Often includes drop-down lists of foods for entry, or allow food terms to be searched. Dietary data can then be automatically coded. Examples include the SuperTracker website, or www.sphealth.com.
2. **Self-administered online 24hr recall**
   Participants are asked to retrospectively report food consumption during the past 24 hours by a series of online questions and prompts. Responses are often entered by means of drop-down lists of food items or through search fields. There is a requirement for internet connectivity. Dietary data can then be automatically coded. Examples include ASA24 or myfood24.
3. **Handheld devices (mobile phone apps, PDAs, tablets)**
   Applications for use on PDAs or smartphones. Similar to web-based techniques, but without the need for internet connectivity (necessarily), and allowing portability. Examples include MyFitnessPal, My Meal Mate, Lose it! or DiaTrace.
4. **Non-automated camera**
   Photographic cameras that are not automated – the participant is in control of when photographs are captured. Includes disposable cameras, digital cameras, video cameras and mobile phone cameras. Often include time stamps to record when the image was taken. This category also includes software and/or algorithms for processing digital images. Cameras can be used in two ways:
   a. **To complement diet diary or diet recall**
   b. **To replace traditional methods**

For each technology category, at least two exemplars were chosen, and all studies involving the exemplar were included in data extraction and synthesis. In this way, conclusions about the advantages, disadvantages and suitability of a technology category were based upon the exemplars, with an assumption that tools within each category share similarities.

Efforts were made to limit bias in selecting exemplars (both investigator and publication bias) by pre-specifying desirable criteria. Exemplars were selected where there was the most complete evidence available. If more than one tool offered a broad range of data, tools in English and used in the UK were prioritised.

The following criteria were identified:

1. Tools based in English language
2. Tools for which there is information on validity (including relative validity)
3. Tools for which there is information on the user experience (such as participant burden, acceptability, adherence etc)
4. Tools for which there is information on costs and resource implications
5. Tools which have been designed for or used in a UK population/sample
6. Tools that have already been employed in other national dietary surveys.

After selection, the exemplars were confirmed as appropriate by the Steering Group (Steering Meeting 2, Appendix A).

2.1.6 Data extraction and synthesis

Relevant data were extracted from the records relating to the chosen exemplars, using the data extraction function in EPPI-Reviewer 4. Data were extracted by a single reviewer. The following information was extracted (if applicable):

- Publication aim
- Details of the exemplar
  - name of tool
  - description
  - requirements for use (e.g. internet access, phone type, software etc)
  - whether a complement or replacement for traditional methods
  - development stage of tool (if known)
  - underlying nutrient database
- Study type (e.g. feasibility, validation, descriptive etc)
- Participant/user information (e.g. country, age, gender, ethnicity)
- Details of study design
- Statistical treatment
- Findings
- Traditional dietary assessment comparator
- User reports of acceptability and/or ease of use
- Aspects of participant burden (e.g. time to complete, portability of tool etc)
- Aspects of researcher/survey manager burden (e.g. time estimates, personnel requirements etc)
- Cost estimates or cost-effectiveness results

Due to the heterogeneity of the literature, meta-analyses were judged inappropriate, and a narrative synthesis was the approach adopted for presenting the results of the literature review.

The extracted data for each individual study were collated in tables (Appendix H). Using this information about exemplars, a summary was drawn up for each new technology category. The summary considered the study findings in context, drawing comparisons where possible between technology categories and with traditional dietary assessment tools. Consideration was given to the quality of the available evidence (see below).

2.1.7 Quality appraisal

Given the anticipated heterogeneity of the literature, a single tool to assess the quality of all included studies would not be appropriate. The decision was made at the outset of the project to apply a quality appraisal tool to validation studies of the exemplar tools only.

A scoping search of existing quality appraisal tools revealed an existing tool developed for dietary intake validation studies [22]. However, there were a number of drawbacks identified in this tool: firstly, the tool involved a weighted summary score system, an approach which has been widely discouraged [23-25] ; and secondly, the authors do not present an indication of reliability or repeatability in describing the development of the tool, therefore information is lacking on a key element of validity for assessing quality [26]. As a result, a new quality appraisal checklist was developed for this review (see Appendix I).

The quality checklist was developed by the literature review team. Initial decisions were made about the concepts and purposes guiding the checklist development: namely, that the tool should comprise a checklist without involving summary scores; that the checklist items concern the quality of a study and not the quality of reporting; and that the checklist be easily adaptable to the purposes of other reviews. Checklist items were then proposed and chosen using a consensus-based methodology. Item selection was guided by the STROBE statement [27], which, although intended as guidance for the reporting rather than quality appraisal of studies, may be presumed to include aspects of study design associated with susceptibility to bias [23]. The study features addressed by the checklist items include: sample size, sample representativeness, response/drop-out rate, reference dietary assessment tool (comparator), outcomes, data collection timing, reliability, analysis and conflicts of interest. Items were included on the checklist only where evidence existed indicating its association with potential for risk of bias.

Following agreement on the wording and presentation, the quality appraisal checklist was used with a randomly selected pilot sample of validation studies featuring exemplar tools (n=5), by two independent reviewers. Discussion of the ratings indicated some necessary clarifications and refinements. The amended checklist was then used to assess the quality of all the validation studies of exemplars included in the review. This was done independently by the two reviewers. Disagreements were resolved by discussion without the need for third reviewer arbitration.

For the purpose of synthesising the validity findings, studies were categorised as: meeting all or most of the checklist criteria (‘++’), some of the criteria (‘+’) or few or none of the criteria (‘-‘) (see Appendices G & H). Studies were not excluded on the basis of quality appraisal, but study quality was taken into account when judging the strength of evidence available.

2.2 Literature review results

2.2.1 Search results

The number of records identified from the database searches and uploaded into the EPPI-Reviewer database was 4,977. A further 61 records were identified through other sources (see Appendix E) and added to the EPPI-Reviewer database. Following de-duplication, there were 3,840 records. First pass screening (searching for dates and terms such as 'animal' within EPPI-Reviewer) eliminated 406 irrelevant articles. A further 2,711 articles were excluded as ineligible following the screening of abstracts against the criteria.

Full-text records were obtained for 723 records. After the third pass screening against the criteria, 365 records were judged as eligible for inclusion in the review: 277 full-text documents, 81 records for which abstracts only were available, and seven articles published in languages other than English. Thirteen abstracts were excluded after linking them to the matching full text article, leaving 352 eligible references.

Following the re-screening against the additional eligibility criteria, a further 61 articles were excluded. A total of 291 records were judged eligible for inclusion, seven of which were non-English. 27% of the eligible records (80 of 291) was grey literature.

The screening process and reasons for exclusion are summarised in Figure 1.

Figure 1 Flow chart of literature screening

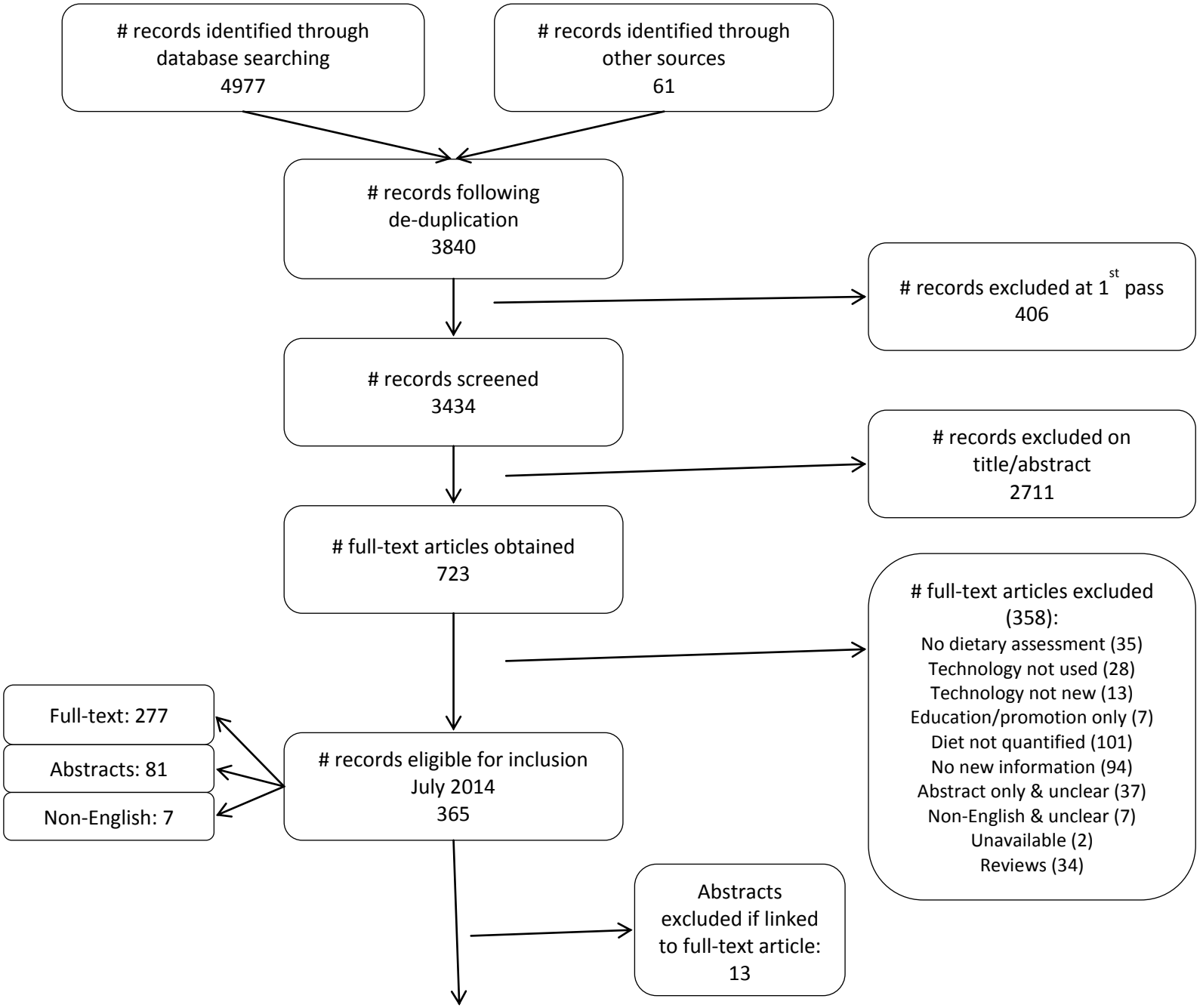
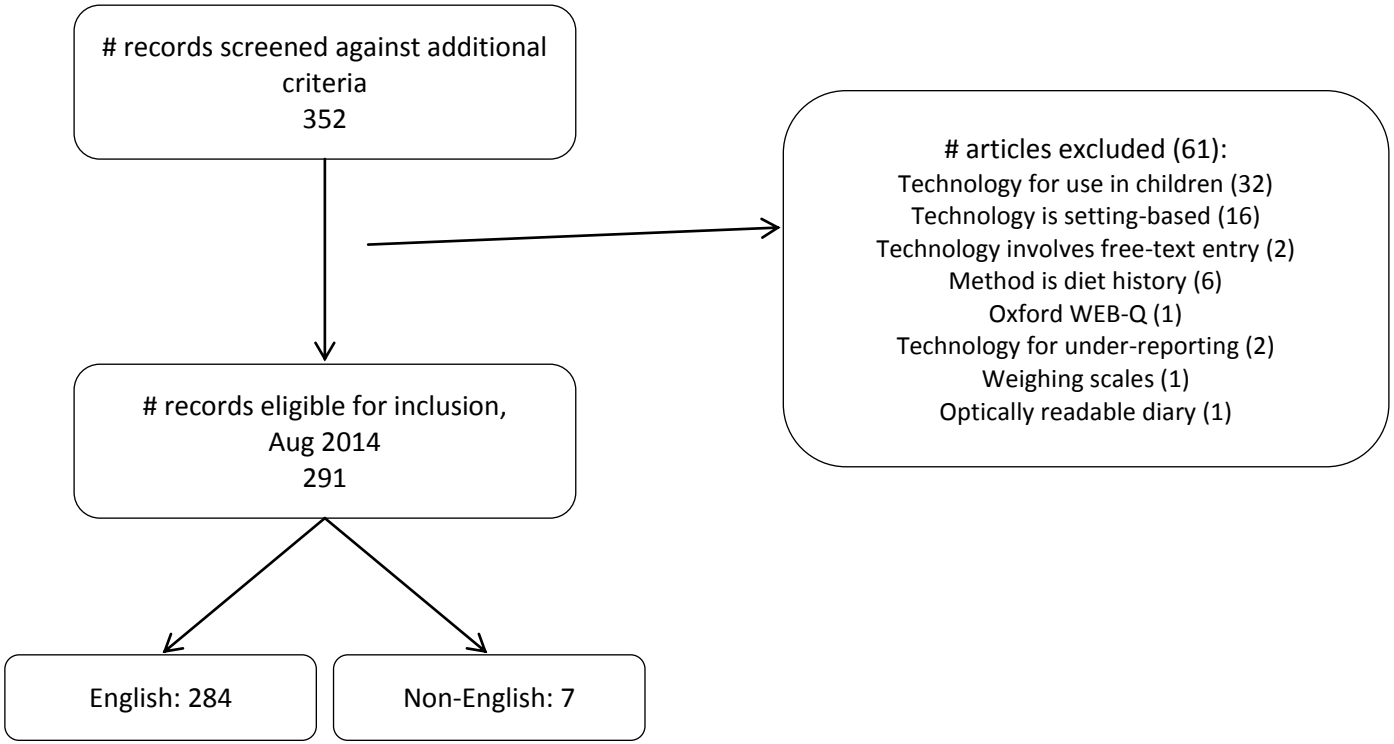


Figure 1 (cont'd)



2.2.2 Itinerary of new technologies

The 291 records contained data on 148 different tools. In addition, a further tool was identified via expert solicitation, for which no references or records were supplied (DietIreland, a web-based 24-hour recall tool). The tools were categorised into 11 technology types to begin with. These are shown in Table 1, along with the number of tools making up each category and the number of associated records.

Table 1 Records and tools for each technology category

Technology category	Number of records/papers	Number of tools
Interviewer-led computerized 24hr recall*	49	9
Self-administered computerized recall/diary*	12	8
Web-based diet diary	37	21
Web-based 24hr-recall	46	16
Mobile phone app	29	24
PDA	27	15
Non-automated camera to complement diet diary or recall	17	16
Non-automated camera to replace traditional methods	67	34
Automated camera to complement diet diary or recall*	5	2
Automated camera to replace traditional methods*	5	3
Bar code scanner*	1	1

* subsequently excluded; exemplars not selected for this category.

All of the tool names (or first authors of papers in which tools do not have a specific name) are shown in the itinerary in Appendix F. A bibliography of associated references is provided in Appendix G.

Tools and technologies in development, for which no associated records or details are available, were identified through grants registries. Details of grant titles and descriptions are shown in Appendix E: 24 grants were identified as eligible (prior to the additional eligibility criteria agreed in the interim meeting).

2.2.3 Selection of exemplars

Within the five chosen technology categories (see Section 2.1.5), the total number of eligible records was 223, featuring 126 tools (Table 1).

From the five categories of technology, 12 exemplars were selected, for which there were 66 records or publications. Justification for each exemplar choice is described in Table 2. A description of each exemplar is presented in Table 3 below.

Table 2 Exemplars selected for each technology category and justification for selection

Technology category	Exemplar name	Reason for exemplar selection
Self-administered online diet diary	MXS-Epidemio [28, 29]	This tool is in French, but was the only tool in this category to include information on both validity and acceptability.
	The Biggest Loser [30-35]	This was the only English language tool that had attempts at validation using DLW (although no real information on user experience or acceptability).
Self-administered online 24hr recall	ASA24 [36-49]	ASA24, a US tool, had a validation study, as well as user experience data.
	SCRAN24/INTAKE24 [50-53]	SCRAN/INTAKE24 met the most criteria.
	NutriNet-Sante [54, 55]	NutriNet-Sante (a French language tool) included cost information as well as acceptability and validity.
Mobile phone app & PDA	MyMealMate, MMM [56-58]	This tool scored best against the criteria amongst the mobile phone apps, including information on both validity and acceptability, as well as being UK-developed.
	BalanceLog [59-63]	Amongst PDAs, this tool scored equally against the criteria as DietMatePro. However, BalanceLog was • used in a variety of samples whilst DietMatePro was tested in weight loss samples only; and • included DLW validation as well as relative validity.
Non-automated camera To complement diet diary or diet recall	Long et al [64]	This tool scored best against the criteria although there was no information available on validity and it was not UK-based.
	NANA [65, 66]	NANA scored best against the criteria, included information on validity, and is UK based.
Non-automated camera To replace traditional methods	Remote Food Photography Method, RFPM [67-71]	The RFPM and the mpFR met the same criteria: both had information available on acceptability and validity, although no cost information.
	Mobile telephone food record, mpFR [72-93]	
	Nutricam [94]	Nutricam presented data on usability and validity, and is designed for adults in general.

Table 3 Descriptions of exemplar tools

Exemplar	Description	User requirements (equipment, training)	User group(s)*	Primary purpose dietary assess-ment?	Real-time feed-back?	Quantification of nutrient intake	Development stage & current usage
Web-based diary							
The Biggest Loser [30-35]	• Users search for each food item and select the best match in the pre-coded database. • Data captured by commercial company (SP Health) and provided to researchers. • English language	• Computer, internet connection • 30min group training session	Overweight adults; Australia-based	N (Weight loss)	Y	• A commercial Australian database which modelled nutrient values from the Nutrient Data Tables for use in Australia (NUTTAB) 1995, plus manufacturer data • Users asked to enter weight of food, household measures or standard portions • Some food/drink combinations pre-coded; users can create own combinations but not enter own individual food items.	• Fully developed & commercially available. • Currently only used in small scale research • UK version of the website is available
MXS-Epidemio [28, 29]	• Users log in online using unique identifier and password. Food items logged for each meal occasion, using drop-down lists or search function. • Processing of data unclear • French language	• Computer, internet connection • User manual	French 18- to 60-year-olds	Y	N	• Underlying database not reported • Web tool includes portion size photographs	• Fully developed • Currently used in French survey CCAF • No UK or English language version
Web-based recall							
ASA24 [36-49]	• 'Respondent website' modelled on USDA multiple pass method: Participants report foods and drinks by browsing food lists or searching. Probes ask for food-specific details. • An animated guide and audio/visual cues are used to instruct participants. • Optional modules allow researchers to query where meals eaten, who with, TV usage and supplement use if desired. • The 'Researcher website' is used to manage data collection and obtain analysis files. • Foods and drinks are automatically linked to codes from FNDDS. • Available in English and Spanish.	• Internet connection, standard computer monitor • Unclear amount of training necessary for participants	All US based: adults, older adults, 8-13-yr-old children, diverse ethnic backgrounds	Y	N	• Uses codes from USDA Food and Nutrient Database for Dietary Studies (FNDSS). • 7765 individual food/drink codes • Portion size images (n= 9730) • Participants must enter individual components of recipes.	• Version 2014 freely available to researchers, clinicians and teachers • Used in several large-scale studies to date • Canadian version in development • No UK version in use, but other UK versions have been developed (myfood24, INTAKE24)

Exemplar	Description	User requirements (equipment, training)	User group(s)*	Primary purpose dietary assess-ment?	Real-time feed-back?	Quantification of nutrient intake	Development stage & current usage
INTAKE24 [50-53]	• Updated version of prototype SCRAN24. • Includes a researcher interface and a user interface. Users enter food and drinks based on multiple pass method. Free text searches only. Meal/snack time slots can be edited by user. • Items coded to match NDNS RP codes.	• Computer, internet connection • Require-ments for training not specified	11- to 24-year-olds, UK –based	Y	N	• Food codes match NDNS RP Year 4 Databank codes. The food list and portion size estimation can be updated by researcher. • Approx 1500 items • Approx 2500 photographs of food portion sizes; all previously validated. • Unclear how composite dishes handled	• Developed but only used in feasibility/validation studies to date (at the time of writing, FSA Scotland has released a call for wider feasibility/validity study) • UK developed tool
NutriNet-Sante [54, 55]	• Interactive 24hr recall on the internet. Participants record foods in a meal-based approach: browsing foods via a classification tree; using a search engine; or manually. • For each food chosen, a list of associated items is proposed. Automated reminders of common foods. • Nutritional values are estimated using French food composition tables (unclear if this is manual or automatic) • French language.	• Computer, internet connection • Detailed instructions are provided on the website in several forms: PDF, video, tips.	Older French adults, 48- to 75-year-olds	Y	N	• French food composition tables are used • Portion size photographs are offered for 250 foods, in 3 different sizes. Participants can choose between 7 choices of amounts, or directly enter a known quantity. • Common recipes used by researchers to assign nutrients to composite dishes.	• Fully developed and in use • Used in the large French cohort study, NutriNet-Sante • Not used in UK
PDAs & mobile phones							
My Meal Mate (MMM) [56-58]	• Foods are selected and logged using the app. Favourite meals can be stored in memory, user's photographs can be used to prompt memory when completing. • Data are uploaded automatically to secure online SQL database.	• Smartphone • 90 mins training session given for validation study	Overweight & normal-weight adults, UK-based	N (Weight loss)	Y	• App uses commercial Weight Loss Resources database [95] • 40,000 food/drink items • Tool contains default portion sizes; participant needs to over-ride default if necessary • Combination items, favourites & recipes can be saved by participant	• Fully developed - available from app store • New version database in development to include full range nutrients • Currently only used in small scale research • UK based
BalanceLog [59-63]	• Software for PDA that allows selection of foods consumed from drop-down lists. • Data must be uploaded by researcher to centralized computer. • Upload is made in pdf format.	• PDA, soft-ware. Data up-loaded to researcher PC. • 20-25mins training	US: military personnel, pregnant low-income women, diabetic adults	N (Diabetes monitor-ing)	Y	• Uses nutrient values from USDA, users able to expand database with user-defined food label information. • >4,300 food/drink items • Standard portion sizes offered as default, user has option to modify. • Option to add own recipes and meals.	• Commercial, used in small-scale studies • No longer available

Exemplar	Description	User requirements (equipment, training)	User group(s)*	Primary purpose dietary assess-ment?	Real-time feed-back?	Quantification of nutrient intake	Development stage & current usage
Non-automated camera complements							
Long et al [64]	• Mobile phones are used to take photos at each eating/drinking occasion. Images then used by participant when filling out web-based recall at end of day. • Images are not processed, but used as a prompt for the participant. Data processing will depend on complementary method used (e.g. on the 24hr recall tool used).	• Camera-enabled mobile phones. • One training/practice session required	US-based adults, 18-31 years	Y	N	• Nutrient analysis depends on complementary method. • Portion size interpreted by participant from photographic image.	• N/A (any camera-enabled phone can be used) • In the UK, disposable cameras have been tested [96]
NANA [65, 66]	• A touch-screen computer designed for older adults. Foods about to be eaten are selected using a pictorial food tree, and a photograph of the meal is taken before consumption. Voice recordings are used for food away from home. • Data need analysing using separate nutrient anaylsis software (e.g. Windiets)	• "Eeetop" touch screen computer, plate guide mat, web camera • Training not specified	Older adults (65y and over), UK-based	Y	N	• Portion sizes estimated by researcher from photographs taken by tool. • Unknown how composite dishes are treated.	• Used in development and feasibility studies only • Method for automated image analysis being investigated • NANA is UK developed
Non-automated camera replacements							
Remote Food Photography Method (RFPM) [67-71]	• Users take photographs of foods and drinks before consumption, and of leftovers. Text (or audio) notes are made to identify the food. • Photos are transferred to the network in near real-time. Prompts can be sent (e.g. if no data received). • An 'archive' contains ~2,500 images of foods of differing portions, matched to energy and nutrient data. User images can be matched to these by researcher or using semi-automated process.	• Camera-enabled mobile phones, Centralized software (Food Photography Application) • 20-30mins user training session.	All US-based: multi-ethnic, adults, overweight adults, pre-school children	Y	N	• USDA Food and Nutrient Database for Dietary Studies (FNDSS), or manufacturer details • Portion size estimation done by researcher or semi-automated process by matching to archive of food portion images (~2,500) • Unclear how composite dishes are handled	• Fully developed • Automated image processing system in development • Used in small-scale research only • Not applied in UK to date

Exemplar	Description	User requirements (equipment, training)	User group(s)*	Primary purpose dietary assess-ment?	Real-time feed-back?	Quantification of nutrient intake	Development stage & current usage
Mobile phone food record (mpFR) [72-93]	• System incorporates a network-enabled mobile phone with a built-in camera and methods for automated image processing. • Participants take photographs before and after eating; images and metadata relayed to server via network. • Automatic image processing identifies volume of food consumed; user is asked for confirmation of food identification and volumes before being linked to FNDSS. Every entry time is stamped. Alternative food entry (and barcode scanning) methods are available if photographs are not possible.	• Camera-enabled mobile phone, fiducial marker (checker-board) • Training required but details not provided	Adolescents (11-18yr) and adults (age 20-65yr) in US	Y	N	• Foods and drinks linked to FNDSS after identification. • Portion sizes estimated automatically via image processing algorithms; confirmed as correct by participant. • It is not clear how image processing handles composite dishes	• Prototype used for testing and feasibility studies only • Not applied in UK
Nutricam [94]	• A mobile phone program used to photograph foods before consumption and make a voice recording to describe the contents. • The information is sent to website to be analysed by a dietitian.	• Mobile phone • Require-ments for training not detailed	Diabetic adults in Australia (aged 48-70years)	Y	N	• Dietary data manually entered into analysis program (FoodWorks v5.1). • A prompt card was included in photographs as a size reference. Subjects were not specifically instructed to state portions. During analysis, quantities were estimated by researcher. • Unclear how composite dishes handled	• Only featured in feasibility studies to date • Unclear if available in UK

* 'User group(s)' refers to the users in which the exemplar has been applied or evaluated.

Abbreviations: CCAF - Comportements et Consommations Alimentaires des Français (a French population survey); FNDSS - Food and Nutrient Database for Dietary Studies (US); NDNS RP – National Diet and Nutrition Survey Rolling Programme (UK); PDA – Personal digital assistant; USDA – United States Department of Agriculture

2.2.4 Summary of evidence

The main findings of each study reporting on an exemplar are described in Appendix H. A summary of the evidence for each technology type (category) is presented below. The evidence is summarised under three main domains:

- **Validity** (incorporating evidence of accuracy, relative validity, repeatability);
- **Acceptability** (refers to evidence of user experience, including participant burden, adherence, preferability, ease of use, accessibility); and
- **Resource use** (includes direct as well as indirect costs, such as implications for researcher burden).

Where numbers of studies are given for each of these domains, it should be borne in mind that some records contain information on more than one study, and therefore the number of studies and number of records are not necessarily equal.

A note on the interpretation of validation studies
Validation studies tend to report a mean difference between estimates of energy intake given by the exemplar and those given by the reference measure. Where limits of agreement are reported, these give an indication of the range of differences at the individual level within which 95% of the sample falls. The wider the limits of agreement, the larger the differences between daily energy intake estimates for some individuals. Limits of agreement will be influenced by sample sizes. Several validation studies reported very small mean differences (as small as 1kcal, for example [40]), which could be an indication that new technologies show promise in terms of validity. However, it is difficult to interpret mean differences in the absence of information about the variation at the individual level, or where limits of agreement have been calculated using a small sample.

2.2.4.1 Web-based diary

Evidence was available from 4 articles relating to 2 exemplars (The Biggest Loser and MXS-Epidemio). Three of the articles presented data on aspects of validity. The other article presented results of an adherence study [35].

There was no evidence of using this technology type in a population applicable to the NDNS RP. Studies were based in either Australia (The Biggest Loser [30, 33, 35]), or in France (MXS-Epidemio [28]). The French sample was drawn from a population survey (CCAF) of adults. The Biggest Loser features a web-based diet diary as part of a self-monitoring programme for weight loss, and the evidence is limited to weight-loss samples.

Two studies (of poor to moderate quality) compared energy intakes estimated by web-based diary to objective measures of energy expenditure: using indirect calorimetry [33] or doubly labelled water (DLW) [30]. Relative to indirect calorimetry, mean EI was found to be about 2800kJ lower (about 660kcal) using an online diary (n=11)[33]. Relative to DLW, mean EI from online diaries was 2301kJ (550kcal) lower (n=12) [30]. A 20% underestimation (relative to DLW) was reported with the online diary [30], albeit in individuals motivated to lose weight.

One study (of poor quality) assessed the relative validity of a web-based diary, finding a small mean difference in daily energy intake compared to paper-based diaries in a general

population (-50kJ, -12kcal; n=246))[28]. Comparing rates of estimated under-reporting based on energy intakes, a different study (of poor quality) found similar rates to traditional methods [33].

There was no evidence relating to participant burden of web-based diaries, such as completion times.

Adherence to dietary recording using web-based diaries was reported within the context of a weight management intervention only.

In terms of acceptability, it was reported that 77% of a French adult population (n=246) showed a preference by opting to use the online diet diary rather than a paper version [28].

There was no evidence of resource implications presented for the exemplars.

2.2.4.2 Web-based recall

Thirteen records offered evidence on the exemplars in the web-based 24-hour recall category. Eleven studies related to aspects of the new technology's validity. There were also 4 usability studies [45, 46, 51], and 1 feasibility study reporting adherence [42].

Evidence from these studies was partially applicable to the NDNS RP population. Samples were drawn from the US (ASA24), the UK (INTAKE24) and France (Nutrinet-Sante). The French sample consisted of adults from the general population. All the evidence surrounding INTAKE24 was drawn from samples of adolescents and young adults only (aged between 11 and 24 years). ASA24 has been applied more extensively, in samples of adults, children (8 to 13 years) [36] and older adults [38]. One study was conducted in overweight adults [37].

With reference to objective measures of energy intake, there was one study (of moderate quality) which compared web recall estimates with directly observed consumption [40], and no studies conducted using DLW as the reference measure. Estimated energy intakes from ASA24 were on average higher than directly observed intakes by 4-1099kJ (1-263kcal) [40].

The remainder of the validation studies examined relative validity of web-based 24-hour recalls: 6 compared against interviewer-led 24-hour recalls [12, 36, 38, 44, 53, 55], 3 compared against diet diaries (1 of which was weighed) [37, 39, 51], and 2 studies specifically investigated portion sizing accuracy [46, 51]. The studies presented mixed findings. In US adults (moderate quality studies), mean estimates of EI using ASA24 were lower than diary estimates by 79-439kJ (19-105kcal) (n=28, n=93 respectively) [37, 39], but were marginally higher than interviewer-led recalls (25kJ, 6kcal; n=1200)) [44]. In French adults (n=147), comparison of web-based and interviewer-led recalls (moderate quality study) showed a mean difference of -145kJ (-35kcal) for men and +23kJ (5kcal) for women [55].

In older adults (moderate quality study; n=47), mean ASA24 estimates of energy intake were 439kJ (105kcal) lower than interviewer-led recall, with a lower range [38]. In addition, six of 37 older participants recorded implausibly low energy intakes using ASA24 (compared to none when giving interviewer-led recalls) [38].

In adolescents (poor to moderate quality studies), SCRAN24 underestimated EI by 20% compared to parent records (n=40), INTAKE24 by 130kJ (31kcal) compared to interviewer-led recall (mean ratio 0.97, limits of agreement 0.52 and 1.82; n=52) [51, 52]. Furthermore, 83% male and 66% female adolescents were judged to be under-reporting with INTAKE24 using the Torun cut-offs [52] – this compares to rates of 54% 11-14-year-old males and 52% 11-14-year-old females in the NDNS RP. In 11-24-year-olds, underestimates in EI of 638kJ (n=20) and 82kJ (n=167) (153kcal and 20kcal respectively) were found in two studies [52, 53], compared to interviewer-led recalls.

In young adults (moderate quality study; n=115), INTAKE24 underestimated EI by 60kJ (14kcal) compared to interviewer-led recall, with a mean ratio close to 1.00 (0.99) but wide limits of agreement (0.50, 1.97) [52]. 45% of energy values were within 10% of the interviewer-led recall estimates and 100% were within 50% of interviewer values.

The evidence relating to participant burden was scant. Mean completion times were reported from 13 minutes for 11-24-year-olds using INTAKE24 to 31 minutes for Nutrinet-Sante [53, 55]. Touvier et al (2011) [55] reported that 26% of Nutrinet-Sante participants took more than one sitting to complete a day's intake.

In terms of acceptability, a greater proportion of adults preferred the web-based recall to interviewer-led [44]; however, in older adults 48% preferred the interviewer-led method [38]. High completion rates were found for a web-based study, of 90% [42], but the rate was lower amongst older adults and many (44%) failed to launch ASA24 at all [38].

Fifty seven per cent of 8- to 13-year-olds reported ASA24 was easy to use [36] and 51% of older adults [38]. Amongst children, reported usability issues included confusion, and not knowing details of foods consumed (e.g. preparation methods) [36, 51].

Evidence of resource implications was available only for the Nutrinet-Sante study [55]. Costs associated with setting up materials and interface for Nutrinet-Sante were €150,000 over 9 months. Additional costs of €38 per subject were given for each interviewer-led recall, but no additional costs were incurred by web-based recalls [55].

2.2.4.3 PDA and mobile phone apps

There was a total of 7 records from which evidence could be extracted. Two studies presented information on validity and 4 studies addressed elements of user acceptability.

Evidence relating to the UK-developed mobile phone app My Meal Mate (MMM) may be partially applicable to the NDNS RP, using a UK sample, although the sample was not representative of the population. The other evidence (BalanceLog) came from US-based samples. Both exemplars featured prospective methods of logging dietary intake.

One study (of moderate quality; n=26) compared estimates of energy intake from handheld technology to DLW [60]. The findings indicated an under-estimation of energy by a mean of 1154kJ (276kcal) with wide limits of agreement.

The evidence of relative validity (moderate quality study; n=49) suggests that handheld technologies gave lower mean energy intake estimates than interviewer-led 24-hour recalls, ranging from a difference of 68kJ to 441kJ (16kcal to 106kcal). Limits of agreement were wide [56].

Adherence to dietary recording was only reported within the context of weight management trials: rates of 20% (recording ≥12 meals per week) [63] and 16% (daily recording) [58] over 6 months were reported.

Indications of participant burden came from 2 studies. Time taken to complete a day's intake on MMM was 16 minutes, compared to 19 minutes for web-based diary and 15 minutes for a paper diary [58]. Usage statistics suggest that 20% foods are entered retrospectively on the following day [58]. Sevick et al (2008) [62] reported that those with problems with fine motor skills may experience difficulty with handheld devices.

Of the acceptability studies, there was 1 usability study [59] and three which reported acceptability in randomised controlled trails (RCT) [57, 62]. Other acceptability outcomes were reported from validity studies [56, 60].

When compared to other methods, PDAs or mobile phones were rated more positively than other methods on a number of aspects [57-60]. However, the elderly, and those with no computer experience may experience difficulty with handheld devices [62]. Participants who dropped out of studies may have done so because they did not like using the equipment [57].

There was an absence of evidence regarding resource implications associated with the exemplars.

2.2.4.4 Non-automated cameras to complement diary or recall

There were 3 articles offering evidence on this type of technology: 1 featuring a usability study [64] and 2 describing aspects of validity [65 66].

In terms of applicability to the NDNS RP, an absence of evidence was identified in the use of this technology type for the purposes of dietary assessment in a general population. The evidence is derived from NANA, designed for and assessed in samples of older adults, and a study intended to assess photography for the purposes of self-monitoring and dietary improvement [64].

There was no evidence available concerning the validity of the exemplars with reference to objective measures of energy expenditure or intake.

There was 1 study (of moderate quality; n=40) which assessed the relative validity of this technology type, comparing NANA estimates against both interviewer-led 24-hour recalls and paper-based diaries [66]. NANA was found to underestimate EI (compared to paper diary) by a mean of 287kJ (67kcal), with wide limits of agreement [66]. A further study addressed NANA's reliability [65], finding the tool to be reproducible [65].

There was no evidence relating to participant burden associated with the exemplars.

In terms of acceptability, the study of Long et al [64] reported that most participants found photographing food to be acceptable and helpful for memory, but a minority reported finding it awkward.

No evidence was available regarding resource implications of this technology type.

2.2.4.5 Non-automated cameras to replace traditional methods

There were 15 records which described evidence relating to non-automated camera methods intended to replace traditional dietary assessment methods. Eight of these pertained to validity of this technology type, and there were 9 usability or feasibility studies reported.

Regarding applicability of the evidence to the NDNS RP, there was no evidence of this technology type in use in the UK. Studies were all based in either the US (RFPM and mpFR) or Australia (Nutricam). Exemplars were applied in a variety of samples, including adults (6 studies), adolescents (6 studies, mpFR), overweight adults (1 study), pre-school children (1 study) and diabetic patients (2 studies, Nutricam).

There were 4 studies comparing energy intake estimates to objectively measured energy: one validity study (of good quality) featured direct observation [69], whilst 3 (of moderate quality) compared against DLW [70, 94]. Estimates of energy intake were lower than objective measurements in all studies. The findings of one study [70] suggested that validity improved with more involved training and prompting of participants.

Only 1 study (of moderate quality; n=10) offered evidence of the relative validity of non-automated cameras [94]. Compared to weighed paper-based diaries, 50 items recorded in the diaries were omitted from the photograph records. 50% of these items were beverages.

Two validity studies (of poor quality) compared against expected energy requirements, as opposed to measured estimates (n=15; n=12) [84, 85]. They reported no significant difference between the energy intake estimates of mpFR compared to estimated energy requirements.

A further 4 studies assessed the validity of food classification methods, either automated or by dietitians. Inter-rater reliability of dietitians classifying foods from photographs was high [69]. Automated classification could reach accuracy of 97% for test images [91], but there could be significant differences in energy estimates (by up to 961kJ, or 230kcal, overestimation) [77], and a minority of images could not be analysed due to quality [69]. Adults were more likely than adolescents to need to take multiple images, but also more likely to obtain a useful image (95% adults vs 84% adolescents) [75, 87]. The reliability of using photography to capture energy intake across 6 days was moderate (ICC 0.74) [70].

Studies reported on a variety of aspects of participant burden. One study described that the majority of participants (75%-98%) found it easy to carry extra equipment (ie the study

phone and/or a fiducial marker[2]) [73, 75, 87]. In another study, time to complete was less than a paper diary in 6/10 participants; for 2 participants the time taken was the same and for 1 it was longer [94]. Furthermore, 1/10 participants reported changing their dietary habits in response to the photography method, compared to 4/10 using a weighed paper record [94]. Pilot studies have also highlighted issues with memory, lighting, and the accompanying descriptions of food items using this technology type [69].

Studies reported high proportions of participants preferring photography methods to paper diaries, from 70%-100% [69, 94]. Overall ease of use was reported as high with 91%-100% of adults describing photography methods as easy [69, 70, 75, 94]. Proportions were lower amongst adolescents (79%) [86] and mothers of young children (80%) [71]. Reports of ease of use outside the home varied considerably, depending on the sample [71, 74, 94]. There was some evidence that adolescents felt the method interfered socially [74]. Ease of remembering to take photographs was higher for meals than snacks, and remembering to take images after meal and snacks was seen to be easier than beforehand [86, 87].

There was no evidence apparent relating to the resource implications of this technology type.

2.2.4.6 Quality of evidence

A total of 25 validation studies, reported in 24 references, were appraised in terms of quality. Of these, 1 study was agreed to be of good quality [69], 17 of moderate quality, and 7 of poor quality. Records were not excluded from the review on the basis of quality. Results of the quality appraisal are displayed in Appendix J.

Studies validating web-based diaries (n=3) scored the poorest in terms of quality. The appraisal suggested that the conclusions in 2 of the 3 studies would be likely to change if criteria were met.

Validation studies of web-based 24-hour recalls were the most numerous (n=11), and all but 2 (which were poor quality, featuring INTAKE24 [51, 53]) were rated as moderate quality. None of the studies in this category were rated good quality.

One study each validated a PDA [60] and a mobile phone app [56]. These were both moderate quality.

Non-automated cameras intended as a complement were the least validated, with only 1 validation study available (validating NANA [66]). This study was of moderate quality.

The only validation study rated as good quality was found in the non-automated camera replacement category [69], assessing the Remote Food Photography Method (RFPM). Other validation studies in this category varied in terms of quality, with 3 studies rated as poor quality [71, 84, 85]. Two of the 3 studies validating the Mobile Phone Food Record (mpFR) were poor quality.

[2] A fiducial marker is an object that is placed within the photograph frame and provides a reference for dimensions and lighting.

Very few studies addressed repeatability or reliability of the tools – only 3 studies met this criterion [69, 71, 94]. Other common issues with study quality were with sample size (7 studies met this criterion) and representativeness (6 studies met this criterion).

3. Qualitative research

3.1 Aims

NatCen Social Research was sub-contracted to carry out a small piece of qualitative research as part of a study undertaken by the University of Leeds for Public Health England and the Department of Health.

The overall aim of the study was to inform Public Health England of the range of new technologies currently available or in development which have the potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme (NDNS RP).

The aim of the qualitative research was to gather perspectives from recent NDNS RP participants, as well as from members of the public who had not participated in the NDNS RP, on the potential use of new technologies in the survey.

The qualitative research focused on the following technologies, which were identified as being of particular interest through the literature review carried out by the University of Leeds:

- recording dietary information using an app on a smartphone or tablet computer
- recording dietary information on a website using a laptop or other computer
- taking photos of food and drink using a mobile phone, digital camera or disposable camera.

3.2 Methods

3.2.1 Interviews with recent NDNS RP participants

12 in-depth interviews were carried out by telephone with recent NDNS RP participants.

The participants were drawn from a sample of people who had taken part in NDNS RP in 2013/2014 and had given permission to be recontacted. They were offered a £20 high street gift card as an incentive.

The participants were men and women (50% each) living in all four nations of the United Kingdom (4 from Wales, 4 from England, 3 from Northern Ireland and 1 from Scotland), mainly in small towns and rural areas. These geographical areas were selected to counterbalance the focus group samples which were based in cities. Participants' ages ranged from 21 to 86: 4 were aged between 21 and 39, 4 were aged between 40 and 65, and 4 were over 65.

The main topics discussed in the interviews were:

- participants' use of new technologies
- experiences of taking part in NDNS RP
- any other experiences of recording what they eat and drink
- views on recording dietary information using an app on a mobile device (a smartphone or tablet)
- views on recording dietary information on a website accessed through a laptop or other computer

A copy of the topic guide can be found in Appendix K. The interviews were recorded and transcribed with the participants' consent.

3.2.2 Focus groups with members of the public

Four focus groups were conducted with members of the public aged 19 and over who had never taken part in NDNS RP.

Two focus groups took place in London and two in Manchester. Two of the groups (one in each city) were with people who identified themselves as smartphone or tablet users. The other two groups were with people who used neither type of device (or had very limited use of these devices). Participants were offered £30 as an incentive.

There were six to eight participants in each of the groups, which were mixed in terms of age, gender and ethnicity. Focus groups of smartphone and tablet users (n=14 participants) were 57% male, with an age range of 21 to 57 years: 5 were aged between 21 and 29, 5 were between 30 and 49, and 4 were over 50 years. Focus groups of non-users (n=14 participants) were 50% male, with an age range of 21 to 70: 3 were aged between 21 and 29 years, 4 between 30 and 49 years, and 7 were aged 50 and over.

The main topics discussed in the focus groups were:

- participants' use of new technologies
- any experiences of recording what they eat and drink
- views on recording dietary information in a paper diary
- views on recording dietary information using an app on a mobile device (a smartphone or tablet)
- views on recording dietary information on a website accessed through a laptop or other computer

A copy of the topic guide can be found in Appendix K. The discussions were recorded and transcribed with the participants' consent.

The transcripts formed the basis of a thematic analysis. The first stage involved reading the transcripts, identifying key themes, and summarising the participants' comments in relation to each theme. The next stage involved searching for patterns and differences between groups, such as contrasts in participants' perspectives associated with their use of

technology, age and location. The final step was to draw conclusions about the potential of the various technologies for the NDNS RP.

3.3 Findings

3.3.1 Attitudes to technology

A clear pattern was evident between the attitudes of those who regularly used mobile devices (smartphones and/or tablets) and those who did not. This was true across both the focus group participants and the telephone interviewees. Whilst technology use formed the basis of focus group selection, it was not a recruitment criterion for the telephone interviews.

3.3.1.1 Non-users of mobile devices

Among participants who did not use mobile devices there was a range of experiences and attitudes to technology. Some participants were uncomfortable with any kind of electronic device. They had minimal experience of computers and no confidence about using them. These people tended to be in their 60s or older, and often referred to their age when explaining their lack of technological prowess:

> *"When you get to my age, machines are very, very hard to keep a trace of. For example, your mind or your memory isn't as sharp as it was ten years ago."*
> (Mobile device non-user, recent NDNS RP participant)

People who did not use mobile devices were sometimes regular users of laptops or desktop computers, which they used for functions such as browsing the internet, listening to music, email, social media, shopping and banking. Despite this, they tended to lack confidence with technology and did not particularly enjoy it. Several described themselves as "*technophobes*". They tended to be younger than the participants who were uncomfortable with technology of any kind – some of them were in their 40s. They were wary of smartphones and tablets, and while the cost of buying and running a mobile device was an issue for some people, others made it clear that they had no desire to have one.

A number of participants had recently bought tablets but in other respects had more in common with the non-users. They saw mobile devices as potentially useful but were not confident about using them and spent as little time as possible on them.

3.3.1.2 Users of mobile devices

Regular users of mobile devices all had smartphones, which they kept with them at all times and used constantly:

> *"My phone's connected to me even…in the middle of the night. I'll wake up and start using my phone."*
> (Mobile device user, not NDNS RP participant)

Many also had tablets. They tended to use these when they were at home. Few carried tablets with them when they went out, because they found tablets bulky and were worried that they might be lost or stolen.

Although members of this group nearly always had laptops or desktop computers, some rarely used them because they felt that it took too long to switch them on and they could do what they wanted just as easily on a smartphone or tablet. In contrast, some people preferred to use a laptop or desktop computer when accessing websites, because they said it was easier to find information this way than when using a mobile app.

These participants tended to describe themselves as confident with all kinds of technology. They used their devices for "*anything and everything*" and had a wide variety of apps. Many said that they enjoyed using technology and were keen to have the latest gadgets. Although their ages spanned a wide range, they tended to be younger than the participants who did not use mobile devices.

Users of mobile devices did not generally raise concerns about privacy issues in relation to apps which involved data sharing. Some said they never thought about it – they agreed to terms and conditions on every app without bothering to read them. However, concerns were raised about information being shared with third parties, and one man said that for this reason he preferred to use the browser rather than apps on his smartphone:

"I try to be quite careful, to be honest. I don't mind giving out information if I know I'm giving it out willingly and I've been informed and I'm fully involved in the process and I'm happy for companies' apps to use my information but I don't like this sort of backdoor third party thing that goes on. So, I tend to use a browser on my phone rather than apps if I can."
(Mobile device user, not NDNS RP participant)

3.3.2 Completing a paper diary

3.3.2.1 Experiences of previous NDNS RP participants

Ease of use

Participants who had taken part in NDNS RP often commented on the level of detail required. Some of them had enjoyed taking part but said that it had been a demanding experience and that they would not have wanted to keep a food diary for much longer than four days.

All participants said that their interviewer gave them clear instructions about how to complete the diary.

"I was given plenty of advice by the lady who came round to see me and … she said if you're just having a mug of tea that's about so many fluid ounces, so just put that down … it was all made very, very easy."
(Mobile device non-user, recent NDNS RP participant)

In some cases, when the interviewer came to pick up the diary, they prompted the participant to correct or expand certain entries:

"He explained every single thing, every detail and then when he came to pick it up we went through it and anything that, that wasn't put down or wasn't right, he corrected it."
(Mobile device non-user, recent NDNS RP participant)

Participants claimed to have recorded what they ate and drink as accurately as possible, but sometimes admitted that they were not as precise about quantities when they ate out or at friends' houses:

"There might be a few things if I was round my friends and I had the odd sweet or a bit of chocolate. There I wouldn't be absolute disciplined – I ate this amount, I'll weigh this and say it was this much kind of thing."
(Mobile device user, recent NDNS RP participant)

Frequency of use

NDNS RP participants varied in how often they completed the diary. Some filled it in immediately after every meal. People with simple diets – for instance, people who ate the same things for breakfast and lunch every day and never snacked – were more likely to say that they filled in the diary in once a day, usually in the evening.

People tended not to carry the diary around with them outside their home, because they found it inconvenient or were worried about losing it. One man described writing down on a scrap of paper everything he ate and drink during a day out, and then completing the diary when he got home. With one exception, participants who were working did not take the diary to work – they waited until they got home to fill it in. Some filled in the diary when preparing packed lunches to take to work. One woman texted herself details of what she ate and drank during the day to help her remember what to write in the diary in the evening.

3.3.2.2 Perspectives on paper diary compared with other methods

Ease of use

People who did not currently use a mobile device said that they would much prefer to use a paper diary than any form of new technology. The main reason was that this method was more familiar to them:

"Just general familiarity I suppose because there's nothing more familiar to me than a pen and paper really.
(Mobile device non-user, recent NDNS RP participant)

A common theme among these participants was that entering information into an electronic device was difficult, time consuming, and less reliable, than using pen and paper:

"It's time consuming and I have a very busy life and I don't have the time [to use an electronic device]. I prefer to do things that I know and trust, like paper and books, they don't let you down. Technology can and does let you down."
(Mobile device non-user, not NDNS RP participant)

Some said that they would be prepared to enter the details onto a tablet lent to them, or onto a website using their own home computer, if these were the only options:

"I could do it but I wouldn't be as happy doing it as I would just doing a written survey…. I would prefer to use good old pen and paper"
(Mobile device non-user, recent NDNS RP participant)

Others made it clear that they would refuse to take part in NDNS RP unless they could use a paper diary:

"It would be an absolute nightmare for me to – I'm sure for many people, perhaps certain generations as well – if I was to sort of get stuck onto a computer. No, just pen and paper for me, really. It's - you just know where you are"
(Mobile device non-user, recent NDNS RP participant)

In contrast, participants who used a mobile device nearly always said that they would rather not use a paper diary. The reasons they gave mirrored those given by non-users of mobile devices in favour of paper diaries. Some participants in their 20s indicated that they rarely wrote things down and that their instinct was to reach for their phone whenever they need to make a note of something. They implied that pen and paper had become as unfamiliar to them as new technologies were to some other people. They described writing in a paper diary as awkward and time consuming compared with using a mobile app:

"I think automatically think it's such a hassle writing it all in a book. If it was an app [and] it was there [you] just put it straight in."
(Mobile device user, not NDNS RP participant)

Unlike those who said that they would refuse to take part in NDNS RP if they could not use a paper diary, these participants did not say that they would definitely refuse to take part if they had to use a paper diary, but some indicated that it would make them less likely to want to take part.

Frequency of use

Just as previous NDNS participants tended to say that they had not carried the diary around outside their home, members of the public who had not taken part in NDNS RP said that they would be unlikely to carry it around (even the smaller A5 version). Instead they said that they would leave the diary at home and complete it once a day – probably in the evening.

Gender was a factor. The only people who said that they would carry the diary with them were women. They said that that they would put the diary in their bag, while a number of men said that the reason why they would not carry it around was that it would not fit in their pocket.

Some participants said that they would write themselves notes on pieces of paper during the day. Mobile-device users sometimes said that they would write notes on their phones, or would send themselves texts or emails which they would refer to when completing the diary later on. They disliked this prospect as they saw it as a duplication of effort. Other participants said that they would complete the diary from memory.

3.3.3 Using a mobile app

People who did not currently use a mobile device said that they would be unwilling to use one for NDNS RP, and some said that it would be out of the question for them. Conversely, people who did use a mobile device generally said that they would prefer to use one. Some participants had already used smartphone and tablet apps such as MyFitnessPal, which they found easy to use, and they believed that a similar app would work well for NDNS RP.

3.3.3.1 Tablet app

Ease of use

Some participants had never heard of tablet computers and, when one was shown to them or described to them over the phone, said they would not consider trying to use one:

"If you sent us a tablet we'd have to work out how to work the blasted thing and send it back to you. We'd be a bit worried because they're expensive. No, I don't think we'll – no"
(Mobile device non-user, recent NDNS RP participant)

Those who would consider using a tablet believed that it would be a straightforward way of recording dietary information. Some thought that it would be easier than using a smartphone because of the larger screen.

Frequency of use

Tablets were seen to share one of the drawbacks of the paper diary – it was widely felt that they were not suitable for use outside the home. Participants found them too bulky to carry around ("*it wouldn't fit in my pocket"; "it's just one more thing to carry around*") and some were worried about the tablet getting lost or stolen. These participants said they would probably enter the information in the tablet in the evening, based either on memory or on notes made during the day, which some felt made a tablet no more convenient than a paper diary:

"I'd probably find it easier just writing it down to be honest… I'd probably end up writing it down to put in the tablet later."
(Mobile device user, recent NDNS RP participant)

Own tablet versus loaned tablet

People who owned a tablet generally said that they would prefer to download an app to use on their own tablet than to be lent a tablet to use for NDNS RP, because they were familiar with the way their own tablet worked. One woman also said that she did not like the idea of using a tablet which other people had be touching, especially as she would be using it at mealtimes.

Some participants did not mind being lent a tablet to use for NDNS RP, and a number of them suggested that it might help them to concentrate on the task because they would not be distracted by social media apps on their own device.

3.3.3.2 Smartphone app

The option of a smartphone app was attractive to people who already had a smartphone, and the idea was suggested spontaneously by participants in several of the interviews and focus groups.

One man in his 20s (who did not himself use a smartphone, partly because of cost) thought that to be "*inclusive*" it was important to offer a smartphone app as well as a paper diary, because many people of his generation would only take part in the survey if they could enter the information on their phone:

> *"I think the majority of people would rather do smartphone … I think it's being inclusive, really. …I think that they'd have to use both, really … whichever people feel most comfortable with … if it's just the handwritten one, that's cutting a lot of people out … a lot of people won't take a little book out and – or they will just throw it to the side.*
> (Mobile device non-user, not NDNS RP participant)

Mobile-device users who raised concerns about privacy issues said that they would be willing to use a smartphone app as long as the terms and conditions made it clear that the data would be used for research and their details would not be shared with third parties:

> *"Like where it's been stored, where it's going and how it's going to be used and I've agreed for it to be used for the purposes of this research but then if you're forwarding it on elsewhere then … I don't really [want] to be a part of that"*
> (Mobile device user, not NDNS RP participant)

Ease of use

Smartphone users felt that it would be straightforward to download an NDNS RP app on their phone, which they carried with them all the time and was therefore more convenient than a paper diary or a tablet:

> *"I'd much prefer having it on my phone. So, send an email saying, 'Download this', and I'd download it and then I'd be on the phone throughout the day anyway…. Because I'm on my phone all the time anyway so I could be doing it whilst I'm on there. It would be something, an extra thing to go on my phone."*
> (Mobile device user, not NDNS RP participant)

There were mixed views on whether the small size of the screen on a smartphone compared with a tablet would make a smartphone app hard to use for the level of detail required by NDNS RP. Some people said that because of this issue they would prefer to use a paper diary or tablet. Others said that this was not a problem for them – they already used their phone for "*everything*" and rarely bothered using their tablet or laptop any more.

Frequency of use

Because smartphone users carried their phones with them all the time, they said that they were far more likely to enter dietary information throughout the day in a well designed smartphone app than in a paper diary or a tablet:

> *"As long as the app was easy to use … I'd probably just do it there and then and then not have to worry about doing it later."*
> (Mobile device user, not NDNS RP participant)

Several participants said that they routinely checked their phones at mealtimes (a habit which some non-users of mobile devices disliked) and that this would make a smartphone app ideal for keeping track of what they ate and drank throughout the day:

> *"A lot of the time when you're eating or drinking, or might be having a quick brew or whatever, you're on your phone anyway…say you're at lunch at work, you'll be on your phone"*
> (Mobile device user, not NDNS RP participant)

3.3.3.3 App design

It was widely agreed among mobile-device users that it would be essential for any app to be easy to use:

> *"The usefulness would be how cleverly designed the app is basically. [If you] can have all these time-saving features put in then it's worth it. But if it's not, you end up having to put the same amount of effort as you would do on the book"*
> (Mobile device user, not NDNS RP participant)

Participants made several suggestions for making the app accurate and easy to navigate:

- The app would have to be underpinned by a comprehensive database of brands and foods, including ethnic foods.
- It should be possible to add items not covered by the database.
- The need for typing should be minimised through drop-downs, tick boxes and predictive text.
- There should be a search function, as well as favourite items and recent items, to avoid the need to scroll through too many options.
- The app should be visually appealing and not display large amounts of text.
- It should be possible to use the app offline, in case wi-fi or a mobile signal were unavailable.

3.3.3.4 Reminders

Users of mobile devices were comfortable with the idea of receiving reminders, and some said they would need them to be able to record accurate information:

"I don't know if [a smartphone app] would have improved [on the paper diary] unless you get notifications or something. It's not like I'd be constantly checking it"
(Mobile device user, recent NDNS RP participant)

When asked how they would like to receive reminders, they generally said that texts would be preferable to emails, which they were more likely to ignore. Some suggested that the notifications be built into the app, as with Twitter and Facebook.

Participants varied in how often they wanted to receive a reminder. Some said that once or twice a day – in the morning and/or evenings – would be enough for them. Others suggested that three times a day at standard mealtimes would be useful. Several participants thought that the app should allow people to set the timing and format of reminders to suit them:

"Hopefully you can control it as well, so I would probably want it for every hour, whereas by the sounds of it people may only want it three times a day or not at all…. If you have your breakfast at eight, let it send you a notification at eight and you can actually put it in there, tell them you need notifications at this time …And you can click maybe 'done' or 'not done' like an alarm, they can snooze it, to remind you again in a certain amount of time."
(Mobile device user, not NDNS RP participant)

3.3.3.5 Internet access and data usage

Mobile device users all had internet access at home, but they said that any app would need to be useable without constant internet access, because wi-fi or a mobile signal were not always available when they were out:

"Hopefully you could still find, you could still enter it, click save and then once it gets to your signal it will upload."
(Mobile device user, not NDNS RP participant)

This issue was not restricted to rural areas – several participants in one of the London focus groups said that obtaining a mobile signal was a problem for them.

Data usage associated with an NDNS RP app was not generally seen as a problem. Some mobile device users had unlimited broadband at home and/or unlimited mobile data, while others thought that the app was unlikely to use up much of their data allowance unless the app incorporated photographs (see below). One participant said that she was "*fairly mean with [mobile] data…I try to save it for emergencies*" but went on to say that she would still use the app as long as she did not have to connect to the internet every time she used it.

3.3.4 Using a website

The option of recording dietary information on a website accessed by a laptop, desktop computer or other device was unpopular with mobile device users and non-users alike.

Some non-users did not have access to any form of computer so this was not option for them. Participants who did have a computer often raised the objection that some associated with paper diaries and tablets: they would either have to try to remember what they ate and drank when they were away from home or they would have to keep a note of it, which meant recording the information twice.

Nearly all mobile device users also thought that accessing a website on a laptop or desktop computer was less convenient than using a smartphone or tablet app, largely because of the time it took to switch it on:

"I would find that more of a pain, because that means that actually I have to go upstairs – it sounds trivial – but go upstairs, turn it on, and you end up sitting away from - it feels like a work environment when I do that. …by the time you've turned it on and waited for it to boot up, it, it starts to be annoying."
(Mobile device user, recent NDNS RP participant)

There was one exception – one man said that when he was at home he preferred to use his laptop for tasks like this because he found it less fiddly than his smartphone or tablet. Along with several others, he suggested that there should be three electronic options – a smartphone app, a tablet app and a website – which would synch so they could be used interchangeably.

Mobile device users were unanimous that they would not want to enter information on a website using a mobile device, especially a smartphone:

"Most [websites] are not fit for working on your phone. …Most of them don't have a mobile browser and therefore it's a lot more clunky and you're having to swipe all the way round to get to"
(Mobile device user, recent NDNS RP participant)

A partially-sighted participant who regularly used the internet with the help of an audio screen reader doubted that they would be able to use a website (or a mobile app) for recording dietary information. This participant had recently taken part in NDNS RP with the help of someone who completed the diary on their behalf:

"I can't see the computer. I can't work the keyboard and that would be rather unfair of me to suggest that [person providing support] does it, whereas sitting down with a paper diary, sitting together chatting about it … didn't seem so bad and not so much pressure."
(Mobile device non-user, recent NDNS RP participant)

3.3.5 Taking photos

Participants were interested in the idea of taking photos of what they ate and drank. They were less keen when they realised that taking photos would be a supplement rather than an alternative to recording the information in a paper diary or electronic device. NDNS RP participants sometimes said that the survey was already onerous enough without making extra demands on people's time:

"It would be twice the work again wouldn't it? You see it's hard enough when you're writing it down in my view. Anything that adds to that – well I probably wouldn't have completed the survey personally."
(Mobile device non-user, recent NDNS RP participant)

The idea of carrying around a digital or disposable camera was unpopular. Those who had cameras on their phones generally said that they would prefer to use these. Mobile device users wanted the photos to be integrated into any smartphone or tablet app:

"I probably wouldn't mind if it…especially if it's just an app on the phone and it's just like a quick snap of the thing and then you're away."
(Mobile device user, recent NDNS RP participant)

Some people said that they would be happy to take photos of everything they ate and drank ("*it'd only take two seconds to do*"). Others said that they would only be willing to take photos of main meals. They thought it was unreasonable to expect them to take photos of drinks and snacks:

"So long as it was only main meals. If it's cups of tea and water, then no."
(Mobile device user, not NDNS RP participant)

Some said that they would be reluctant to take photos in restaurants or other public places. Several people also said that they might be embarrassed to take photos of "*unhealthy*" food which they were about to eat. They said that they would be willing to enter information about it into a diary or electronic device, but taking a photo was another matter:

"Even though it's listed, but actually seeing it, it might be a little bit embarrassing"
(Mobile device user, not NDNS RP participant)

The high data demand associated with uploading photos was mentioned by some mobile device users:

"That [taking photos] does kill data, if you're uploading every single time … because they can be quite large now, can't they? Because the camera films are getting, the mega pixels are getting really big. It's like 40 mega pixels on an iPhone 6 or something like that, isn't it? And the data in that is probably about 10 mega bytes per photo, if not more."
(Mobile device user, not NDNS RP participant)

One person suggested that this problem could be addressed in an app by allowing survey participants to choose to upload photos only when they had a wi-fi connection.

3.3.6 Using a voice recorder

Several participants suggested that a voice recorder might be a convenient alternative to completing a paper diary or manually entering detailed information into an electronic device:

"I would have thought some sort of voice recorder would be the best. I can see me say sitting there at this table. I'd say…'It's 2.55, a cup of black coffee, medium sized mug, one sweetener, one M&S chocolate digestive biscuit' and just say those words and that's done

and then go on to drink the drink and eat the biscuit. Now that to me is simpler than writing all that down. So … for me that would be the very quickest way of doing it."
(Mobile device non-user, recent NDNS RP participant)

This idea was attractive to others, but some thought that it might not achieve the level of detail required by the survey, while others suspected that it was unrealistic because of the time it would take researchers to interpret the information and enter it into the NDNS RP database.

3.4 Conclusions of the qualitative research

The paper diary is still needed
Among participants who did not use a mobile device, there was a strong preference for the paper diary currently used for NDNS RP. Some of these people were unwilling to use any form of electronic device and said that if the paper diary were not an option they would refuse to take part in the survey. These participants tended to be older than the mobile device users. If their views are widely shared among other older people and are characterisitic of other non-mobile device users, the paper diary will have to remain for these groups to be fully included in NDNS RP, which would be important to maintain a sample representative across the UK population.

A smartphone app might encourage more mobile device users to take part
Mobile device users wanted to be able to complete the survey using a smartphone app, because they carried their smartphones with them all the time and felt it would be the most convenient method, as long as the app was well designed. They did not feel as strongly about being able to use a smartphone app as non-users felt about being able to use a paper diary, but some said that not being able to use a smartphone was a disincentive. It is possible that offering a smartphone app might encourage more mobile device users – who tend to be younger than non-users – to take part in NDNS RP and thus improve survey response rates and representativeness.

A smartphone app has the potential to capture more accurate information
Smartphone users claimed that they would be much more likely to enter dietary information throughout the day if they were able to use their phone than if they had to use a paper diary or tablet, which many people – especially men – said they would not be prepared to carry around. This suggests that introducing a smartphone app might result in more accurate dietary information for NDNS RP.

A tablet app and website (in synch with a smartphone app) have less appeal than a smartphone app but would still be welcomed
It was suggested that if possible there should be three electronic options – a smartphone app, a tablet app and website – which would synch so that participants could switch between them, depending on where they were and what device they had to hand. However, the prospect of using a tablet app, or a website accessed by a laptop or other computer, had less appeal than a smartphone app. One of the main reasons was that these were generally seen as things to be used at home, which led some participants to complain that they would

have to try to remember what they had eaten and drunk during the daytime, or they would have to record the information twice – first on paper or a smartphone, and then on the tablet or website. Some participants liked the idea of being able to use a tablet or website when they were at home because they found the smaller screen on the smartphone fiddly.

Cameras should be optional and integrated into a mobile app

Some participants said that they would not be willing to take any photos, because entering information about what they ate and drink was already enough of a burden. Others were willing to take photos of everything they ate and drank, especially if it could be done quickly using an app on their smartphone. Some said that they would not want to take photos of snacks or drinks, of meals eaten in restaurants and other public places, or of food which might be regarded as unhealthy. It is clear that if NDNS RP participants are to be asked to take photos, this should be optional and, if possible, integrated into a mobile app.

4. Discussion

4.1 Description of evidence from literature review and qualitative research

A summary of the literature review and qualitative findings are presented below, organised under the 5 technology categories. Key details are compiled in Table 4, along with an indication of the strength of evidence in each case and an overall assessment of fitness for purpose. Strength of evidence relates to evidence from exemplar tools only, and fitness for purpose of each technology category is inferred from the evidence from exemplar tools.

4.1.1 Self-administered online diet diary

The two exemplars selected to represent this technology category were MXS-Epidemio, a French online diary employed in the CCAF dietary survey, and The Biggest Loser, a self-monitoring diary featured within an online weight management programme.

There was a lack of evidence in the literature upon which to judge the feasibility of this technology type for the NDNS RP: validation studies were judged to be of poor quality and were not applicable to the UK population; adherence was reported, but within a weight-loss programme; there was no evidence relating to participant burden; nor was there evidence relating to costs or researcher burden. The only evidence of acceptability to participants came from the French population survey [28], which offered a choice to participants of either a paper-based or a web-based diary. Although the majority opted to use the web-based diary, 23% of the sample still chose to use the paper version.

Evidence from the qualitative research suggested this technology type was viewed as unpopular: for some this was because they had no internet access, whilst others described the time taken to start the computer as inconvenient, and one partially sighted participant voiced concerns about access.

4.1.2 Self-administered online 24hr recall

There were three online 24-hour recall tools selected as exemplars, all of which were developed for the primary purpose of dietary assessment: the US-based ASA24, the UK-based INTAKE24 and the France-based Nutrinet-Sante. ASA24 and Nutrinet-Sante have already been used in large dietary assessment studies, whilst INTAKE24 is still undergoing validation. INTAKE24 is designed for adolescents and young adults, aged 11-24 years.

Evidence in the literature relating to these exemplars was broad and varied. However, despite the quantity of validation studies, only one study [40] (of moderate quality) attempted to validate an online 24-hour recall against an objective measure of intake, direct observation.

There were no studies conducted using DLW as a comparator. The reported mean differences in energy intake compared to direct observation, paper diaries or interviewer-led recalls tended to be small, but values are difficult to interpret due to inappropriate analysis and inadequate sampling. None of the validation studies were rated as good quality. Given the quality and heterogeneity of the evidence, a firm conclusion about the validity of web-based 24-hour recalls cannot be drawn.

There was some (limited) evidence that participants found online 24-hour recalls burdensome [38] along with a suggestion that this encouraged some participants to drop out. Time to complete appeared to depend on the specific tool: mean times of 13 minutes (INTAKE24) and 31 minutes (Nutrinet-Sante) were reported. A small body of evidence suggested that acceptability of online 24-hour recalls varied according to the population group: being high amongst working-age adults, but with much lower proportions of children and older adults reporting tools as easy to use. Completion rates in the literature support this, with a 90% completion reported for a sample of undergraduates, compared to much lower completion rates amongst older adults. There was also some evidence that children might need assistance in completing recalls.

The only evidence of resource implications was offered for the French tool Nutrinet-Sante. Although this study did not assess cost-effectiveness directly, the authors indicated potential cost savings after initial set-up of the website and tool, compared to the cost of hiring an interviewer for each recall. This assumes recalls are to be fully self-administered by participants (which may not be appropriate given the findings of difficulties experienced by children and adolescents). Self-administration would also imply reduced researcher burden, as long as automatic coding of dietary intake is a feature of the tool.

The qualitative research discussions focussed on online desktop computer-based tools, without distinguishing between prospective (diary) and retrospective (recall) tools. Therefore the findings described for self-administered online diet diaries, above, similarly apply to online 24-hour recalls.

4.1.3 Mobile phone apps and PDAs

Two tools were selected as exemplars of handheld technologies: BalanceLog, PDA-based software which is no longer available; and My Meal Mate (MMM), a smartphone app developed for weight management in the UK.

For each exemplar, the findings of one validation study were presented. Both studies were of moderate quality, and both found a tendency for the handheld technology to provide an underestimate of intakes, with wide limits of agreement. Both studies however were also in small, non-representative samples, making firm conclusions on the validity of handheld technologies difficult.

In general, handheld devices were reported to be received more favourably than other assessment methods by participants. There was some evidence that handheld devices were perceived as less burdensome; however there were also reports in the literature that some

groups of people experienced difficulties with handheld devices, and there was some indication that dislike of handheld devices was responsible for some participant drop-out.

The qualitative research similarly found an obvious split in the attitudes towards handheld technologies between regular users of handheld technologies and non-users, which reinforced the reports in the literature. Regular users of mobile devices appeared to prefer the idea of using them over paper diaries, whilst non-users stated a preference for paper diaries, and indicated that they would be reluctant to take part if only technology-based tools were offered.

Reports from both the qualitative research and the literature suggest that people believe they will be more likely to prospectively record diet using a handheld device, as opposed to a paper-based diary. However, usage data from the MMM trial showed that 20% of entries were made on the following day.

No evidence was presented relating to the resource implications of handheld technologies.

4.1.4 Non-automated camera to complement diet diary or diet recall

The 2 exemplars selected for this category were: NANA, a photographic tool with touch-screen interface for older adults; and the smartphone photography methods described by Long and colleagues. The primary purpose of both was dietary assessment.

Evidence of validity was available only for NANA, for which there was only an indication of relative validity. Compared against paper diaries, NANA underestimated energy intake by a mean of 287kJ (69kcal) with wide limits of agreement. There was no evidence using objective measures of energy intake or expenditure.

There was no evidence of participant burden and no evidence given regarding resource implications of this technology type.

There was scant evidence in the literature concerning acceptability amongst participants. Long et al [64] reported both that participants found the method acceptable but that some described awkwardness in social situations.

The qualitative research indicated that participants would consider additional requirements to photograph foods and drinks as well as record intake using traditional methods would be onerous. There were also concerns about social awkwardness of the method.

4.1.5 Non-automated camera to replace traditional methods

Three exemplars were chosen to represent this category: the Remote Food Photography Method (FRPM), the mobile phone food record (mpFR) and Nutricam. FRPM and mpFR are US-developed tools for dietary assessment, whilst studies of Nutricam, a tool intended for diabetic self-monitoring, were Australia-based.

Evidence in the literature relating to the validity of this technology type varied considerably in design and quality. The best quality evidence showed estimates of energy intake lower than reference measurements when using objective comparators. A comparison to paper diaries identified a large number of omissions (especially of beverages) in the photographic record. There was the suggestion that validity improved with participant training and experience.

The impact of this technology type on researcher burden would depend on whether automated image processing and coding was possible. The evidence in the literature showed the classification and quantification of foods from photographic images was challenging and not yet fully developed. Processing also depends on the quality of the images taken by participants, which early indications suggest can be variable.

Studies reported high rates of acceptability and ease of use, but acceptability varied according to sample characteristics. As with the other camera-based technology type (see above), there were some concerns regarding social awkwardness and memory.

The findings of the qualitative research did not address this technology type, as participants were asked to consider photography methods only as a supplement to traditional methods.

Table 4 Evidence summary table

Technology type	Key findings from the exemplar tools	Strength of evidence	Fit for purpose
Web-based diary	• Mean differences in energy estimates compared to reference measures were -2.3MJ, and about -2.8MJ • No evidence of participant burden • No evidence of resource implications • In a French survey, the majority opted for web-based version of diary, but 23% still opted for paper version • Desktop-based technologies were unpopular amongst qualitative research participants	- Poor quality studies ? None ? None + Single study, large sample, national survey - Single study, small sample	Unknown Recommendation cannot be made on available evidence
Web-based recall	• There were no studies conducted using DLW as a comparator. • Mean differences in energy intake compared to direct observation, paper diaries or interviewer-led recalls were both positive and negative, and tended to be small • Acceptability varied according to the population group and could affect participant retention • Potential savings were described compared to interviewer-led recalls • Desktop-based technologies were unpopular with qualitative research participants	? None - Inadequate sampling & inappropriate analyses + Study designs & samples not applicable to NDNS RP - Single study, no formal cost analysis - Single study, small sample	Unknown Recommendation cannot be made on available evidence
Handheld technologies	• At group level, handheld devices give similar estimated EI to DLW and interviewer-led 24-hour recalls, with mean differences showing an underestimation • Handheld devices were preferred by regular mobile users, but not by non-users • Perceptions of participant burden differed between regular mobile users and non-users • 20% diary entries entered retrospectively on another day • No evidence of resource implications	- Small, non-representative samples + Multiple studies, several aspects - Based on 2 questions in 2 studies - Single study ? None	Possibly Better-quality evidence of validity is required. An alternative method of dietary recording would have to be offered for non-regular users of mobiles
Non-automated camera to complement traditional methods	• NANA underestimated EI compared to paper diary • No evidence of participant burden • No evidence of resource implications • Scant evidence on acceptability in the literature • Qualitative research indicated perceptions of extra burden and awkwardness	- Single study, small sample, older adults only ? None ? None - Single study - Single study, small sample	Unknown Recommendation cannot be made on available evidence

Technology type	Key findings from the exemplar tools	Strength of evidence	Fit for purpose
Non-automated camera to replace traditional methods	• Compared to objective measures, energy intake was underestimated • Methods for automated coding of images still under development • 75%-98% participants found it easy to carry extra equipment • Acceptability varied according to sample characteristics • No evidence of resource implications • No findings available from qualitative research	+ Multiple studies, 1 good quality + Multiple reports - Based on short time-frame or hypothetical experience + Multiple studies ? None ? None	No Image processing technology is not yet advanced enough

The strength of evidence is judged for each bullet-pointed finding. Strength was judged on the basis of the availability (breadth), quality and applicability of the evidence, using the symbols, '++', '+', '-' and '?' to indicate 'strong evidence', 'some evidence', 'poor evidence' or 'no evidence' respectively. 'Fitness for purpose' indicates the applicability to the NDNS RP, on the basis of the key findings and strength of evidence.

4.2 Limitations of the evidence base

The review uncovered a number of limitations with the current evidence base. Perhaps most conspicuous is the lack of evidence around the cost and resource implications of new technologies used for dietary assessment. Despite frequent assertions of cost savings by authors, only 1 study [55], out of 291, described costs associated with a new technology, and there were no formal cost analyses identified at all.

Secondly, it became apparent that there is much variation in the quality of validation studies of new technologies for dietary assessment. Only 1 study [69] was rated as good quality by the checklist. The main drawbacks of validation studies related to the sample sizes and representativeness of the populations studied. As a consequence, results of the validation studies must be interpreted with caution.

Another limitation was that only a minority of the tools had been developed for or applied in a population survey setting. Many of the tools listed in the itinerary were developed for purposes other than dietary assessment, and much of the evidence relating to their validity and acceptability derives from intervention studies with special populations or patient groups. This was the case for 5 of the 12 exemplars. Of those tools designed primarily for dietary assessment, many are not intended for use across the whole population. As a result, findings may have limited applicability to the NDNS RP.

Interestingly, although the tools have been categorised into distinct categories for this review, several of the tools were described as being adaptable to other formats – for example, myfood24 is available as a web diary or as a 24-hour recall, and websites may be accessed by mobile phone. Unfortunately, no evidence was found to assess different versions of the same tool.

Descriptions of iterative testing during development of some tools indicate that tool-specific and version-specific details can affect the user experience substantially. There are also tool-specific bugs and issues, particularly in beta versions – for example, Kirkpatrick et al [40] mention specific issues with ASA24 in recording multi-component and composite dishes. Other studies featuring beta versions include Frankenfeld et al (ASA24 [39]), Baranowski et al (ASA24 [36]) and Foster et al (INTAKE24 [52]). Many of these issues are resolved as tools are updated (as described by Kirkpatrick et al). However, an assessment of the most up-to-date version of a tool is recommended before making decisions about its usefulness.

Finally, a comment must be made about the nature of the evidence base. Much evidence came from grey literature (80 of 291 records, or 27%). This was considered advantageous for the purposes of compiling the itinerary. However, findings from grey literature may relate to beta versions of tools, and, particularly in the case of conference proceedings, sometimes lacked important detail.

4.3 Recommendations & future directions

On the basis of the current evidence, taking on board evidence in the literature and from the qualitative research, a recommendation to replace current methods in the NDNS RP with new technologies cannot be made. Instead, the Review Team recommends that investment is made into good-quality feasibility, cost-effectiveness and validation studies, in order to fill the evidence gap.

The following key points arose in this review:

1. **There was not enough evidence to indicate either an improved or inferior validity as compared to traditional dietary assessment methods.**
   Both the quantity and quality of validation studies were found to be lacking in the literature. Applying the quality checklist (Appendix I) revealed that the majority of studies had important flaws in sampling, design and analysis, making interpretation of findings problematic. Furthermore, a minority of studies provided evidence on the performance of new technologies *relative* to 4-day paper-based diaries, as used in the NDNS RP. Nor is it possible to judge the relative merits of the different categories of new technology because of the paucity of evidence. A final point is that several of these studies were conducted using early or beta versions of tools, which may have since been updated and improved. More research is necessary to gauge the validity of new technologies and their feasibility for use in a setting similar to the NDNS RP (see Recommendation 4).

2. **There was a critical lack of evidence regarding the costs of new technologies for a dietary survey.**
   Despite being given as a common motive for introducing new technologies to dietary research, there was an absence of data provided on the costs associated with their use. Only one study gave details of costs, whereas no examples of cost analyses were identified at all. Research into the costs, both direct and indirect, of using new technologies for dietary surveys, as well as formal cost comparisons with traditional methods, are strongly recommended (Recommendation 4).

3. **Camera methods are unsuitable for use in the NDNS RP at this moment in time.**
   There was a lack of evidence surrounding the use of cameras as a complementary method, whilst the qualitative research indicated resistance to the additional burden implied. As a replacement, the literature suggested that the processing of images for nutritional analysis needs further refinement. In addition, there are under-explored potential issues with the potential for participant forgetfulness and image quality, both of which are likely to impact on the accuracy of data. This category of technology needs further development before it could be considered for use in a survey.

4. **Piloting the feasibility of adopting a new technology in the context of the NDNS RP is crucial.**
   The review identified a paucity of evidence using new technologies in a setting applicable to national surveys. Furthermore, variability in the results of iterative

testing indicates that nuanced difference between particular tools and versions of tools may impact on usability and validity. A direct evaluation of preferred tools (those identified as potentially useful), as well as a feasibility study in a setting similar to the NDNS RP, would be necessary. A feasibility study should include measurements of response rates, compliance rates, validity or relative validity and costs.

5. **New technologies for dietary assessment should only be considered as an adjunct or alternative option in the NDNS RP.**
   Evidence from the literature and the qualitative research highlighted important issues in the acceptability of new technologies amongst some people. As well as being reflected in preferences, this has been shown in at least one instance to seriously impact on recruitment and participant retention rate [38]. In order to preserve the representativeness of the NDNS RP sample, it is currently unlikely to be possible to use a new technology for dietary assessment across the full sample and a traditional alternative (the paper-based diary) would have to be offered. Rates of acceptability, however, may change with time, if trends in technology use continue [2] (see Recommendation 7). Conversely, as technology use increases, the findings of the qualitative research imply that there could be similar consequences on the representativeness of the sample by *not* incorporating new technologies within the NDNS RP, as users of new technologies could find traditional paper-based methods to be unacceptable. Offering a choice of tools to participants could potentially help improve participation in the survey by increasing levels of participant acceptability across the sample and therefore reducing perceived participant burden. However, there is as yet little evidence of the impact of such an approach in a population dietary survey (see Recommendation 6).

6. **Future research should focus on the implications of employing multiple methods of dietary assessment within a survey.**
   From the qualitative research, it would seem there are individual differences in preferences for different types of technology, as well as for traditional methods. This suggests that whether particular elements of a technology category are considered to be acceptable or not largely depends upon the user. A consideration for the NDNS RP is to offer a choice or combination of tools and technology types (see Recommendation 5). If new technologies are to be considered as an adjunct or alternative to traditional methods, evidence is needed of the impact of using mixed dietary assessment methods within a survey – particularly mixing traditional and technology-based tools, or offering participants a choice of tools (for example, if they would prefer to use a mobile phone app, a web-based diary or a paper diary. There was little evidence available in the literature, although one survey in France (CCAF [28]) has taken this approach, offering participants the choice of a paper-based or a web-based dietary diary. Unfortunately, details of this comparison study were unavailable (the report is in preparation – personal communication, Justine Colin). Investigations would also be welcomed into the use of the same tool across different technology platforms (for example, where mobile apps and web-based versions of a tool are available). Evidence is needed on the anticipated effects of these approaches on response rates, compliance and completion rates, costs, and validity. Pilot or feasibility studies are recommended. In particular, the potential merits and disadvantages should be assessed with reference to current NDNS RP methods.

7. **Monitoring of future developments in new technologies and in the evidence is recommended.**
   Given the pace of development in this field, it is recommended that efforts are made to revisit the evidence at regular intervals. Grants databases revealed 24 ongoing funded projects for which no publications or records were yet available. Of these, 6 projects (all US-based) concerned dietary assessment as the primary purpose: 3 using web-based 24-hour recall tools (1 of which is used in conjunction with an automated camera), 2 using camera methods and 1 using speech recognition technology. In addition, communication with research groups in the UK has identified 1 ongoing validation (University of Leeds) of a UK-based 24-hour recall, myfood24, and a funding bid (Food Standards Agency Scotland) to further evaluate another UK-based 24-hour recall tool, INTAKE24. The US-based 24-hour recall tool ASA24 also appears to have upcoming validation research in progress, Consideration should be given to monitor the evidence of selected tools or technologies at yearly intervals, with efforts to revisit the wider literature (such as every 5 years) in order to log the emergence of new tools or technologies. Appraisal of forthcoming validity evidence in terms of quality is essential (see Appendix I).

4.4 Strengths & limitations of this review

This literature review identified many more records (n=291) than previously published reviews. In large part, this can be explained by the narrower focus of earlier reviews [4, 7, 9, 14]. However, less narrowly focussed reviews found between 15 [17] and 74 studies [19]. This is testament to the more comprehensive search strategy adopted by the current literature review, but is also indicative of the pace of publication in this field. Of the 291 records found by the current literature search, 111 (38%) were published in 2012 or later. The literature search was also not limited to English-language publications, which are included in the itinerary, although data were not extracted from non-English studies.

Another strength of the literature review is that an assessment was made about the quality of validation studies, which aided in judging the strength of evidence. A checklist (Appendix I) was developed for this purpose, and independently applied to each validation study. Previously published reviews did not make a formal appraisal of study quality.

Furthermore, this review implemented a unique approach by incorporating findings from specially commissioned qualitative research. The contribution of this research was vital, given the limited applicability of the evidence in the literature to the NDNS RP and to the UK population. Even so, it should be noted that the sample size was small, and opinions expressed may not reflect those of all past and future NDNS RP participants. With current rates of smartphone uptake in the UK at 61% of adults [2], the focus groups used in the qualitative research could be said to have over-sampled non-users of smartphones and tablets, which comprised two of the four focus groups. However, opinions of non-users are still valid, given that a currently representative UK sample is likely to feature non-users of technology. Furthermore, efforts were made to recruit a varied sample of non-users, with a range of ages, sex and ethnicity.

An obvious and important limitation of this review was the necessity of extracting data from only a proportion of the literature. Exemplars were selected on the basis of breadth of evidence, therefore newer, more refined, but as yet under-evaluated tools may be under-represented. Furthermore, the review was unable to gauge the extent of within-category variation of tools, and instead assumed shared similarities within a category. However, one of the key conclusions of the review is that there is a paucity of good-quality evidence. Given that the exemplars were chosen on the basis of breadth of evidence, it is unlikely that conclusions would change had other tools been selected as exemplars. Readers are directed to the accompanying bibliography for further sources of information about non-exemplar tools, the findings of which have not been considered in this review.

Time constraints were also responsible for limiting data extraction to energy intake in validation studies, as opposed to any other nutrients. Therefore, it cannot be determined from this review how exemplar tools perform in the assessment of other nutrients.

Resource constraints did not allow for data extraction to be performed by more than one reviewer, and thus the possibility of bias was introduced. However, attempts were made to limit bias by using pre-developed data extraction forms.

Finally, it should be noted that the evidence presented here represents an *indirect* evaluation of new technologies' strengths and weaknesses. A direct evaluation would have involved obtaining each tool to make an assessment of the features directly, but was not feasible for this review. Furthermore, the qualitative research was performed on a hypothetical level, and participants did not actually use any new technology to record diet.

5. Conclusion

The evidence for exemplar tools alongside the qualitative research indicates that, at present, it is premature to fully implement new technologies to assess diet in the NDNS RP. Largely this is because there is not enough evidence available with which to predict the impact these technologies would have on accuracy, response rates, compliance and costs. It is also because qualitative research, both in the literature and in this review, indicates that new technologies are likely to be resisted by some people, with likely consequences for participant recruitment and retention, and sample representativeness. Therefore, at present, it seems premature to fully implement new technologies alone to assess diet in the NDNS RP without further investment in their development, validation and assessment of feasibility.

In the future, it is possible that disregarding new technologies may become detrimental to the NDNS RP, as new technology use becomes more widespread and traditional paper-based tools possibly become less acceptable to respondents. The adoption of multiple tools, or different versions of the same tool, may be desirable and improve acceptability and response rates within the survey. However, good-quality research is needed to demonstrate such tools will enhance compliance without adversely affecting the validity and comparability of dietary data. In this fast-paced field of development, it is recommended that progress in technology development, validity and acceptability is monitored.

Appendices

Appendix A: Steering Meeting minutes

The University of Leeds

School of Food Science and Nutrition

NDNS New Technologies Review Start-up Meeting

Wednesday 23rd April 2014

Minutes

Present: Victoria Burley (chair), Janet Cade, Neil Collins (minutes), Bob Erens, Darren Greenwood, Louise Knowles, Alison Lennox, Polly Page, Katharine Roberts, Gillian Swan, Kate Timmins

Apologies: Bev Bates, Claire Hulme, Toni Steer, Fatima Husain

Welcome, introduction to team members, roles and responsibilities

VB welcomed the attendees to the meeting. Each attendee introduced him/herself and his/her role:

- **Kate Timmins:** Post-doctoral Research Associate (University of Leeds);
- **Janet Cade:** Head of Nutritional Epidemiology Group (University of Leeds)
- **Darren Greenwood:** Statistical advisor (University of Leeds);
- **Katharine Roberts:** Lead on Nutrition, Public Health England (PHE);
- **Louise Knowles:** Policy Research Programme, Department of Health;
- **Bob Erens:** Independent expert **(**London School of Hygiene and Tropical Medicine);
- **Alison Lennox:** Independent expert (University of Surrey);
- **Gillian Swan:** (PHE);
- **Polly Page:** (MRC HNR);
- **Victoria Burley:** Project lead (University of Leeds).

Terms of Reference for the Steering Group

The Terms of Reference for the Steering Group have already been distributed. The Terms were agreed, although LK wished to make an addition to the section on decision-making. The full wording of this addition will be disseminated to the group's members.

Project Background and Department of Health Objectives

VB delivered a presentation which briefly described that background to the project, and the aims of the Department of Health, as understood by the team based in the School.

The stated aims were agreed; however it was also agreed that a third aim should be added, in order to provide specific recommendations around the use of novel technologies, on the basis of NDNS requirements.

The Research Protocol

The research questions

These were agreed as stated in the Protocol document. CR and JC expressed the view that it would be necessary to consider the extent to which compatibility with previous surveys could or should be

maintained. AL also made the point that it may be necessary to consider the possibility that different technologies may be more or less suited to different age groups.

It was agreed that there is a need to state that for any new technology to be recommended, it would need to be able to provide a detailed breakdown of nutritional intake, and that it would need to be able to maximise response and the representativeness of the sample.

Literature review search terms

These were explained and were agreed.

Literature review eligibility criteria

The following amendments to the draft document were agreed:

- Date range (p7): database searches will locate references published from 2000 onwards, not 1995 as per draft.
- Language (p7): the review will no longer be limited to papers written in English. Papers not written in English (but with an English translation of the abstract) will now be logged, although they will not ordinarily be translated.
- Definitions (p7): it will be clarified that the phrase 'new technology' will refer specifically to the context of the NDNS.
- Selection criteria inclusion (p9): the examples listed under the first bullet point will be removed, in order to avoid the impression of exclusivity.
- The first bullet point on p10 will be amended to read: 'Data gathered must be suitable for use in NDNS'.
- The second, third and fourth bullet points on p10 will be removed.
- The fifth bullet point on p10 will be amended to read 'Studies published since 2000'. There will no longer be any reference to studies published only in English
- Selection criteria exclusion (p10): The second, fifth, eighth, ninth, tenth and eleventh bullet points will be removed.
- The sixth bullet point under exclusion criteria will be amended to remove reference to computer-assisted interview.
- The final bullet point will be amended to read 'Studies published before 2000', as above.

Literature review databases

A need to state which journals will be hand searched was identified. AL also drew attention to the need to consider studies that may have used new technologies, but which are not specifically about new technologies.

Literature review data extraction and management

It was agreed that the third bullet point on p11 will be clarified. It was also agreed that under 'Details of new technology', a new heading for 'Category of tool' will be added, as it was felt that the priority should be to consider categories of tool, rather than specific examples. It was also agreed that only tools for which some form of evaluation existed, would be considered in satisfying Aim 2.

It was further agreed that findings would be passed to NDNS for comment, prior to qualitative research being carried out.

Qualitative research

Not discussed.

Project deliverables and timeline

These were agreed, although there was a general feeling that the timescales are rather tight. PP is to confirm whether or not the timings are suitable to allow the qualitative research to be carried out prior to the next meeting of the Steering Group.

VB / KT will arrange for a draft table / grid against which to assess the new technologies to be circulated to the Steering Group.

Dissemination

The Department of Health only requires access to the final report. They are happy with publication elsewhere, provided that they receive prior notification, and that their 28 day peer review policy is adhered to.

There was a general feeling that publication of the report should be an aim of the project.

Any other business

Not discussed.

Date of next meeting

Tbc

The University of Leeds

School of Food Science and Nutrition

NDNS New Technologies Review 2nd Steering Meeting

Thursday 11th September 2014

Minutes

Present: Bev Bates, Victoria Burley, Janet Cade, George Clark, Bob Erens, Darren Greenwood, Claire Hulme, Louise Knowles, Alison Lennox, Di Rees-Morris, Toni Steer, Gillian Swan, Kate Timmins, Kim Vowden

Apologies: Fatima Husain, Polly Page, Kath Roberts

1. **Welcome, introduction to team members**
   VB welcomed the attendees to the meeting. Each attendee introduced him/herself and his/her role:
   - **Victoria Burley:** Project lead (University of Leeds);
   - **Toni Steer:** (MRC HNR);
   - **Alison Lennox:** Independent expert (University of Surrey);
   - **Darren Greenwood:** Statistical advisor (University of Leeds);
   - **Louise Knowles:** Policy Research Programme (Department of Health);
   - **Kim Vowden:** Qualitative research (NatCen);
   - **Gillian Swan:** (PHE);
   - **Bev Bates:** (NatCen);
   - **Di Rees-Morris:** Lay representative;
   - **George Clark:** Lay representative;
   - **Janet Cade:** Head of Nutritional Epidemiology Group (University of Leeds)
   - **Claire Hulme:** Health economics advisor (University of Leeds);
   - **Bob Erens:** Independent expert **(**London School of Hygiene and Tropical Medicine);
   - **Kate Timmins:** Post-doctoral Research Associate (University of Leeds).

2. **Review progress**
   VB and KT delivered a presentation to summarise to the Steering Group the literature search results, the revisions to protocol that were agreed with DH/PHE in July and the proposed approach to categorise technologies and select exemplars.

3. **Changes to protocol**
   a. **Additional eligibility criteria**
      The additional eligibility criteria were agreed as being pragmatic.

      There was a suggestion that that technologies used for retrospective methods could be considered ineligible. However, concern was expressed that some information about a technology could be applied across retrospective/prospective methods.

      AL raised a concern that non-English records would be excluded; KT clarified that this was not one of the exclusion criteria, and that one non-English (French)

record had been judged eligible as an exemplar. AL offered to translate.

b. Exemplar selection

DG stated that the exemplar approach would allow comparisons across categories, but would not provide information on the variation within a category. TS proposed 2 or 3 exemplars would be needed for each category.

It was agreed that, in order to select multiple exemplars for each category, the number of categories should be reduced. The Steering Group agreed to **exclude** the following categories from further data extraction & synthesis:

i. Interviewer-led, direct-entry 24-hour recall
ii. Self-administered, computerized recall/diary
iii. Automated cameras
iv. Barcode scanners

A summary paragraph/commentary about these categories is to be included in the report.

It was agreed that the 'multiple media' category be reallocated because the category definition was not clear, and the assumption that tools within a category share similarities may not hold. The tools in this category will be reassigned according to their predominant features. In addition, it was agreed that the PDA category be combined with the mobile phone category.

This reduces the number of technology categories to five (self-administered online diet diaries, self-administered online 24-hour recall, PDAs/mobile phones, non-automated cameras to complement traditional methods and non-automated cameras to replace traditional methods).

The exemplar selection criteria were agreed to be appropriate. However, JC and AL felt that ASA24 would make a more appropriate exemplar than DietDay, given the wide adoption of ASA24. This was agreed by the group.

c. Synthesis and presentation of results

i. *Description of exemplars*
The group agreed the proposed table was suitable to describe the exemplars. It was agreed that the user group in which the tool had been applied was more appropriate to state than the *intended* user group.

ii. *Evidence summary*
A rating of the strength of evidence was deemed appropriate, but it was emphasised that a full description of the codes used and approach to grading be included in the report if used. It may be feasible to adapt the approach used by NICE.

KT and VB informed the group that a quality checklist was in development with the help of DG, to be validated and applied. The group confirmed that study quality assessment details be included in an appendix rather than presented in the main report.

AL reminded that suitability across a range of age ranges was an

important consideration for the NDNS, and needed to be addressed in the synthesis.

CH pointed out that costs were crucial in making recommendations, and proposed researching associated costs from sources outside the literature. Concerns were raised whether time constraints would allow this and whether this information was available. It was also questioned whether the costs for an exemplar would be indicative of costs across tools within the same category. JC stressed the importance of including an indication of resource implications and DG recommended a narrative summary of cost and resource implications (as evidenced in the literature) as well as an indication of further evidence required.

iii. *Recommendation on suitability for NDNS*

BE wondered if a checklist or score would be useful in summarising each technology type in terms of 'fitness for purpose'. GS pointed out that useful information may be lost by reducing it to a checklist, and comments would be more helpful to DH/PHE. Instead KT proposed changing the column headings of the final table to match the statements on which fitness for purpose will be judged (appropriate for analytical purposes, likely to maintain/improve accuracy etc).

Several minor presentational points were raised: TS asked for consistency in referring to tools, technologies, categories or types; AL cautioned against non-quantified statements in summary table; JC recommended qualifying assumptions of fitness for purpose with 'is likely to', given that there is no evidence yet applying these technologies in the NDNS.

4. Qualitative research

a. Methods

KV delivered a summary of the qualitative research methods.

Some concerns were raised that all the previous NDNS participants were to be recruited from rural addresses, whereas all the focus groups with non-participants would be urban. The group discussed the implications of this, but the overall conclusion was that the group sizes would not allow a representative sample and would limit the interpretation of between-group comparisons in any case. It was also pointed out that the definition of 'rural' was perhaps broader than at first thought. It was agreed that the sampling would go ahead as proposed.

In the recruitment of the focus groups, VB wondered if it would be more useful to ask whether potential participants *regularly used* smartphones or tablets, rather than just having them. This was agreed by the group.

b. Materials

i. *Information sheets*

JC suggested it may be advisable to include a statement about ethical approval. KV agreed to add this.

TS requested that the wording on the information sheet for the focus

groups be changed from ‘each group discussion’ to ‘the group discussion’.

ii. *Topic guides*
VB wondered whether it would be worth applying the Technology Readiness Index to describe the focus groups. LK questioned whether this level of detail was necessary. VB to forward a reference to the TRI so that any relevant aspects may be incorporated into the discussions.

As a result of the suggested changes to eligible categories for the literature synthesis, it was agreed to drop discussions around automated cameras, multiple media and verbal recount methods.

BE and AL felt it important to ask participants to compare the new technologies to written paper diaries. TS suggested it would be useful for focus group participants to be shown a completed food diary from the NDNS. This was agreed by the group. BE also stressed the importance of including food consumed away from home in the discussions.

AL pointed out that it would preferable to show images of technologies without the dietary feedback (e.g. calorie count) and ideally showing the entry of food and drinks. KT and VB to look up some alternative images. Otherwise KV suggested hiding the feedback on the screenshots.

KV to forward changes to materials.

c. Reporting

It was agreed that the reporting of the qualitative methods and findings would form a standalone section of the report, with the key findings being selected by VB/KT for inclusion in the summary and recommendations. NatCen also requested to provide an executive summary of the qualitative research.

5. Any other business
Not discussed.

Appendix B: Project protocol

Making the best use of new technologies in the National Diet and Nutrition Survey: a review

Nutritional Epidemiology Group, University of Leeds

May 2014

1.0 Overall aim

The overall aim of the project is to inform the Department of Health of the range of new technologies currently available and in development internationally that have potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme (NDNS RP).

The specific aims are:

- To generate an itinerary of new and emerging technologies that may be suitable for use in the NDNS RP in the future.
- Through systematic review of the literature and qualitative research, to critically appraise these technologies in terms of meeting requirements of the NDNS RP and other relevant population surveys by exploring their limitations, relative validity, cost-effectiveness and current and future potential.
- To recommend which of these new technologies, if any, would be appropriate for future use in the NDNS RP and/or complementary surveys, with an indication of the degree to which they fit the survey requirements and the degree to which current technologies may need adapting, as well as a description of the perceived benefits and limitations.

To achieve these aims, the research project comprises two key elements: the first, to systematically review the literature; and the second, to investigate the suitability of new technologies in terms of participant perspective through qualitative research methods.

2.0 Research Team

The research will be undertaken by a team based at the University of Leeds, and by sub-contractors at MRC Human Nutrition Research (HNR), and NatCen Social Research.

2.1 Literature review team

The team at the University of Leeds will be primarily responsible for undertaking the systematic review of the literature. The team comprises:

- Victoria Burley (project lead)
- Janet Cade (head of group)
- Kate Timmins (post-doctoral research associate)
- Neil Hancock (database management)
- Darren Greenwood (statistical support)
- Claire Hulme (health economics advisor)

2.2 Qualitative research team

The qualitative research element of the project will be sub-contracted to researchers at MRC HNR and NatCen. This work will be led by:

- Polly Page (MRC HNR)
- Toni Steer (MRC HNR)
- Bev Bates (NatCen)
- Fatima Husain (NatCen)

3.0 Steering Group

In addition to the Research Team, the project will be guided by input from a Steering Group. Membership of the Steering Group includes independent experts (Prof Alison Lennox, University of Surrey; Bob Erens, London School of Hygiene and Tropical Medicine), observers from the funding body (Louise Knowles, Department of Health; Gillian Swan and Katharine Roberts, Public Health England) and lay members. Lay members will be recruited once the project has commenced, to be trained for attendance at the second meeting of the Steering Group.

4.0 Background

Accurate and timely information about dietary practices and nutrient intakes of the UK population is required by government to monitor dietary quality, to track dietary changes over time and to develop policy. Using representative samples of the population, the National Diet and Nutrition Survey (NDNS) is designed to assess what and how much people are eating in the UK. The methods used to capture dietary practices have evolved since its inception in the late 1980s.

The ability to accurately assess diet is of paramount importance in establishing nutrition related disease risks and evaluating the effectiveness of public health interventions. Established methods of dietary assessment such as weighed food records, 24-hour recalls and food frequency questionnaires (FFQs) present a challenge to researchers due to their inherent limitations. Retrospective methods suffer from reliance on respondent memory, potential recall bias and mis-reporting and prospective methods can place a high burden on the respondent and risk an alteration of habitual intake. Nutritional coding of the data collected by these traditional methods requires a trained individual and can be extremely time consuming and expensive. These limitations have been well described previously in the MRC Diet and Physical activity measurements toolkit (http:www.dapa-toolkit.mrc.ac.uk).

There is increasing interest in employing new technologies to assist in the process of dietary data collection. Such technologies include, but are not restricted to, the use of camera and mobile telephone technology to capture food and meal images, interactive computer-based methods and handheld personal digital assistants. Some research has suggested that these innovative technologies improve dietary assessment across a range of settings.

Automated systems have the potential to improve the accuracy of data collected, reduce costs, provide immediate feedback and reduce respondent and researcher burden by automating the nutritional coding process (Ngo et al. 2009). Studies investigating innovative technologies for dietary assessment have included computerised methods such as automated self administered 24 hour recalls (Touvier et al., 2011; Arab et al., 2010; Zoellner et al., 2005) and FFQs (Slattery et al. 2008), personal digital assistants (PDAs) (Beasley et al. 2005; Yon et al., 2007; Wang et al., 2006; Boushey et al., 2009), camera-enabled cell-phones (Martin et al., 2009) and smartcards (Lambert et al., 2005).

New and emerging technologies may be employed in different ways - to replace, improve, or

complement traditional methods of dietary assessment. Replacement methods may include repeat internet-based 24 hour recalls, such as the Automated Self Administered 24-hour recall (ASA24) developed by the National Cancer Institute (Subar et al., 2007; Subar et al., 2010). This method has the potential to capture a complete dietary pattern, but is reliant on internet access and participant computer literacy skills. Alternatively, the new technology may be employed as a means to improve response rates or to complement existing pen and paper-based methods. These may include for example, techniques that improve or facilitate quantification of amounts consumed, such as the use of cameras or smartphone applications that involve image capture and quantification (Chae et al., 2011) or smart cards that capture selected meal consumption (Lambert et al., 2005).

A review of new technology methods for dietary assessment concluded that these methods have potential to accurately measure dietary intakes but further work is necessary for improving and evaluating established and new tools (Ngo et al., 2009). Illner and colleagues were somewhat less positive, but concluded that whilst the critical limitation of individual bias remained, innovative technologies showed promise in terms of being more cost- and time-effective (Illner et al., 2012).

Since this is a fast-moving field of research, an updated review of the potential application of new technologies in dietary assessment is warranted on several counts, not least of which would be to inform the Department of Health of the range of new technologies that have potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme (NDNS RP). Currently, the NDNS involves an interview, a four-day dietary diary and blood and urine sampling, and annually collects information from about 1000 individuals across a wide age range. As described above, traditional methods are subject to a number of limitations. It is important to evaluate the robustness of existing methods against new and emerging approaches to ensure the best approaches to dietary assessment are employed. A review of new technologies is necessary both to catalogue and to appraise these technologies in terms of meeting the requirements of the NDNS RP.

To facilitate the decision-making process of the Department of Health with regard to the inclusion of technologies in the NDNS RP, this project was set up to identify and categorise new technologies in dietary assessment and critically appraise their strengths and limitations. A systematic review of the literature is the first stage necessary to address the project aims. The review will locate published and unpublished studies that describe comparisons of new technologies against traditional dietary assessment methods, and

critically evaluate these studies. An inventory of potentially appropriate technologies will be generated for the Department of Health, which will guide the second facet of the project, in which views of potential users will be elicited using qualitative research methods. The findings of both the literature and the qualitative research will contribute to the appraisal of new technologies.

5.0 Research questions

With these aims in mind, the following research questions are proposed in order to direct the focus of the literature search:

- What are the new and emerging technologies suitable for use in population dietary surveys?
- Do new technologies improve accuracy or enhance validity in dietary assessment?
- What is the relative validity of new technologies, when compared to traditional dietary assessment methods?
- What impact do new technologies have on participant burden in dietary assessment?
- What impact do new technologies have on researcher burden in dietary surveys?
- How do new technologies rate in terms of acceptability amongst participants of dietary surveys?
- What are the conclusions around feasibility of these new technologies?
- Are new technologies cost-effective for population dietary surveys?
- What recommendations can be made regarding the use of new technologies in the NDNS RP or other complementary national dietary surveys?

6.0 Methods

6.1 Literature review

6.1.1 Search strategy

Search for existing reviews

Existing reviews will be identified primarily through searches of review databases (Cochrane Database of Systematic Reviews; Database of Abstracts of Reviews of Effectiveness (DARE; 'other reviews' in Cochrane Library)). Reviews may also be found through the main database searching, citation searching or in contacting experts (see below).

Database searching

A search will be conducted to locate papers published from 2000 onwards. The following databases will be searched for data:

- Web of Science
- Ovid MEDLINE and MEDLINE In-Process
- Embase
- NHS EED (Economic Evaluation Database)

Citation & hand searching

In addition to searching these resources for relevant papers and articles, reference lists of reviews and relevant papers will be consulted to identify possible relevant articles that may have been missed in the database searches. A citation search will be conducted by searching databases for key words (such as the author) to identify extra studies that may be relevant to the project. The contents of highly relevant journals which are not indexed in the above databases will also be hand searched – for example, the *Journal of Medical Internet Research*. This will be supplemented by searching within the National Cancer Institute database, the Dietary Assessment Calibration/Validation Register which is available at http://appliedresearch.cancer.gov/cgi-bin/dacv/index.pl for calibration studies of new technologies.

Grey literature searching

In order to capture emerging or newly developed technologies that may not have reached the stage of full publication as peer-reviewed journal articles, we propose to also search for unpublished studies from 2011 onwards. This will be achieved by searching within:

- Web of Science in the Conference Proceedings Citation Indices for Science
- Web of Science in the Conference Proceedings Citation Indices for Social Science & Humanities
- OpenGrey
- EPPI Centre databases (TRoPHI)
- The abstract book of the 8th International Conference on Diet and Activity Methods (2012)

Searchable online databases are also available of research grants awarded (and associated reports), such as 'rePORT' and clinicaltrials.gov, which catalogue NIH-funded awards and funded trials (http://report.nih.gov/).These and any other similar non-US grants databases, e.g. the BBSRC grants database (http://www.bbsrc.ac.uk/PA/grants/Default.aspx), will be explored.

A list of key research teams in the field will be compiled from the search results. These researchers will then be contacted to request information concerning any innovative technologies or approaches they are actively pursuing or that they that they have been alerted to that are not in the public domain. Contacts and responses will be systematically logged.

In addition, government health department and research websites will be searched for reports of national dietary surveys. The methodologies will be checked for new technology use, and links to primary descriptions or evaluations of these technologies, if applicable, will be followed up.

Social media relevant to academic research, such as Research Gate and LinkedIn, will also be used to locate unpublished work on new technologies or emerging approaches. This will be achieved by posting direct questions on these sites, requesting information from researchers who may be developing and testing new methods of dietary assessment. Identified researchers in the field will also be contacted via science social media websites to request information around emerging technologies, and calls for information will be circulated via relevant societies – the Nutrition Society and the British Dietetic Association, for example.

6.1.2 Date range

The database searches will locate references published from 2000 onwards. The searches for grey literature will identify papers prepared from 2011 onwards.

6.1.3 Language

The literature search will not be limited to publications or grey literature written in English. However, literature published in languages other than English will be logged only, and not included in the full review.

6.1.4 Definitions

For the purposes of this review, **'new technologies'** are taken to refer to new or novel *ways* of collecting (and processing) dietary data, including, but not limited to, devices (hard ware) and applications (software) such as cameras, mobile phones, sensors, audio-recording devices, optical readers, phone applications, hand-held digital technology, PC- and web-based programmes.

Technologies are considered 'new' if they are ways of dietary data collection that have not been used, previously or currently, in the NDNS RP or related surveys.

These may fall broadly into the following main categories (based on descriptions provided in the review by Illner et al., 2012):

- **Interactive computer-based technologies**
    - In which participants are asked to report food consumption during a pre-specified time period (past 24 hours, previous week/month, dietary history) in the past. May include interactive multimedia technology, involving listening and touch-screen options. For example, 'HEST', a CD-ROM-mediated food record reported by Di Noia et al. (2009)

- **Web-based technologies**
    - These overlap with interactive computer-based approaches, but have a requirement for internet connection. As above, participants are asked to report food consumption during a pre-specified time period (past 24 hours, previous week/month, dietary history) in the past. For example, ASA24.

- **Mobile-devise based technologies**

- Mobile devices permit ‘real-time’ short-term dietary assessment. Tools may include digital photography and/or voice recording, and they may include digital image and segmentation analysis for determination of portion sizes. Examples include ‘Welnavi’, a mobile phone and camera tool reported by Wang et al. (2006); and ‘mpFIR’, reported in Daugherty et al. (2012).

- **Camera and audio-recording based technologies (not mobile phone)**
  - These include the use of digital cameras/disposable cameras (for example, ‘Remote Food Photography Method’ by Martin et al., 2009) as well as tape recorders (such as in Lindquist et al. 2000).

- **Scan and sensor-based**
  - This includes the scanning of barcodes using hand-held barcode scanners or the use of supermarket or cafeteria smartcards (for example, Eyles et al., 2010), as well as on-body sensors that detect, for example, eating movements (chewing), arm movements etc. (Amft et al. 2009).

- **Data entry systems – post data collection**
  - This refers to software designed for food diary processing, e.g. as compared in Murphy et al., 2009.

- **Other technologies**
  - This category will be used for new technologies which are found in the literature that do not fit into the pre-defined categories proposed by Illner et al.

6.1.5 Literature management

Bibliographic details of records identified using the search strategy will be imported into EPPI Reviewer 4 software. References will then be deduplicated using the bibliographic software algorithms.

Study selection procedure

Once imported into the review database, the search results will be rapidly assessed and categorised according to relevance (see criteria below). This screening process will comprise three stages:

1. Keyword searches in the bibliographic database will be used to identify and exclude any obviously irrelevant hits

2. Title/abstract screening, following which full-text copies of papers meeting the eligibility criteria will be obtained; and
3. Full paper screening.

The first part of the three-stage screening process will use keyword searches within the EPPI Reviewer library to identify obviously irrelevant papers. Searches will be performed for the following:

- In the Year field: “19” (to identify papers published prior to 2000)
- In the Title/abstract field: “animal”, “vet”, “veterinary”, “drug”, “plant”, “brain”, “neurological” and “x-ray”.

Titles of records identified by the above keyword search results will be rapidly assessed and excluded if obviously ineligible. If the eligibility is unclear from the title, the record will be retained for second-pass (title/abstract) screening.

In the second and third stages of screening, studies will be screened by two independent reviewers. To ensure a high degree of inter-rater reliability, the team will work through a sample of studies meeting the inclusion criteria and discuss any relevance issues before screening the rest of the retrieved studies. If the reviewers disagree on a study’s relevance, a discussion will be held with a third reviewer to resolve the issue.

The number of records included or excluded at each stage will be recorded, according to the PRISMA template (Moher et al., 2009).

Selection criteria (inclusion & exclusion)

Studies will be selected for inclusion based on pre-specified eligibility criteria. Studies which do not meet the criteria at the full-text screening stage will be coded according to the criteria for which they did not meet eligibility. Reviewers will use a standardised screening process as set out in Appendix 2.

Inclusion:

Studies involving technologies, new to the NDNS RP, which can be used to automate or assist the collection of food consumption data and the coding of foods and portion sizes. These technologies may be currently available or beta versions, public domain or commercial

- Studies that address the development, features, or evaluation of new technology
- Eligible technologies must be appropriate for the requirements of the NDNS RP in terms of nutritional analysis, with capacity to collect quantifiable consumption data at the food level

- Studies published since the year 2000
- Grey literature from 2011 onwards, which is considered a primary source of information on a new technology

Exclusion:

- Studies that do not provide new information on the development, features, or evaluation of new technology for dietary assessment, such as intervention or observational studies that have utilised the technology for research purposes e.g. to describe diet-disease associations or dietary survey or change
- Tools used in nutrition education or e-learning, where food consumption is not measured and quantified and the tool is not appropriate for adapting to the purposes of the NDNS RP
- Tools that do not have the capability of capturing a sufficient level of detail for full nutritional analysis, for example, tools which measure specific foods or drink or a limited range of foods or drink, or tools in which consumption of foods and drink are not quantified
- Technologies which are not considered new to the NDNS
- Tools employed in recruiting, screening and tracking subject flow in dietary surveys
- Tools which measure purchasing of foods and drinks, in the absence of data on dietary consumption
- Second-hand references to new technologies, such as commentaries, reviews, editorials or other opinion articles
- Studies published before 2000

Following screening, the included references will be compiled into a list (Deliverable 4) and supplied to the Department of Health. Prior to data extraction, the literature review team will meet with the Department of Health and Public Health England representatives to discuss the search findings and evaluate the desired scope of the critical appraisal.

Data extraction

Relevant data will be extracted from all included studies. This will be performed using the data extraction software EPPI Reviewer 4.

Data extraction will collect information on the following:

- Bibliographic details
- Publication aim

- Study type (feasibility, validation, descriptive)
- Details of the new technology
    - Name of tool
    - Description of tool
    - Category of new technology
    - Requirements for use (eg internet access, phone type, software etc)
    - Whether a complement or replacement for traditional methods
    - Intended user group (eg age, gender, anticipated IT literacy)
    - Development stage of tool (including number of years from availability if applicable)
    - Underlying nutrient database
    - Number of foods (and recipes if applicable) listed
    - Type of data captured in current format of the tool
    - Portion size estimation approach (if applicable)
- Subject information (e.g. Country, Age, Gender, Ethnicity) (if calibration/validation study)
- Study design details (sampling etc)
- Statistical treatment (e.g. correlation, Bland Altman, power calculation) and results
- Traditional dietary assessment comparator (for validation or comparability studies)
- User reports of acceptability and/or ease of use
- Aspects of participant burden (time to complete, portability of tool etc)
- Aspects of researcher/survey manager burden (time estimates, personnel requirements)
- Cost estimates or cost-effectiveness results (if available)
- Study quality – see below
- Summary of key limitations and strengths (including appropriateness for various population groups)

The software will allow the grouping of publications by broad group and by specific dietary assessment tool, e.g. ASA24. This will reduce the chance that data are duplicated in the review as well as allowing reviewers to map out all publications linked to a particular tool. In this manner, a complete picture of each tool may be drawn up for narrative review.

Quality assessment

It is anticipated that the relevant literature will feature validation or comparison studies in which new technologies are assessed against traditional dietary assessment tools or against

biomarkers of energy or nutrient intake. These types of studies may be considered key to evaluating new technologies' suitability for surveys, and therefore it is important to consider the quality of the comparison study itself.

For this purpose, a brief checklist will be developed which will reflect study quality of dietary intake validation or comparison studies. This checklist will draw on the approach used by Serra-Majem et al. (2009), but will also incorporate approaches employed within existing checklists for evaluating the methodological quality of measures of physical activity (e.g. as in Hagstromer et al., 2012). The quality assessment of each dietary validation study will be presented within the main table in the evidence review.

The quality of economic evaluations, if any, will also need to be appraised. An economic evaluation refers to a study such as cost-effectiveness or cost-benefit analyses, and does not include non-comparative costing studies. The NICE Public Health Methods Manual (2012) will be used to guide the appraisal of economic evaluations (http://publications.nice.org.uk/methods-for-the-development-of-nice-public-health-guidance-third-edition-pmg4/appendix-i-quality-appraisal-checklist-economic-evaluations). This includes a checklist for overall methodological quality and for overall applicability of the study. The checklists may need to be adapted to suit evaluations of tools designed for research outcomes as opposed to medical or health outcomes. In line with NICE guidance the review team will record its judgements based on the economic evaluation checklist. A short economic evidence statement will be included at the end of the economic evidence synthesis, summarising key features of the evidence on cost effectiveness.

6.1.6 Data synthesis

The potential to undertake statistical synthesis of study results using meta-analysis will be explored, however it is not anticipated that there will be sufficient data presented in a consistent manner to do this. The data extracted from the included studies will therefore likely be presented in a narrative synthesis only.

As part of the synthesis, a comprehensive main evidence table will be created, in which the new technologies included in the review will be listed by type (for example, all mobile phone applications grouped together). The table will include a column for each dimension of interest: including judgements about strength of relative validity for individuals and populations, reproducibility, accessibility (addressing health inequities), participant burden, cost-effectiveness estimates (if available), nearness to 'market', and other strengths and

limitations of each approach. This table may be repeated for each major age group included in the NDNS RP so the appropriateness of each method within each age group can be evaluated. Technologies are also likely to be clearly defined as prospective or retrospective methods, to allow them to be judged in relation to the NDNS RP current methods (which are prospective).

The appropriateness of a scoring approach will be considered, in which each technology is scored on the relevant dimensions. For example '+++' could indicate a high degree of relative validity, '++' a moderate degree and so on.

Summary tables for each main group of new technologies will then be generated and a narrative summary of the findings prepared.

Initial findings will be presented in a grid/table format and circulated to the Steering Group prior to the second Steering Group meeting. This will guide the discussion of the Steering Group with regard to decision-making around recommendations and conclusions to be included in the final report.

6.2 Qualitative research

In addition to the information gathered from the literature, some small-scale qualitative work will be carried out to gauge the views of both NDNS RP participants and non participants regarding the emerging technologies that have the potential for inclusion in the NDNS RP. The qualitative work will be undertaken by the team comprising individuals from MRC HNR Cambridge and NatCen Social Research who will be sub-contracted to the University of Leeds.

The initial findings of the literature review will be used to select potentially relevant tools from the itinerary of new technologies, to feature in the qualitative research. The qualitative research will involve:

1. Telephone interviews with 12 NDNS RP participants
2. Focus group meetings with non-NDNS RP participants (2 in London, 2 elsewhere in UK)

The recruitment procedures and research materials for the qualitative work will be agreed with the steering group.

6.2.1 Telephone interviews

People who have taken part in NDNS RP will have a good understanding of what it is like to complete a four day food diary, and how this fits in with their everyday life. They will therefore have a view on how the potential new approaches compare with the method that is currently used.

NatCen will contact NDNS RP participants who have completed a four day food diary within the previous six months to ask if they would be willing to take part in this work. An unstructured topic guide will be developed in conjunction with the research team, which will be used to gauge views on the use of new technologies within the NDNS RP. Given the geographical spread of participants, conducting these interviews by phone will be appropriate and cost effective.

Those who agree to take part will be sent materials in advance of the interview, which will be refined to ensure they are accessible and easily understood. These will include:

- The overall aim/background of the project and a summary of the initial findings of the systematic review
- Instructions for review and what is required from them – this would cover details of the potential new technologies and how they would work.

NatCen will then telephone participants and discuss and record their views on the uses of new technologies, based on their knowledge of what it was like to take part in the survey. The questions will cover issues such as feasibility, practicality, burden, acceptability, understanding and interest.

6.2.2 Focus groups

In addition to involving people who have taken part in the NDNS RP, a small number of focus groups will be conducted with non-participants.

Focus groups offer a dynamic space for discussing a range of issues and enable participants to express their attitudes, beliefs and experiences in a way that would not be possible with other forms of data collection such as telephone or face-to-face interviews. Researchers are able to gain large amounts of data and gather multiple perspectives at the same time. Focus

groups are particularly useful for exploring views and thoughts about a specific issue while capitalising on communication between research participants. They offer a useful platform to formulate policy and practice recommendations.

The focus groups will be used to see how people react to the use of the potential new technologies in a survey setting. The positive points and possible downsides of the relevant technologies could be discussed, enabling the researchers to understand how the technologies are seen by members of the general public, and to assess how practical their use would be in a survey setting.

Four focus groups will be run (two each in two different geographic areas) with members of the general public (non-NDNS participants). Each group is to consist of around 6-8 people, and recruitment for each group might draw from specific population groups – for example, certain age groups, or users of specific technologies (eg smartphone users) – depending on the technologies identified for discussion by the steering group. A topic guide will be agreed with the research team. With the agreement of the participants, each group would be audio-recorded and then transcribed to help with analysis.

Following this work, a report will be prepared by the qualitative research team and sent to the University of Leeds, for incorporation with the literature review results in the final report.

7.0 Reporting

The findings of both the literature review and the qualitative research will be presented in a final report, alongside recommendations and conclusions for the Department of Health regarding suitability for the NDNS RP. The Department of Health will comment on a draft of the report, before amendments are made and the final version submitted at the end of the project.

It is anticipated that the report will be presented in the following format:

Executive summary;

- Introduction, including:
    - Background
    - Objectives
    - Research questions

    - Operational definitions
    - Review team
- Review methodology, including:
    - Inclusion/exclusion criteria
    - PRISMA flow chart
    - Quality appraisal processes
    - Software used for record selection, data extraction, analysis and synthesis
    - Qualitative research methodology
- Results, including:
    - Itinerary of new technologies
    - Overview of the included studies for each research question
    - Narrative summary and evidence statements for each question
    - Outcomes from the qualitative research
        - Telephone interviews
        - Focus groups
- Discussion, including:
    - Findings in context
    - Implications of findings
    - Limitations of the evidence
    - Limitations of the review and potential impact on findings
- Conclusion and recommendations to the Department of Health
- Appendices, including:
    - PRISMA table
    - Search strategies
    - Bibliography of included studies
    - Evidence tables
    - Quality checklist for validation studies
    - Excluded studies table

In addition to the project report, the following will also be supplied to the Department of Health:

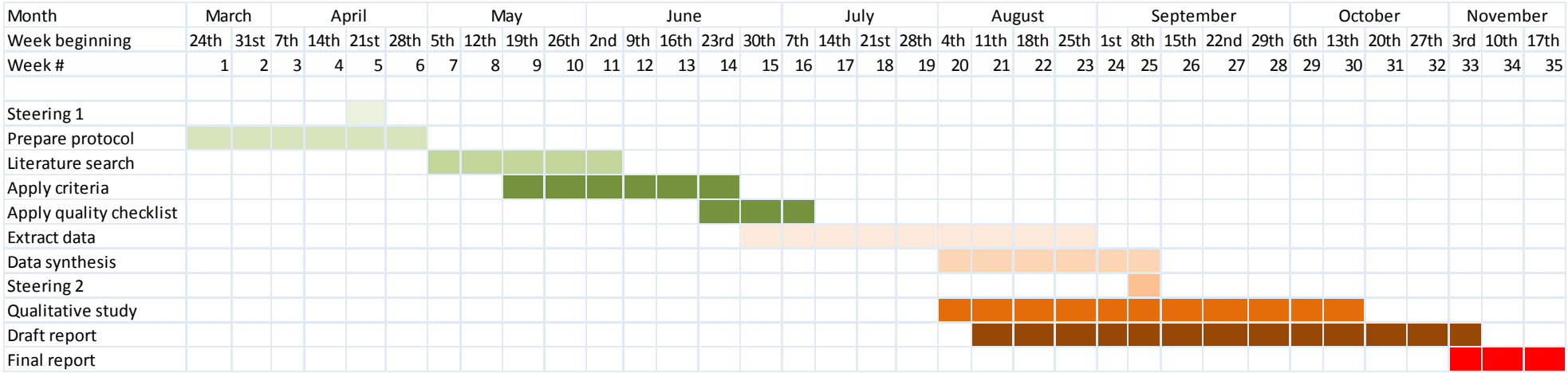
- Bibliographic records in a format compatible with Reference Manager or other bibliographic software as required
- A list of papers excluded at the full paper screening stage
- Electronic versions of included articles (subject to copyright laws)

8.0 Project deliverables

The following deliverables for this project have been identified by the Department of Health:

Deliverable number	Deliverable title	Target date
1	Steering Meeting 1	23.04.2014
2	Research protocol	02.05.2014
3	Quality checklist for validation and comparability studies	23.06.2014
4	List of included references	07.07.2014
5	Steering Meeting 2	12.09.2014
6	Draft report	27.10.2014
7	Final report	24.11.2014

9.0 Project timeline



Month	March		April				May				June					July				August				September				October				November		
Week beginning	24th	31st	7th	14th	21st	28th	5th	12th	19th	26th	2nd	9th	16th	23rd	30th	7th	14th	21st	28th	4th	11th	18th	25th	1st	8th	15th	22nd	29th	6th	13th	20th	27th	3rd	10th	17th
Week #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Steering 1																																			
Prepare protocol																																			
Literature search																																			
Apply criteria																																			
Apply quality checklist																																			
Extract data																																			
Data synthesis																																			
Steering 2																																			
Qualitative study																																			
Draft report																																			
■ Final report																																			

Revisions to Protocol

August 2014

1.0 Introduction

This document sets out agreed mid-project amendments to the review on 'making the best use of new technologies in the National Diet and Nutrition Survey'. A protocol for the project was drawn up with agreement from the steering group and circulated in May 2014. An interim meeting was scheduled between the University of Leeds (lead research team) and the Department of Health/Public Health England (funding body) in July, to present the initial results from the literature screening, and discuss priorities for data extraction and synthesis. Due to the large volume of eligible references found in the literature search, a number of changes to the original protocol were agreed, as described below.

2.0 Amendments to protocol

2.1 Research team

The literature review team has been expanded to include:

- Cath Rycroft (research assistant) and
- Sarah Matthews (Rank Prize Fund student)

The qualitative research team now also includes:

- Kim Vowden (senior researcher, NatCen)
- Valdeep Gill (senior researcher, NatCen)

2.2Literature review

The number of eligible references was found to be in excess of 300 records. Due to the short timeframe of the project, it would not be feasible to extract data and synthesise all of these records in the necessary time. Therefore, a number of strategies for prioritisation were agreed during the interim meeting: firstly, some further eligibility criteria were agreed; and secondly, it was proposed that the eligible tools be categorised into narrower definitions of technology type, from each of which an exemplar tool would be selected for inclusion in the review. Each exemplar tool selected should be a good representative of tools in its particular category, to facilitate the comparison of generic features of tools. Details of the protocol amendments are presented below.

2.2.1 Eligibility criteria

In order to help narrow the focus of the review, some further exclusion criteria were agreed. The following amendments to the eligibility criteria were agreed:

Additional exclusion criteria:

- Tools which use a diet history method to gauge usual intake
- Tools which are setting-based (for example, those that are only cafeteria based)
- Photography methods which focus on behavioural indicators of under-reporting
- Tools designed exclusively for use in young children (primary school age (11years) and below)
- Papers featuring the Oxford WebQ (identified as a form of FFQ)
- Free-text entry, unstructured tools, such as Twitter or text messaging
- Computerized weighing scales
- Optically readable pre-coded diaries

2.2.2 New technology categories

In order to facilitate the selection of exemplar tools, it was judged necessary to categorise eligible technologies using narrower category definitions than originally proposed (the original protocol specified seven broad technology categories). The new categories have been identified as follows:

1. Interviewer-led, direct-entry 24hr recall

Computerized tools (e.g. software) to aid interviewer-administered 24hr dietary recall, in which the interviewer enters the reported intake directly into the program for nutrient analysis. Often incorporates computerized prompts for the recall. Can be delivered face-to-face or by telephone. Examples include EPIC-Soft and Nutrition Data System for Research (NDSR).

2. Self-administered, computerized recall/diary

Computer software or devices which allow participants to record their dietary intake prospectively or retrospectively, independently of an interviewer. This category applies to non-portable computers. It includes, for example, CD-ROM-based software such as 'HEST', non-web-based recalls, such as YANA-C (Young Adolescents' Nutrition Assessment on Computer) or other digital, 'soft' versions of traditional diet diaries, and audio technologies which allow participants to make voice recordings of dietary intake.

3. Handheld digital computers

Portable digital computers, such as personal digital assistants (PDAs; e.g. the Palm Tungsten E2 PDA) or tablet computers, or software designed for such handheld computers.

4. Self-administered online diet diary

Web-based sites which allow participants to log in and record their dietary intake prospectively. There is a requirement for internet connectivity. Often includes drop-down lists of foods for entry, or allow food terms to be searched. Dietary data can then be automatically coded. Examples include the SuperTracker website, or www.sphealth.com.

5. Self-administered online 24hr recall

Participants are asked to report food consumption during the past 24 hours by a series of online questions and prompts. Responses are often entered by means of drop-down lists of food items or through search fields. There is a requirement for internet connectivity. Dietary data can then be automatically coded. Examples include ASA24 or myfood24.

6. Mobile phone app

Applications for use on Smartphones, which can be downloaded and installed. Similar to web-based techniques, but without the need for internet connectivity (necessarily), and allowing portability. Examples include MyFitnessPal, My Meal Mate, Lose it! or DiaTrace.

7. Non-automated camera

Photographic cameras that are not automated – ie the participant is in control of when photographs are captured. Includes disposable cameras, digital cameras, video cameras and mobile phone cameras. Often include time stamps to record when the image was taken. This category also includes software and/or algorithms used for processing digital images. Cameras can be used in two primary ways:

a. To complement diet diary or diet recall
b. To replace traditional methods

8. Automated camera

Photographic cameras that are automated, and are programmed to take continuous imaging at set time intervals. These include mobile phone cameras, and tools such

as SensCam and the eButton. .This category also includes software and/or algorithms used for processing digital images. Again, automated cameras can be used:

a. To complement diet diary or diet recall

b. To replace traditional methods

9. Barcode scanner

Tools used for barcode scanning, intended to complement diet diaries. Predominantly mobile phone-based.

10. Tools employing multiple media

Tools which incorporate two or more of the above described subcategories of tool. These are predominantly mobile-phone based, for example combining a Smartphone app with voice recording and photographs.

2.2.3 Data extraction & synthesis

Due to the large volume of eligible studies, it will not be feasible to extract data from all included studies within the necessary timeframe. Therefore, the decision was made by the funding body (Department of Health and Public Health England) and the review team at the University of Leeds to limit data extraction, synthesis and presentation to the literature focussing on selected exemplars of new technologies.

For each of the tool types listed above, an exemplar will be chosen, and all studies involving the exemplar will be included in data extraction and synthesis. In this way, conclusions about the advantages, disadvantages and suitability of a tool category will be based upon a single exemplar tool (or a limited number of tools if more than one is identified as an exemplar), with an assumption that tools within each category share similarities.

Tools not selected as exemplars will be retained in the itinerary of existing technologies as part of the final report.

2.2.4 Exemplar selection

In order to select an exemplar, efforts will be made to limit bias (both investigator and publication bias) by pre-specifying desirable criteria. Exemplars will be selected where there

is the most complete evidence available (not necessarily reflected by the number of publications). If more than one tool offers a broad range of information, tools which are in English and appropriate for the UK population will be prioritised. The chosen exemplars, along with a description of the reasons underlying their selection, will be presented to the funders for approval prior to data extraction. The following criteria were identified as being desirable in an exemplar:

1. Tools based in English language
2. Tools for which there is information on validity (including relative validity)
3. Tools for which there is information on the user experience (such as participant burden, acceptability, adherence etc)
4. Tools for which there is information on costs and resource implications
5. Tools which have been designed for or used in a UK population/sample.

Once identified, and confirmed as appropriate by the Department of Health, all the literature relating to the exemplars will go forward in the review process to have relevant data extracted and synthesised.

2.3 Qualitative research

The 'unit of analysis' in this review is the technology subcategory, as defined above (represented by an exemplar tool in each category). Therefore, it was agreed during the interim meeting that the qualitative research should take categories as the subject of the focus groups and interviews, as opposed to individual tools.

For the purposes of the qualitative research, the subcategories described above were grouped according to commonalities in the participant experience. Qualitative research participants will be asked their opinions on the usability and acceptability of:

- Dietary recording directly onto a device, using
    - Handheld personal computers,
    - A PC, or
    - A mobile phone
- Dietary recording through image capture (camera),
    - Non-automated, or
    - Automated
- Tools employing multiple approaches

Questions may focus on:

- how readily these tools might be employed in different individuals

- how comfortable people would be in recording as they go, rather than recalling their intake from the day before
- if using a Smartphone, how would they feel about receiving text reminders, or email alerts.

In the telephone interviews with previous NDNS participants, it may be possible to also ask about how they might feel about using cameras or audio equipment as an add-on method to support the paper-based record.

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Protocol Appendix 1

MEDLINE search terms

1. exp *Nutrition Assessment/
2. exp Diet Records/
3. exp *Diet Surveys/ or *Diet/ or *Energy intake/
4. exp *Eating/ not (exp *Dentistry/ or exp *Mastication/)
5. exp *Nutritional Status/
6. exp Dietetics/mt
7. exp Food Habits/ not (exp *smoking/ or tobacco/ or tobacco smoke pollution/ or smoking cessation/)
8. (food adj (intake or consumption)).tw.
9. (food adj (diar* or record* or journal* or log*)).tw.
10. (diet* adj (intake or consumption)).tw.
11. (diet* adj (diar* or record* or journal* or log*)).tw.
12. Nutrient*.tw.
13. *computing methodologies/ or exp *automatic data processing/ or exp *computer systems/ or *computers, molecular/ or exp *image processing, computer-assisted/ or exp *software/
14. exp Cellular Phone/
15. exp Copying Processes/ or exp informatics/ or pattern recognition, automated/ or user-computer interface/
16. exp Photography/
17. (web-based or online).tw.
18. (((mobile or smart or cell*) adj phone*) or smartphone* or iPhone* or ((Mobile or handheld) adj device*)).tw.
19. ((Mobile or iphone or android) adj1 app*).tw.
20. ecological momentar*.tw.
21. ("computer-assisted" and "self-admin*").tw.
22. (m-health or mhealth).tw.
23. ((portable or handheld) adj computer).tw.
24. (digital adj (camera or photo*)).tw.
25. camera.tw.
26. (computeri*ed or computer-mediated).tw.
27. (computeri*ed adj (tomography or (medical adj record*))).tw.
28. exp positron-emission tomography/ or exp tomography, X-ray computed/
29. exp *bronchography/
30. ((retinal or fundus) adj photo*).tw.
31. (CT adj scan*).tw.
32. (computer* adj2 (battery or task* or cogniti*)).tw.
33. exp *Street drugs/

34. or/1-12

35. or/13-26

36. 34 and 35

37. or/27-33

38. 36 not 37

39. limit 38 to yr="2000-Current"

40. exp animals/ not (exp animals/ and exp humans/)

41. exp Veterinary Medicine/

42. exp Animal Experimentation/

43. or/40-42

44. 39 not 43

EMBASE search terms

1. exp *Nutrition Assessment/

2. exp *Diet Surveys/ or *Diet/ or *Energy intake/

3. exp *Eating/ not (exp *Dentistry/ or exp *Mastication/)

4. exp *Nutritional Status/

5. exp Dietetics/mt

6. (food adj (intake or consumption)).tw.

7. (food adj (diar* or record* or journal* or log*)).tw.

8. (diet* adj (intake or consumption)).tw.

9. (diet* adj (diar* or record* or journal* or log*)).tw.

10. Nutrient*.tw.

11. exp Cellular Phone/

12. (web-based or online).tw.

13. (((mobile or smart or cell*) adj phone*) or smartphone* or iPhone* or ((Mobile or handheld) adj device*)).tw.

14. ((Mobile or iphone or android) adj1 app*).tw.

15. ecological momentar*.tw.

16. ("computer-assisted" and "self-admin*").tw.

17. (m-health or mhealth).tw.

18. ((portable or handheld) adj computer).tw.

19. (digital adj (camera or photo*)).tw.

20. camera.tw.

21. (computeri*ed or computer-mediated).tw.

22. (computeri*ed adj (tomography or (medical adj record*))).tw.

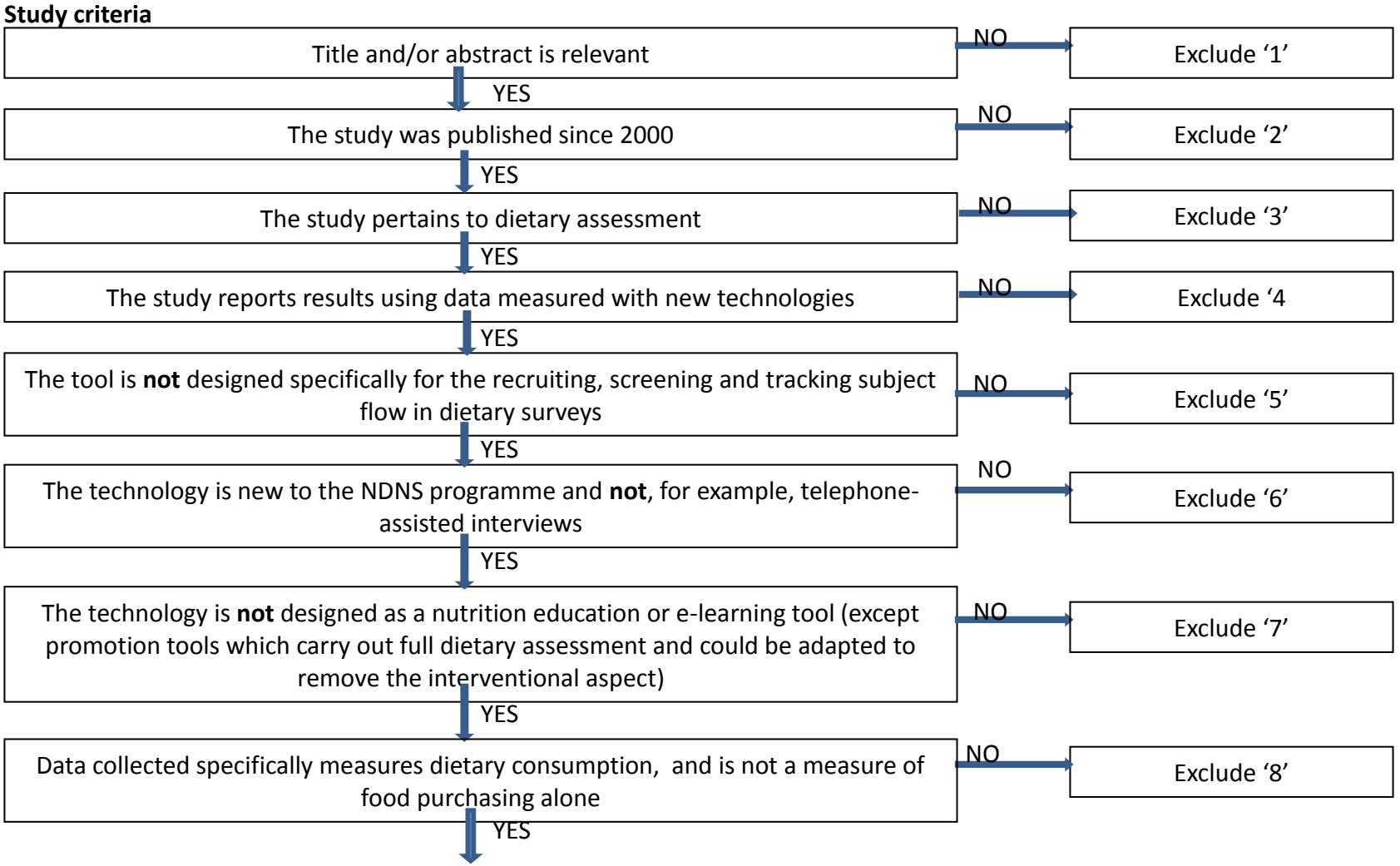
23. exp positron-emission tomography/ or exp tomography, X-ray computed/

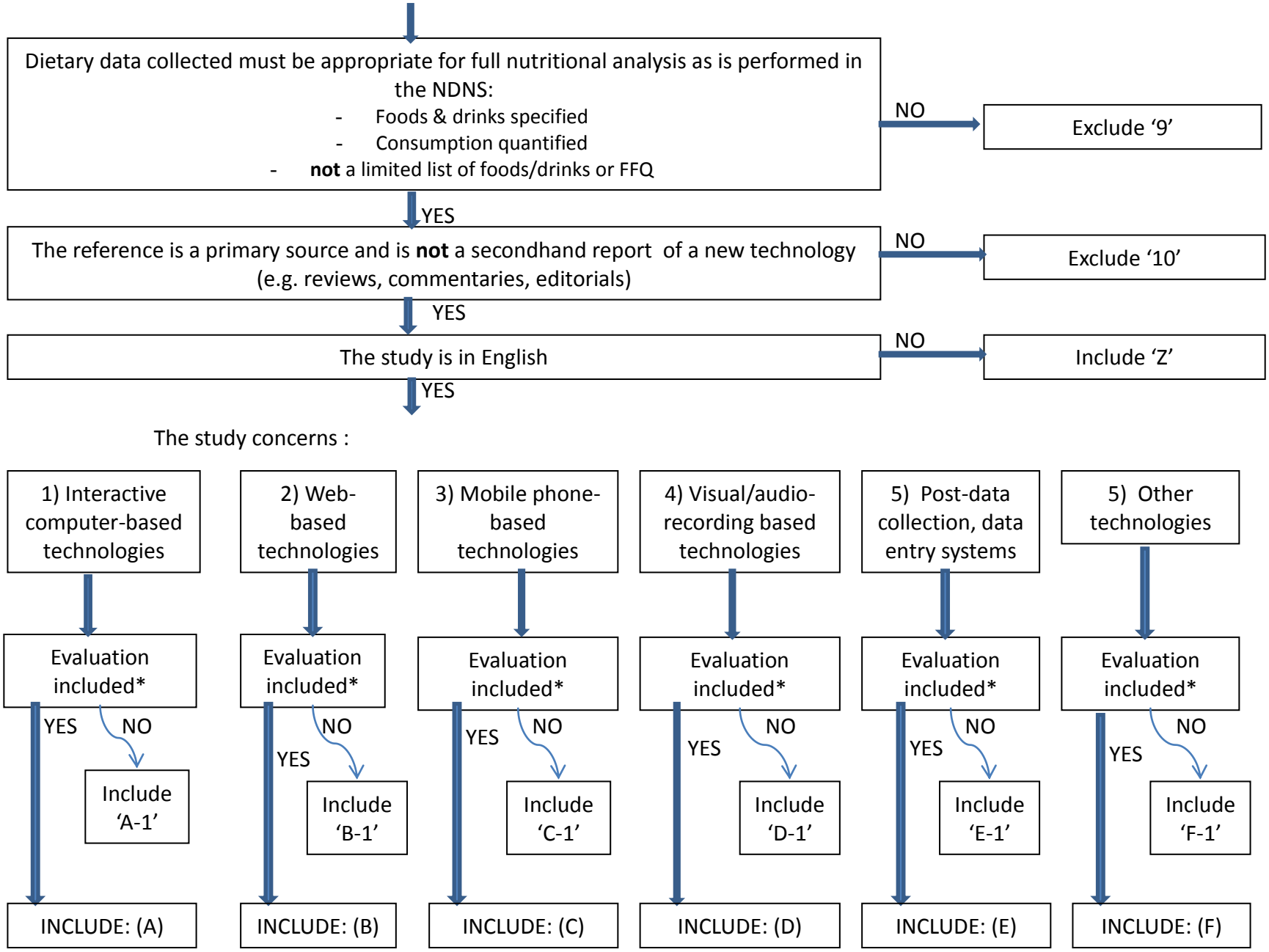
24. exp *bronchography/

25. ((retinal or fundus) adj photo*).tw.
26. (CT adj scan*).tw.
27. (computer* adj2 (battery or task* or cogniti*)).tw.
28. exp *Street drugs/
29. exp animals/ not (exp animals/ and exp humans/)
30. exp Veterinary Medicine/
31. exp Animal Experimentation/
32. exp diet selection/
33. (or/1-10) or 32
34. *computer analysis/ or exp *information processing/ or exp *computer systems/ or exp *image processing, computer-assisted/ or exp *software/
35. exp Copying Processes/ or pattern recognition, automated/ or user-computer interface/
36. Photography/
37. (or/11-21) or (or/34-36)
38. 33 and 37
39. or/22-31
40. 38 not 39
41. limit 40 to yr="2000-Current"

Protocol Appendix 2

Reviewer screening process





*The study provides new information on the development, features or evaluation of the technology, and is not merely a study that utilises the technology for dietary assessment without addressing these points

Appendix C: First pass screening

The first part of the three-stage screening process used keyword searches within the EPPI-Reviewer library to identify obviously irrelevant papers. The following searches were run:

- In the Year field:
  - "19" (to identify papers published prior to 2000)
- In the Title/abstract field:
  - "animal"
  - "vet"
  - "veterinary"
  - "drug"
  - "plant"
  - "brain"
  - "neurological"
  - "x-ray"

Titles of records identified by the above search results were rapidly assessed and excluded if obviously ineligible (see Table 5). If eligibility was unclear from the title, the record was retained for further screening.

Table 5 First pass screening results (19/05/2014)

Search term	Number of hits	Number excluded at 1st pass	Number unclear – continued to 2nd pass
19	9	9	0
animal	157	118	39
vet	3	2	1
veterinary	2	1	1
drug	122	94	28
plant	116	92	24
brain	120	99	21
neurological	14	8	6
x-ray	76	44	32
TOTAL	539*	406*	133*

*Some references were returned by more than one search.

Appendix D: Descriptions of technology categories

Following the literature search (and prior to the addition of further eligibility criteria), the tools described in the literature were grouped into categories based upon similarities in administration and user experience. Eleven categories were identified (five of which proceeded to the data extraction phase of the literature review):

1. Interviewer-led, direct-entry 24hr recall

Computerized tools (e.g. software) to aid interviewer-administered 24hr dietary recall, in which the interviewer enters the reported intake directly into the program for nutrient analysis. Often incorporates computerized prompts for the recall. Can be delivered face-to-face or by telephone. Examples include EPIC-Soft and Nutrition Data System for Research (NDSR).

2. Self-administered, computerized recall/diary

Computer software or devices which allow participants to record their dietary intake prospectively or retrospectively, independently of an interviewer. This category applies to non-portable computers. It includes, for example, CD-ROM-based software such as 'HEST', non-web-based recalls, such as YANA-C (Young Adolescents' Nutrition Assessment on Computer) or other digital, 'soft' versions of traditional diet diaries, and audio technologies which allow participants to make voice recordings of dietary intake.

3. Handheld digital computers

Portable digital computers, such as personal digital assistants (PDAs; e.g. the Palm Tungsten E2 PDA) or tablet computers, or software designed for such handheld computers.

4. Self-administered online diet diary

Web-based sites which allow participants to log in and record their dietary intake prospectively. There is a requirement for internet connectivity. Often includes drop-down lists of foods for entry, or allow food terms to be searched. Dietary data can then be automatically coded. Examples include the SuperTracker website, or www.sphealth.com.

5. Self-administered online 24hr recall

Participants are asked to report food consumption during the past 24 hours by a series of online questions and prompts. Responses are often entered by means of drop-down lists of food items or through search fields. There is a requirement for internet connectivity. Dietary data can then be automatically coded. Examples include ASA24 or myfood24.

6. Mobile phone app

Applications for use on smartphones, which can be downloaded and installed. Similar to web-based techniques, but without the need for internet connectivity (necessarily), and allowing portability. Examples include MyFitnessPal, My Meal Mate, Lose it! or DiaTrace.

7.& 8. Non-automated camera

Photographic cameras that are not automated – ie the participant is in control of when photographs are captured. Includes disposable cameras, digital cameras, video cameras and mobile phone cameras. Often include time stamps to record when the image was taken. This category also includes software and/or algorithms used for processing digital images. Cameras can be used in two primary ways:

7. To complement diet diary or diet recall

8. To replace traditional methods

9. & 10. Automated camera

Photographic cameras that are automated, and are programmed to take continuous imaging at set time intervals. These include mobile phone cameras, and tools such as SensCam and the eButton. This category also includes software and/or algorithms used for processing digital images. Again, automated cameras can be used:

9. To complement diet diary or diet recall

10. To replace traditional methods

11. Barcode scanner Tools used for barcode scanning, intended to complement diet diaries. Predominantly mobile phone-based.

Appendix E: Search results from non-database sources

A summary of the records identified from non-database sources and imported into the EPPI-Reviewer database can be seen in Table 6. A summary of ongoing grants (with no associated publications to date) is shown in Table 7. Details of search results for each source is described below.

Review citations

A total of 31 reviews were identified in the database searches and were screened for relevant citations. Of these, 23 were found to include potentially relevant citations. After checking these citations against the EPPI-Reviewer database and the eligibility criteria, 18 new references were identified, from 10 reviews. These were added to the EPPI-Reviewer database.

Non-review citations

During the full-text screening, records were excluded if they had used a new technology for dietary assessment, but included no new information on the development, features, or evaluation of the new technology. These records (n=94) were hand-searched for references to articles containing a description of the development or evaluation of the technology used. Relevant citations were then checked against the EPPI-Reviewer database to identify any records that had not been captured in the literature searches. Six new articles were identified in this manner, and added to the EPPI-Reviewer database.

After exemplars had been selected, the key papers describing each exemplar were entered in a citation search using Web of Science Core Collection. A further 7 references were found using this strategy.

Conference proceedings

Twelve presentations, posters or abstracts from 4 conferences or meetings, that had not been previously included in the EPPI-Reviewer database, were found to meet the eligibility criteria: 6 from ICDAM 2012; 3 from ISBNPA 2013; 1 from the Nutrition Society Irish Section Meeting 2014; and 1 from the Nutrition Society Summer Meeting 2014. The proceedings from ISBNPA 2013 included titles only, and were therefore excluded during the eligibility screening after being imported into the EPPI-Reviewer database.

Journal hand-searches

The recent issues of two journals were hand-searched in June 2014, revealing 1 relevant article, from the Journal of Medical Internet Research, that had not been captured in the database searching. This was imported into the EPPI-Reviewer database.

NCI Register

The National Cancer Institute (NCI) Dietary Assessment Calibration/Validation Register was searched for studies featuring new technologies. Potentially relevant articles were identified, and checked against the records already held in the EPPI-Reviewer database. Two new articles were identified and incorporated in the database.

National surveys

Details of 16 national dietary surveys were located for the 34 OECD member states. Four of these mentioned new technology in the dietary assessment methods. These were:

- Belgium (EPIC-Soft, computer-assisted 24hr recall);
- Finland – FINDIET (Finessi, computer-assisted recall with barcode scanning);
- New Zealand – LEDDAS (computer-assisted 24hr recall); and
- USA – AMPM (computer-assisted 24hr recall).

Three associated references were found for the technologies that had not already been captured in the database searches: Finessi and LEDDAS. These were imported into the EPPI-Reviewer database.

Mobile phone application stores

Over 2000 apps were returned for searches using the term 'diet' on each of the mobile application store websites that reported search statistics (Apple and Amazon). The 60 apps compiled were assessed against the review criteria, and eligible apps were entered as search terms on Web of Science Core Collection. One app was found to have associated publications (FitBit). These publications featured the physical activity components of the app only, with no information regarding the dietary aspects of the app, and were therefore ineligible for this review.

Expert solicitations

Nine eligible records were provided through expert solicitation, predominantly from grey literature (presentations, project reports, working papers). Three of these came to light through the Bristol Online Survey publicised at meetings and to society members. No tools or records were identified through ResearchGate.

In addition, 3 PhD theses were identified in which the development and evaluation of new technologies (MMM, The Biggest Loser and Nutricam) was featured.

Grants registries

The search terms entered into the BBSRC database returned 30 hits, of which none were found to meet the review criteria.

Searching NIH rePORT returned 140 hits, of which 18 were judged eligible against the review criteria. Of these, 15 grants did not have any associated publications, either listed in the grants registry or in our review database (3 had associated records listed in the EPPI-Reviewer database).

Nineteen potentially relevant grants were identified from ClinicalTrials.gov, of which 8 had associated papers included already in the EPPI-Reviewer database and 2 had already been identified through NIH rePORT. The remaining 9 records from ClinicalTrials.gov had no associated records included in the review.

From all grants information sources, 24 relevant projects without associated publications were found. These grants are detailed in Table 7. Note that these projects were logged and identified as relevant before the additional eligibility criteria were agreed in July 2014.

Table 6 Eligible records identified through non-database sources

Source(s)	Number of new records identified and imported
Review citations	18
Non-review citations	13
Conference proceedings	12
Journal hand-searches	1
NCI registry	2
Grants registries/databases	0
National dietary surveys	3
Mobile app stores	0
Expert solicitations	9
Theses	3
Total	**61**

Table 7 Summary of grants with no matching publications

Grant ID	Year (project start date)	Awardee organisation	PI	Title	Tool/technology	Description
NIH rePORT						
1R21CA172864-01A1	Sep 2013	Baylor College of Medicine	Tom Baranowski	Minimizing memory errors in child diet assessment	Sun-ASA24-Kids	A children's version of ASA24, combined with the 'Sun System' which includes the e.button for image capture
5R01HL103737-03	Jul 2012	UNIVERSITY OF SOUTH CAROLINA AT COLUMBIA	Suzanne Baxter	Children's dietary recalls: prompts; retention interval; and accuracy		Web-based 24hr-recalls tested in 4th graders
5R01HL107370-04	Mar 2014	University of Pittsburgh	Lora Burke	REAL TIME DATA COLLECTION WITH ADAPTIVE SAMPLING AND INNOVATIVE TECHNOLOGIES	EMA	Real-time transmission of data to link information from smart-phones, weight scales, daily diaries, actigraphs, and accelerometers.
5R43MD008595-02	Sep 2013	enviroNMENT AND HEALTH GROUP, INC.	Dharma Cortes	Mobile healthy food purchasing intervention for Hispanics		Mobile app the ability to create a user-generated a grocery list, analyze nutritional value and cost of food, and promote the USDA's MyPlate visual method, Spanish language
2R44DK085748-02	Oct 2009	BodiMojo, Inc	Elizabeth Donovan	Mobile motivation for health promotion among adolescents	BodiMojo	Health promotion app, with ability to 'monitor and reward progress' of adolescents
5R21CA155965-02	Jul 2011	Duke University	Bernard Fuemmler	FITFAB 4 SURVIVORS		"The app will include tools for near effortless self-monitoring of diet, physical activity, and weight; motivational messages and the use of a virtual token-economy to encourage participation; and a social-networking component"
5R01CA142919-03	Feb 2012	Baylor College of medicine	Theresa Nicklas	Validation of a digital diet method for use with preschool children.	The Food Photography Application [FPA])	RFPM adapted for parents to use smartphones to capture preschoolers' food intake.
1R21HL118347-01	Sep 2013	Tuffts University Boston	Susan Roberts	Assessment of food intake using speech-understanding technology.		Building on WAMI (Web-accessible Multimodal Interface) to develop a "spoken dialogue system to solicit sufficient information to determine quantitative amounts of specific food items"
5R01DK095078-02	May	Penn State	Christopher	Impact of integrating an internet		Internet weight control program in primary care

Grant ID	Year (project start date)	Awardee organisation	PI	Title	Tool/technology	Description
	2012	University	Sciamanna	weight control program into primary care.		settings. Unclear if "diet behaviour" monitoring includes dietary assessment.
5R01HL075451-09	Dec 2003	Northwestern University at Chicago	Bonnie Spring	Make better choices (MBC) - multiple behavior change in diet and activity.	MBC	A smart phone with behavioral decision support tools to self- monitor and transmit data and will be coached by telephone. A publication relating to the first trial exists, but this grant is for further trials.
5U01CA152904-04	Sep 2010	Harvard School of Public Health	Meir Stampfer	Validity of diet and activity measures in men	ASA24	Long-term validity trial comparing against 7-d records and repeat FFQs as well as urine, DLW and fasting blood.
1F31NR013811-01A1	Jan 2014	Johns Hopkins University	Janna Stephens	Smartphone technology to decrease BMI in overweight and obese adolescents		Smartphone application is used for self-monitoring of dietary habits and physical activity and will be combined with a one time behavioral counselling for weight loss.
5R01CA165255-02	Sep 2012	University of Pittsburgh	Mingui Sun	Wearable e-button for evaluation of energy balance with environmental context and...	eButton	A button- like device, eButton, will be worn on the chest, including an optical eating detector to monitor eating/drinking/smoking, two miniature cameras to measure food portion size without depending on a reference card, an ear-based oximeter for measurement of heart rate and oxygen saturation, and an extrapolation formula to measure outdoor environment using the US environmental protection agency (EPA) database.
5R01DK095779-02	Jul 2012	Miriam Hosptial	J. Graham Thomas	Live smart: smartphone intervention for weight control.		Smartphone app for self-monitoring. 18-month weight loss intervention.
1R43HL118812-01	Aug 2013	Viocare, Inc	Rick Weiss	Diet assessment communications portal for data sharing within the PCMN	VioScreen PCMN (patient-centred medical neighborhood)	A technology-based interface to improve the efficiency of dietary intake assessment of referred patients; linked to electronic medical record.
ClinicalTrials.gov						

Grant ID	Year (project start date)	Awardee organisation	PI	Title	Tool/technology	Description
NCT01682317	Sep 2012	University of Tennessee	Hollie Raynor	Healthy Eating Patterns during a Lifestyle Intervention (HEP)		PalmPilot-based EMA used to collect real-time information on consumption cues.
NCT01516411	Jan 2012	Stanford University	Abby King	Promoting Healthy Lifestyles Using Mobile Phones		Nutrition app promotes behavior change via tracking of food consumption
NCT00624598	Feb 2008	Colorado Center for Chronic Care Innovations, Inc.	Scott McDoniel	The Short-Term Effect of a Technology Driven Weight Control (SMART) Program for Obese Adults (WCPC)		Study of Integrating RMR Technology and Email Counseling in a PCP Office. Includes use of a computer application for journalizing food and exercise
NCT01668316	Aug 2012	University of North Carolina, Greensboro	Cheryl Lovelady	Get Active and Eat Right: Moms at Work (GEM)	MyPlate SuperTracker	USDA web tool to complement MyPyramid Menu Planner. Trial is for weight loss during lactation.
NCT01693250	Sep 2012	University of California, San Francisco	Jyu-Lin Chen	Phase 1 Study of Fitbit and Apps on Healthy Weight Management in Obese Teens in Primary Care Clinics	Fitbit and apps	Healthy weight management trial in teens.
NCT01862796	May 2013	NIDDK	Marci Gluck	Predicting Adherence to a Heart-Healthy Diet in Lean and Obese Individuals		Smartphone daily food records.
NCT01650337	July 2012	UCLA	Brian Laing	mFit: The Mobile Fitness Project		Randomized Trial of a smartphone Application for Weight Loss in Primary Care
NCT01477255	Nov 2011	St Jude's Children's Research Hospital	Sean Phipps	The Feasibility of a Daily Diary Methodology With a Pediatric Cancer Population (DIARY1) Pilot study	iPads	
NCT01579292	Apr 2012	University of California, San Francisco	Yoshimi Fukuoka	mDPP Pilot RCT of a Motivational Mobile Diabetes Prevention Program (mDPP)		Mobile phone based physical activity intervention with diet diary

Appendix F: Itinerary of tool names

Interviewer-led, direct-entry 24hr recall
USDA Automated Multiple-Pass Method, AMPM
EPIC-Soft
NINA-DISH
UNyDIET
Nutrition Data System for Research, NDSR
Leemoo
Dietary Intake Data System, DIDS
FINDIET 2007
LEDDAS

Self-administered, computerized recall/diary (non-web)
Probst (2005)
Young Adolescents Nutrition Assessment on Computer, YANA-C
Cano (2013)
Nutri-Genie
Executive Diet Helper, EDH
Mennen (2002) - Minitel
Computerized Interactive Multimedia, IMM
Spoken Dietary Records, SDR

Self-administered online diet diary
dietmeter
DieetInzicht.nl
SuperTracker/MyPyramid Tracker
My IBD Portal
Christensen (2014)
SP Health Weight Management Program - The Biggest Loser Club
PREDIRCAM
Harvey-Berino (2002)
www.eatfit.net
Nutracheck
eaTracker
DIET tracker
Pacific Tracker (PacTrac)
My Health, My Life
Nutrition Analysis Tool, NAT
NutriQuanti
KiloCoach
Calorie King
van der Mark (2009)
MXS-Epidemio, MXS
Williamson (2006)

Self-administered online 24hr recall
myfood24
DietDay
Automated Self Administered 24 hour diet recall, ASA24
Web-SPAN
SCRAN24/INTAKE24
Web-based Food Behaviour Questionnaire, FBQ
NutriNet-Sante
Hutchesson (2013)
Jaeger (2009)
Park (2009)
GRUNUMUR 2.0
DietAdvice
Wadsworth (2012)
Hellenic Health Foundation (HHF) Nutrition Tool
Synchronised Nutrition and Activity Program for Adults, SNAPA
DietIreland

Mobile phone app
Lose It! Weight loss app
Pattern-Oreinted Nutrition Diary, POND
smartERB
Booth (2013)
MyMealMate, MMM
NutriMeter
Weight Management Mentor (WMM)
Guyon (2013)
BALANCE
Hutchesson (2013)
Lavinia
SmartDiet
SapoFitness/SapoFit
health-e-living
Ni Mhurchu (2013)
ENGAGED (with CalorieKing)
MyPlate
Fat Secret (used ASA24)
Wohlers (2009)
Doherty (2012)
Dorman (2010)
Dietary Intake Monitoring Application, DIMA
HyperFit
King (2011)

PDA
DietMatePro
Personal Electronic Device, PED Cushing (2011)
A Personal Digital Assistant for Obesity Treatment, PDA+
BalanceLog
Fukuo (2009)
Glanz (2006) (2007)
Mobile device food record, MDFR
Ma (2006)
Oliver (2013)
Park (2005)
Calorie King
Spring (2010)
DMS (Diabetes Monitoring System)
Diabetes Pilot
Holm (2011)

Non-automated camera
To complement diet diary or diet recall
Amano (2007)
Brown (2012)
disposable camera (Gregory, 2006)
The Eatery app
Food on Film research kit
Kawabata (2010)
Food Photography 24h recall method, FP 24-hR
Long (2013) (with MyPyramid Tracker)
Nutrition Data System for Research (NDSR) with cell-phone photographs
iPad with NDSR (Ptomey, 2013)
Rafamantanantsoa (2003)
Schap (2012)
Photovoice
Recaller
Multimedia Diet record, MMDR
NANA

To replace traditional methods
Anthimopolous (2013)/Scarnato (2011)
Aoki (2006)
Mobile telephone food record (mpFR)/Technology Assisted Dietary Assessment (TADA)
Food Record application, FRapp
Chen (2010)
Chung (2010)
FoodLog
Remote Food Photography Method, RFPM
Ehrmann (2014)
Elinder (2012)

Health Aware
Higgins (2009) (disposable camera)
Humphries (2009, 2010)
Wellnavi
DietCam
Kubota (2013)
Lassen (2010)
Health Support Intelligent System of Diabetic, HSISD
Most-Windhauser (2001)
Dietary data recorder system, DDRS
Siapco (2014)
Stumbo (2011)
Sullivan (2003)
Sun (2008)
Suzuki (2002)
SPIN (food recognition tool)
Williamson (2001, 2003)
Woo (2010)
Yue (2012)
Zhang (2010)
Nguyen (2014)
Nutricam
DiaTrace
Food Intake Visual and voice Recognizer, FIVR

Automated camera

To complement diet diary or diet recall
Image-DietDay
SenseCam

To replace traditional methods
eButton
Sun (2010)
Yao (2007)

Barcode scanner
Personal Allergy Assistant, PAA

Appendix G: Bibliography of eligible records

Exemplars

The Biggest Loser Club

Collins C E; Morgan P J; Jones P, et al (2010) Evaluation of a commercial web-based weight loss and weight loss maintenance program in overweight and obese adults: a randomized controlled trial. BMC Public Health. 10: 669.

Hutchesson M J; Truby H, Callister R, et al (2013) Can a Web-based food record accurately assess energy intake in overweight and obese women? A pilot study. Journal of Human Nutrition and Dietetics: 26 (S1): 140-144.

Hutchesson M J; Callister R, Collins C E; (2013) Is a web, smartphone or paper based food record more accurate or acceptable? ISBNPA, Ghent, Belgium.

Hutchesson M J; Collins C E; Morgan P J; et al (2014) Changes to dietary intake during a 12-week commercial web-based weight loss program: A randomized controlled trial. European Journal of Clinical Nutrition. 68(1): 64-70.

Neve M, Callister R, Collins C, Morgan P (2009) Under-reporting of energy intake among overweight women using a web-based food diary. Annals of Nutrition and Metabolism. 55: 89-89.

Neve M J; (2011) Innovative approaches to treat overweight and obesity in adults: An investigation of a commercial web-based weight loss program. PhD: University of Newcastle.

Neve M, Morgan P, Collins C E; (2011) Weight change in a commercial web-based weight loss program and its association with website use: cohort study. Journal of Medical Internet Research. 13(4): e83.

MXS-Epidemio, MXS

Vergne S, Monnerie B, Tavoularis G, et al (2011) Optimized E-diary to increase accuracy and acceptability of dietary surveys. 11th European Nutrition Conference, FENS 2011 Madrid Spain.

Anonymous (2013) Tutoriel outil online CCAF 2013 (Online Tutorial Tool). Paris: Credoc.

Automated Self Administered 24 hour diet recall, ASA24

Baranowski T, Islam N, Baranowski J, et al (2012) Comparison of a Web-Based versus Traditional Diet Recall among Children. Journal of the Academy of Nutrition and Dietetics. 112(4): 527-532.

Bjorge-Schohl B, Johnston CS; Trier CM; et al (2014) Agreement in Participant-Coded and Investigator-Coded Food-Record Analysis in Overweight Research Participants: An Examination of Interpretation Bias. Journal of the Academy of Nutrition and Dietetics. 114(5): 796-801.

Ettienne-Gittens R, Boushey C J; Au D, et al (2013) Evaluating the feasibility of utilizing the Automated Self-administered 24-hour (ASA24) dietary recall in a sample of multiethnic older adults. Procedia Food Science. 2: 134–144

Frankenfeld C L; Poudrier J K; Waters N M; et al (2012) Dietary Intake Measured from a Self-Administered, Online 24-Hour Recall System Compared with 4-Day Diet Records in an Adult US Population. Journal of the Academy of Nutrition and Dietetics. 112(10): 1642-1647.

Kirkpatrick S I; Subar A F; Douglass D, et al (2014) Performance of the Automated Self-Administered 24-hour Recall relative to a measure of true intakes and to an interviewer-administered 24-h recall. AJCN. 100(1):233-240

Massarelli I, Rondeau I, Roach P (2012) Adapting the ASA24 for use in Canada. ICDAM, Rome.

Stote K S; Carrico P, Cole R (2011) Assessing adults' dietary intake, utilizing the national cancer institute's automated self-administered 24-hour dietary recall, in virtual learning environments. Experimental Biology 2011, Washington, DC, United States.

Subar A F; Thompson F E; Potischman N, et al (2007) Formative Research of a Quick List for an Automated Self-Administered 24-Hour Dietary Recall. Journal of the American Dietetic Association. 107(6): 1002-1007.

Subar A F; Crafts J, Zimmerman T P; et al (2010) Assessment of the Accuracy of Portion Size Reports Using Computer-Based Food Photographs Aids in the Development of an Automated Self-Administered 24-Hour Recall. Journal of the American Dietetic Association. 110(1): 55-64.

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To complement diet diary or diet recall

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To replace traditional methods

eButton

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Yao (2007)

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Barcode scanner

Personal Allergy Assistant, PAA

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Appendix H: Detailed results of literature review

Exemplar	Domain	Reference*	Study description	Findings
Web-based diet diary				
The Biggest Loser	Validity	- Neve (2009)[33]	Australian women signed up for a 10-week weight loss program. Participants (n=11) filled out 5-day web-based food diaries at baseline and post-intervention. Indirect calorimetry was used to measure resting energy expenditure, accelerometers to estimate physical activity.	• The mean differences between energy intake estimated from indirect calorimetry and reported energy intake were 668.9kcal/d (SD 448.1) at baseline and 686.3kcal/d (SD 407.2) post-intervention.
		+ Hutchesson (2013)[30]	A pilot study prior to a weight-loss programme, conducted amongst women (n=12, mean age 34.5yr (SD 11.3)) affiliated with the University of Newcastle, Australia, with a self-reported moderate level of computer skills. Data were collected over 10 days, with laboratory visits on days 1 and 10. The web-based record was maintained for 9 days. Urine was collected daily for 9 days for DLW. Participants not weight stable were excluded (n=3).	• Mean difference between self-reported energy intake and total energy expenditure was -2301 (SD 1535) kJ per day. • The mean reporting accuracy (EI/TEE) was 79.6% (SD 14.1%). The 95% limits of agreement were -5305 and 707 kJ per day.
	Relative validity	- Neve (2009)[33]	As described above.	• Prevalance of under-reporting (using Goldberg cut-offs) was similar to other assessment methods (n=2 at baseline and n=4 post-intervention).
	Acceptability	Neve (2011)[34]	The study used data from participants enrolled on a commercial web-based weight-loss program in Australia. Participants were encouraged to self-monitor using the online diet diary or SMS. 11, 341 adults enrolled in the program, of which 6,943 still subscribed at 12 weeks and 2,656 subscribed at 52 weeks (subjects were 86% female, mean age 35.7yr (SD 9.5), predominantly moderate-to-high socioeconomic status (85%) and had an initial BMI of 22kg/m2 or over).	• 75.5% of 12-week subscribers used the food diary, and 75% of 52-week subscribers. • 12-week users made food entries a median of 7 days (IQR 1-20). 52-week users made food entries a median of 8 days (IQR 1-34).
	Resources	None		

Exemplar	Domain	Reference*	Study description	Findings
Web-based diet diary (cont'd)				
MXS-Epidemio	Validity	None		
	Relative validity	- Vergne (2011)[28]	The comparability study was conducted amongst French 18- to 60-year olds (n=246), who used both an online food diary and an unweighed paper-based diary to record food. A cross-over design was used, with a 1-week washout period. A questionnaire on acceptability was administered at the end.	• There was no significant difference between the methods in energy intake: 1824kcal/d (SD 39) for online and 1836 kcal/d (SD 41) paper.
	Acceptability	Vergne (2011)[28]	As above	• 77% of participants preferred the online method.
	Resources	None		
Web-based 24-hour recall				
ASA24	Validity	+ Subar (2010)[46]	Formative research to guide portion size image development, comprising 2 studies. For both studies, participants attended study site on two consecutive days: on the 1st day, fed 2 meals (self-served from buffet); on the second filled out recall. Serving containers and plate waste were weighed unobtrusively. Participants were allocated into 3 groups (Study 1) and 2 groups (Study 2). In study 1 (n=29), 4 types of image were presented (aerial photos, 45 degree angled photos, images of household measures, images of food mounds). Images were shown either simultaneously or sequentially. Ordering of different screen layouts was random. In study 2 (n=20), images were shown either small or large, and either 4 or 8 were shown simultaneously. Participants were 50% female, 50% non-White, 33% had high school education.	• The mean difference in gram weights was smallest using angled photographs for the majority of foods. Only one comparison (corn chips) reached statistical significance. • For most foods, mean difference was smallest when images were presented simultaneously. • In study 1, approx 15% of all estimates were within 10% of weight consumed. • In study 2, mean % accuracy ranged from 9% (foods represented by household measures) to 23% (single-unit foods). • Greater accuracy was found when 8 photos were shown (statistically significant only for carrots). • For 50% of foods, a lower mean difference was apparent with small images, for 33%, with large images (ns). • In study 2, 14% of estimates were within 10% of weighed amounts: 16% with 4 images, 12% with 8 images.

Exemplar	Domain	Reference*	Study description	Findings
	Web-based 24-hour recall (cont'd)			
ASA24 (cont'd)	Validity (cont'd)	+ Kirkpatrick (2014)[40]	Participants (n=83) attended the research centre on 1d and consumed 3 meals, self-selected from buffet. Serving containers were inconspicuously weighed, as was plate waste. They returned the following day for an unannounced recall, and questionnaires. 50% respondents completed ASA24, 50% AMPM (stratified random split). The sample was US-based, 53% female, aged 20 to 70yr, 68% white, 18% had an income <$25,000, 45% $25,000-$99,000. Two participants were excluded/dropped out.	• ASA24 food entries were 66% exact matches to actual intakes, 10% close and 3% far matches. • Total matches (79.6%) did not significantly differ to those found with AMPM method (83.2%) (p=0.07). Match rates were significantly higher using AMPM for breakfast (95% vs 89%, p=0.01), but not for lunch or dinner. AMPM also had a better rate of exclusions at breakfast but not the other meals (5% vs 11%, p=0.01). • ASA24 food entries had 20% exclusions and 3% intrusions, compared to 17% exclusions and 1% intrusions for AMPM (p=0.07 and p<0.01). • Mean difference in reported energy intakes and true intakes were 125kcal for ASA24 (CI -136, 386; p=0.34) and for AMPM -134kcal (CI -364, 95.4; p=0.24). For women this was 0.52kcal for ASA24 (CI -236, 237) and -51.6kcal (CI -427, 324); for men 263kcal for ASA24 (CI -244, 770) and for AMPM -221kcal (CI -511, 68.5).
	Relative validity	+ Baranowski (2012)[36]	A test of whether US children could complete an early version of the ASA24. 1d intake was entered in presence of observer, after which an interview took place. Interview-administered 24hr recalls were conducted for the same 24hr period, face-to-face. Participants (n=120) were 8- to 13-year-olds, 50% female, of mixed ethnicity.	• 48% food reported in ASA24 were matches to interviewer-administered recall. 18% matched at food level (not item level). 12.5% were intrusions and 19% were omissions. There were 2.6% non-matches. • Percentage food match had significant age group and ethnicity main effects (p=0.001, p=0.002). Older age associated with a higher percentage of food matches (p=0.001), and lower percentage of omissions (p<0.0001). Boys omitted more and had more non-matches (p=0.026).
		+ Frankenfeld (2012)[39]	4d paper-based food records were kept over consecutive days, 1 of which was a weekend day. The record included a pictorial serving guide sheet. Within 2wks, participants were prompted by email to complete 2 online recalls using ASA24: 1 weekday and 1 weekend day (mean time between was 7d (median 4d)). Additional reminders were sent if recall not completed. US adults (n=173; n=80 lost to follow-up), 64.5% female, mean age 27yr (SD 11), 51.6% white.	• Mean energy estimated by 24hr recall was 1831kcal (SD 732, range 586 to 4580); mean from 4d record was 1850 (SD 584, range 854-3660). • Energy intakes showed a correlation of 0.44. • The % agreement of quartiles was 70.6%, with a kappa statistic of 0.30 (p<0.001).

Exemplar	Domain	Reference*	Study description	Findings
	Web-based 24-hour recall (cont'd)			
ASA24 (cont'd)	Relative validity (cont'd)	+ Ettienne-Gittens (2013)[38]	A feasibility study of using web-based alternative dietary data collection methods in Multiethnic Cohort (MEC) of Hawaii and LA, using a subsample (n=100). Participants were 56% female, aged 56 to 80yr, 33% white, 25% Japanese American, 21% native Hawaiian, majority college graduate or higher (54%). Participants completed three unannounced telephone-administered 24hr recalls on randomly selected days (2 weekdays, 1 weekend), at least 1wk apart. They were then mailed instructions, usernames and passcodes to access (the beta version of) ASA24 as well as a 6-item evaluation form. They were given 2wk to complete 1d recall. Email reminders were sent. 22 participants did not complete the questionnaire, 63 did not complete the validation study.	• Mean energy intakes were 1883kcal (SD 599) for interview and 1576kcal (SD 795) for ASA24. The mean difference was -307kcal and the limits of agreement ~-1600 and 1050kcal (actual values not given). • The correlation coefficient for energy intakes was 0.56 ($p<0.001$). • 6/37 reported implausible energy intakes using ASA24 (17-534kcal), compared to none of the interviewer-administered.
		+ Bjorge-Schohl (2014)[37]	Participants (n=28) were taking part in a trial examining satiety. They completed 3d handwritten food records before the start of the trial, and at weeks 1, 4 and 8. Participants were instructed to code their food records using ASA24. The sample was US-based, 89% female, mean age 41yrs (SD 11), and had a BMI of 25kg/m2 or greater.	• Mean energy intake from ASA24 was 1581kcal (SD 610) and from investigator-coded 1686kcal (SD 692) (n=161). The medians for each were 1502 and 1515kcal respectively. The median difference (ASA24 - investigator/investigator) was -7%. The ICC r was 0.797 ($p<0.001$). • Taking average intakes for participants who recorded 3 or more days (n=21), mean energy was 1592kcal (SD 328, median 1473) with ASA24 and 1694kcal (SD369, median 1717kcal). The median difference was -6% and ICC r was 0.876 ($p<0.020$).
		+ Subar (2014)[44]	Participants completed 2x 24hr recalls, 4-7wk apart. They were randomized into 4 groups: ASA24 only, AMPM only, ASA24 1st and AMPM 2nd, AMPM1st and ASA24 2nd. Participants were recruited from 3 US integrated health systems using quota sampling to ensure representations from a range of ages and race/ethnicity groups (n=1200; 20% non-completers).	• Mean energy intake estimated by ASA24 was 2132kcal, vs 2126kcal estimated by AMPM.

Exemplar	Domain	Reference*	Study description	Findings
	Web-based 24-hour recall (cont'd)			
ASA24 (cont'd)	Acceptability	Subar (2007)[45]	A formative study to inform development, involving a convenience sample of 18 adults (US, 50% female, 33% white, 33% Asian, 67% college educated or higher, minimum 6th grade literacy, with 'varying levels' of computer experience). Participant filled out a 24hr recall using two versions of quicklists: meal-based or unstructured (without usual multimedia attributes). Two recalls were conducted, 1 week apart, in the study centre using a crossover design. Participants were observed and had a debriefing interview.	• 13 participants (72%) preferred meal-based approach, 3 preferred unstructured and 2 had no preference. • Participants liked a single screen for all tasks. • Beverages were routinely reported non-chronologically (in contrast to most foods). • Neither typing nor browsing was clearly preferred for food searching. • No clear difference between the versions in number of foods reported, moved or deleted. • Participants requested fewer 'click' requirements, a 'copy' feature, automated tutorials, decreased scrolling, multiple names (e.g. brands).
		Subar (2010)[46]	Procedure described above.	• Participants generally preferred aerial photos (except for the 'spreads' category, for which household measures were preferred). • 28/29 participants preferred simultaneous over sequential presentation. • Participants strongly preferred larger over smaller photos and four over eight images.
		Stote (2011)[42]	Feasibility study of dietary assessment in students of an online nutrition undergraduate course in US. Participants (n=37, 70% female, mean age 36yr (SD 11)) completed ASA24 for 3d and questionnaire at beginning of course.	• 90% students completed all 3 recalls.
		Baranowski (2012)[36]	Procedure described above.	• 57% children reported ASA24 was easy to use. 8- to 9-year-olds were more likely to report finding it harder to understand. • Problems encountered included: often not knowing the answer to probes; the tutorial was frequently ignored; misspelled search terms; deviation from tasks; unintentional clicking of buttons; lack of visual cues causing confusion; between-meal snacking not considered a meal.

Exemplar	Domain	Reference*	Study description	Findings
	Web-based 24-hour recall (cont'd)			
ASA24 (cont'd)	Acceptability (cont'd)	Ettienne-Gittens (2013)[38]	Procedure described above.	• 56% (44 of 78) were able to successfully access ASA24. The younger age group (56-65yrs) were significantly more likely to do so (p=0.027). • Of those who accessed the system, 84% (37/44) were able to 'launch' - ie complete enough information for nutrient analysis. • 5 of 28 participants who did not complete a recall indicated it was because it was difficult to use, 2 said it took longer than expected, and 7 gave both reasons. • 51% (30/59) agreed website was easy to understand. • 48% (29/60) would not prefer ASA24 compared to telephone interview.
		Subar (2014)[44]	Procedure described above.	• Of participants completing both ASA24 and AMPM, a greater proportion preferred ASA24.
	Resources	None		
INTAKE24	Validity	- Newcastle (2013)[53]	Portion size validation: food in front (FIF) interview used, with real food portions presented to participant, who then estimated the portion size using photographs. Items were presented in a random order. 30 participants aged 11-17yr, 30 aged 18-24yr	• Portion size validation: 12/15 new photos were found to be more accurate (comparing means) and more precise (comparing range).
	Relative validity	- Foster (2013)[51]	Formative research using prototype system (SCRAN24) in UK 11- to 16-year-olds (n=40), consisting of 2 focus groups and 1 validation. Focus groups conducted in classroom in 3 schools. Focus group 1: Participants completed recall using either free recall, meal-based recall or time-of-day recall. Focus group 2: Participants completed recall using three methods for time allocation, in random order: drag-and-drop onto AM/PM clock, drag-and-drop onto timeline, enter time in 24hr format. Validation: Parents kept 1d weighed record, children completed 24hr recall the following day using SCRAN24.	• 53% of foods reported by children were an exact match to those reported by parents; 15% were approximate matches. • 26% of parent-reported foods were omitted in the child's report. There was an intrusion rate of <6%. • There was a tendency to under-estimate energy intake by 20% using SCRAN24.

Exemplar	Domain	Reference*	Study description	Findings
Web-based 24-hour recall (cont'd)				
INTAKE24 (cont'd)	Relative validity (cont'd)	- Newcastle (2013)[53]	Final focus group/validation: participants used INTAKE24 to recall previous day's dietary intake under observation followed by a semi-structured interview and a usability scale. An interviewer-led 24hr recall was then conducted, as per LIDNS methods. 10 participants aged 11-16yr, 10 aged 17-24yr. Participants recruited through schools or university.	• Final focus group/validation: Mean energy intake was lower using INTAKE24: 7075.4 kJ (SD 2926.5) vs 7713.2 kJ (SD 2595.9) (difference -637.8kJ, p=0.031), an 8% under-estimation (as a ratio, 0.89). • 82% foods exactly matched, 7% omissions (25 foods - mostly 'additions' such as sauces and drinks) and 5% intrusions.
		+ Foster (2014)[52]	The study involved a sample of 11-16 year-olds from 2 UK schools (n=74, 64% female, 93% white, 47% SIMD 1) and a sample of 17-24 year-olds (n=217, 52% female, 95% white, 36% in education, 42% in employment). Participants completed INTAKE24 and an interviewer-led 24hr recall on the same day on four non-consecutive days over a month. The 1st recall was face-to-face; subsequent recalls by telephone. A weighted randomisation was applied with 75% participants completing INTAKE24 first. Reminders were sent (17-24 year-olds). At least 1 weekend day included for each tool and weekdays were equally represented. 39% 1-16 year-olds and 61% 17-24 year-olds did not complete.	• 80.9% of foods were exact matches to interviewer-led (79.2% 11-16 year-olds, 82.6% 17-24 year-olds); 1.3% were approximate (1.5% and 1.1% respectively). • 7.1% were intrusions and 10.7% omissions (6.7% and 12.5% respectively for 11-16yr-olds, 7.5% and 9% for 17-24 yr-olds). • Amongst older age group, bread/cereal accounted for the most omissions (19.8%), then drinks (12.8%); in 11-16 year olds, it was vegetables (17.3%) followed by drinks (16.7%). • Using all participants (n=167), mean energy from INTAKE24 was 7695.7kJ and from interview was 7777.7kJ (mean ratio 0.99, LOA 0.51 to 1.92). • In 11-16 year-olds this was 7023.7kJ vs 7152.5kJ (mean ratio 0.97, LOA 0.52, 1.82). In 17-24 year-olds, 8014.6kJ vs 8074.4kJ (mean ratio 0.99, LOA 0.50, 1.97). • Of 11-16yrs, 83% boys, 66% girls deemed under-reporters. • Comparing completers (4d) to NDNS values, the ratio of EI (INTAKE24/NDNS) was 0.89 for males and 0.98 for females in the younger age group (11-16 vs 11-18yrs), and 0.96 and 1.04 in the older age group (17-24 vs 19-65yr).
	Acceptability	Foster (2013)[51]	Procedure described above.	• A clear preference was shown for the meal-based format. • Many children did not have knowledge of food preparation. • For time allocation, there was a strong preference for the timeline method.
		Newcastle (2013)[53]	Procedure described above.	• Mean time to complete was 13.41min (range 6.21 to 20.30).
	Resources	None		

Exemplar	Domain	Reference*	Study description	Findings
	Web-based 24-hour recall (cont'd)			
Nutrinet-Sante	Validity	None		
	Relative validity	+ Touvier (2011)[55]	Participants filled out self-administered web-based 24hr recall on date agreed (20% weekdays, 80% weekend days). The following day, a telephone 24hr recall was conducted. Participants filled in web-based questionnaire. Subjects (n=170, 59.2% female) recruited from existing French cohort (SV-MAX) who had compatible computers, email address and internet access. 22.6% considered themselves inexperienced in computer use. Majority of men had university-level qualifications (44.1%); women mostly had secondary school level education (53%). Occupational class was predominantly managerial (men 45.8%) or intermediate professions (women 62.8%). Mean age 60.8yr (SD 6), range 48-75yr. 23 participants did not complete.	• 107 food items were manually entered in the self-administered recalls (ie items not found), compared to 7 manually entered by dietitians. • For men (n=60), mean energy intake was 8992.7kJ (SD 2285.8) with interview and 8847.9kJ (SD 2582.9) by web. Pearson correlation was 0.86 (95% CI 0.77, 0.91). • For women (n=87), mean energy intake was 7181.5kJ (SD 2079.6) by interview and 7204.2kJ (SD 2467.4) by web. Pearson correlation was 0.85 (95% CI 0.78, 0.90). • Across nutrients, mean Pearson correlation higher in subjects <60yrs (0.8 vs 0.7) and experienced with computers (0.8 vs 0.7). No difference in correlations across education strata.
	Acceptability	Touvier (2011)[55]	Procedure described above.	• Mean completion time of web recall was 31mins (SD 29, n=124), compared to 27mins (SD 13) for interview (p=0.2). The median for both methods was 25mins. 63.7% participants completed the recall in one sitting. • 97.6% found the web recall completion time acceptable compared to 93.5% for the interview (p=0.1). • A majority reported amount quantification to be easy (97.6% for interview and 93.5% for web recall, p=0.06). • 92.7% found the interface user-friendly. 63.7% consulted the help section, of which 88.6% were satisfied. 80.7% found that the 'e-frame supervisor' enabled them to correct their record. • 66% participants preferred the web-based method.
	Resources	Touvier (2011)[55]	Procedure described above.	• Development of Nutrinet-Sante study (not just web-based interface) cost 150,000euro and took 9 months. This includes baseline questionnaires, cohort monitoring, secure encryption system, equipment and hosting. • There is no supplementary cost for an additional day of 24hr record. For each dietitian-administered interview, there was an associated cost of 38.14euro per subject (including salary, telephone costs, printing and mailing picture booklets).

Exemplar	Domain	Reference*	Study description	Findings
PDAs/mobile phone apps				
Balance-Log	Validity	+ McClung (2009) [60]	A comparison of energy measured using DLW with EI using a PDA or written food record in weight-stable individuals over 7d. The sample was drawn from free-living active-duty military personnel (n=31, 8% female, mean age 23.5yr (SD 2)). Participants were randomly assigned (matched for sex, age and BMI) to record EI using either written record or PDA. Questionnaires were administered at baseline (demographic) and on day 8 (user feedback). EI records were reviewed by researchers on days 2, 5 and 8. 5 participants were excluded/lost to follow-up.	• Mean EI by PDA was 2865kcal/d (SD 716), and by TEE was 3141kcal/d (SD 647). EI was not significantly different to DLW estimates. • The correlation between PDA estimates and TEE was r=0.60 ($p<0.05$). • The limits of agreement were wide: -1472kcal/d and 920kcal/d.
	Relative validity	+ McClung (2009) [60]	Procedure described above.	• Mean EI by written record was 3266kcal/d (SD 635) and by TEE was 3158kcal/d (SD 614). EI was not significantly different to DLW estimates. • The correlation between written diaries and TEE was r=0.45 ($p>0.05$). • The limits of agreement were wide: -1177kcal/d to 1394kcal/d.
	Acceptability	Fowles (2008) [59]	Pregnant women (n=10) were recruited from WIC clinic. Participants filled out demographic form and completed face-to-face AMPM 24hr recall. They received instruction on using the PDA and portion size estimation. Participants were then instructed to keep dietary records for the following 2d using the PDA. Sample was low-income (family at or below 185% poverty level). 60% had completed high school, 50% white, 40% black, mean age 23yrs, range 18-31yrs.	• Perceptions of ease of use of the PDA and the 24hr recall significantly differed ($p=0.012$), with the PDA seen as easier. • There was no significant difference in the ease of remembering for either method. • 70% women like the PDA more than the recall. • 50% felt that the PDA reflected food intake more accurately.
		Sevick (2008) [62]	PDA self-monitoring was a component of the ENHANCE study, an RCT of type 2 diabetes management. The trial consisted of a 6mo intervention (completed by 6 cohorts) which aimed to improve adherence to diabetes self-management regimen. The intervention group received a program of 13 group meetings and encouraged PDA monitoring. Participants (n=151) visited the laboratory at baseline, 3 and 6mo, handing in questionnaires and 3d food diaries. PDA training occurred in the 2nd and 3rd meetings. PDA data were uploaded at meetings. 22 participants lost to follow-up.	• No participant dropped out due to difficulties with the PDA. • 84.8% participants agreed that entering foods was easy. 82% said they would continue to use the PDA. • Participants entered an average of 43% of meals (assuming 4 per day) over the intervention (58% if assume 3 meals per day). 12 participants entered < 10% of expected meals. • Individuals who had difficulty using the PDA were typically elderly, those with no experience of computers and/or had fine motor skills problems.

Exemplar	Domain	Reference*	Study description	Findings
	PDAs/mobile phone apps (cont'd)			
Balance-Log (cont'd)	Acceptability (cont'd)	McClung (2009) [60]	Procedure described above.	• 58% volunteers reported PDA easy to use for portion sizes, compared to 35% of those using written diaries. • More of those using written diaries reported being likely to carry paper records with them compared to those using PDAs (85% vs 62%).
		Sevick (2010) [63]	The paper reports adherence of PDA self-monitoring within the first 10 waves of the ENHANCE trial. The procedure of the RCT is described in Sevick et al (2008). The sample (n=123) was 65.8% female, mean age 54.7yr (SD 11.4), 34.2% minority race, mean education 14.2yr (SD 2.9), 15% with income below $10,000, 50% >$30,000. For this paper, participants were classified as nonadherent (entering 0 meals for that week), suboptimally adherent (1-11 meals for that week) or adherent (12 or more meals that week). 19.5% of participants did not complete/were lost to follow-up	• Average weekly number of meals entered in the PDAs was 11 in Phase 1, 7 in Phase 2 and 4 in Phase 3. • 20% of participants remained adherent by end of the study. • In Phase 1, 84.8% of participants who were adherent in a given week remained adherent the following week. The probability of nonadherence increased with time. Consistency of nonadherence also increased. The probability of suboptimal adherence decreased with time. Suboptimal adherence was the least consistent behaviour. • There were no statisically significant RRRs of adherence, suboptimal adherence or nonadherence when comparing demographic or clinical characteristics.
	Resources	None		
MMM	Validity	None		
	Relative validity	+ Carter (2013a) [56]	Participants (n=50, 72% female, mean age 35yr (SD 9), 82% white) recorded food and drink for 7 days using the app. During the recording period, interviewers conducted two multiple-pass 24hr recalls by telephone, at random on both weekend and week days. 96% of the sample reported using a mobile phone regularly, 48% a smartphone, and 46% had used an app before.	• Comparison of Day 1 24hr recall with the matched day from MMM showed a higher EI (8422kJ vs 8355kJ, p=0.78; r=0.77 (p<0.001); n=49). The mean difference was 68kJ, with limits of agreement of -3378 and 3243kJ. • On Day 2, EI was estimated at 8619kJ with the recall vs 8180kJ from MMM (p=0.04; r=0.85 (p<0.001); n=45), mean difference 441kJ, limits of agreement of -3133 and 2251kJ. • Taking an average of both days, the difference was 8401kJ vs 8196kJ (p=0.23; r=0.85 (P<0.001); n=45), mean difference 206kJ, limits of agreement of -2434 and 2022kJ. • Using an average of all 7d of MMM records, the difference was 8242kJ vs 8020kJ (p=0.30; r=0.68 (p<0.001); n=41).

Exemplar	Domain	Reference*	Study description	Findings
	PDAs/mobile phone apps (cont'd)			
MMM (cont'd)	Acceptability (cont'd)	Carter (2013b) [57]	This was a pilot weight-loss trial. Participants (n=99, 77% female, BMI 27kg/m2 or over) were randomized (using minimization) to one of 3 trial arms: using a smartphone for dietary self-monitoring, using a paper diary, or using an online diary. All participants had access to an online forum. Repeat measures were taken at 6 weeks and 6 months follow-up, at which timepoints evaluation questionnaires were administered. Mean age in each arm was 41.2y (SD 8.5), 42.5y (SD 8.3) and 41.9y (SD 10.6). 72.1% had university degree in smartphone arm, 55.8% in diary arm and 52.4% in website arm.	• 3 smartphone participants dropped out, compared to 23 in other arms. All smartphone non-completers reported the reason for drop-out as not liking the equipment. • Usage was highest in smartphone group (mean 92d recorded, vs 29d in diary group and 35d in web group). • Those who reported being satisfied with study equipment were: 86.8% MMM at 6 weeks, 57.7% diary and 50% web; at 6 months 63.2% of MMM, 50% diary and 42.1% website. • No significant differences in reported ease of use. 64.9% MMM users, 35% diary users and 52.6% web users (p<0.01). • 76.3% of smartphone group felt comfortable recording diet in social settings compared to 40% of diary and 21.1% of web.
		Carter (2013c)[58]	Procedure as described in Carter (2013b)	• 7 participants used the smartphone every day for 6mo (16%). • 95% smartphone users complete at least 7d, compared to 56% paper diary users and 76% website users. • 40% paper diary users and 7% website users, but 0% smartphone users, did not complete any days. • More foods were entered in evening than rest of day. • 20% food items had a 'created on' date the day after the 'diary date', 3% were created the day before. • Median scores for statement 'I would continue to use the equipment' were 2 (IQR 2, 4) for paper diary, 2 (IQR 1, 4) for web and 4 (IQR 3, 5) for smartphone (p=0.009). • 45% paper diary users, 58% MMM users and 58% web users agreed that time taken was acceptable. Mean self-reported time taken per day was 16.3mins MMM (95% CI 10, 23), 15mins paper diary (95% CI 8, 22) and 19.4mins website (95% CI 12, 27) (p=0.4). • 42% MMM users encountered bugs most or all of the time. • 84% rated the MMM 'favourites' feature as helpful, 17% rated photo prompts and 6% rated help videos as helpful. • 70% MMM users would find useful barcode scanning, 82% keyword searching and 49% portion sizes pictures.

Exemplar	Domain	Reference*	Study description	Findings
	PDAs/mobile phone apps (cont'd)			
MMM (cont'd)	Resources	None		
Non-automated cameras to complement diary/recall				
Long	Validity	None		
	Relative validity	None		
	Acceptability	Long (2013)[64]	Participants were asked to enter intake at the end of each day on mypyramidtracker.gov. A crossover design was used, whereby one group of participants recorded 3d intake using the website before taking photos of foods and completing a further 3d using the photos as memory aid, and vice versa. Email reminders and text messages were sent. The study took place over 3wk; consecutive days were not specified. Following dietary data collection, participants attended focus groups. A convenience sample from a local university was recruited (n=146, 61% female, aged 18 to 31yrs, 84% Caucasian). Participants had to have camera-enabled phone. 53% did not complete. Data on fruit and vegetable intakes only were analysed.	• 84% of participants found the cell phone pictures acceptable. • Positive comments included: finding it easier than relying on memory alone, useful in estimating portion sizes, increasing awareness of diet. • A small number addressed issues about the awkwardness of taking pictures in front of others. 3% felt the pictures were not helpful. 4% said they felt initially awkward but got over it. • Other comments included: finding it inconvenient to remember to take photos, taking up memory space on the phone, feelings of self-consciousness. One participant reported revisiting the photographs made them hungry. • Suggested improvements included: alarms, text message reminders, Facebook reminders.
	Resources	None		
NANA	Validity	Moore (2013) [65]	To assess the feasibility of using the NANA system for the longitudinal capture of dietary intake data, participants (n=40) were asked to use NANA to record dietary intake for 7d, on 3 occasions, at the start of 3 consecutive months. The sample was aged 65yr and over (mean age 72yr), UK-based and 60% female.	• There were no significant differences in mean energy intake, the number of data entries or the number of voice recordings across the 3 recording periods.
	Relative validity	+ Timon [66]	The validation study took place over 10wks: in wk 1 a 24hr recall was administered; wks 2-4 participants recorded diet using NANA (3wk) (4d from 2nd week used in analysis), a 2nd 24hr recall was taken in wk 2, and fasted blood and urine samples were taken in wk 3; a 3rd 24hr recall was administered in wk 6; participants kept a 4d food diary in wk 9. Participants were in the UK, 57.5% female, mean age 72yr (SD 5). 9%did not complete.	• Mean energy estimated by NANA was 7965kJ (SD 1455.6), and by food diary was 8252kJ (1774.9). Means were significantly different (Wilcoxon, p=0.022). • EI estimates were correlated (Spearman r=0.867, p<0.001). • The mean difference between energy intake estimates was 287kJ (diary-NANA). Limits of agreement (figures not reported in text) were ~1200 and -~1800.

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to complement diary/recall (cont'd)			
NANA (cont'd)	Acceptability	None		
	Resources	None		
Non-automated cameras to replace traditional methods				
mpFR	Validity	Zhu (2010)[91] + Lee (2012) [77]	The study comprised automated classification tests of 63 images taken by adolescents in a previous study (Six et al, 2010). There were 3 experiments: 1, 10% of images, randomly selected, were used for 'training' and the remainder for testing; 2, 24% images used for training; 3, 50% images used for training. Groundtruth segmentation was used to evaluate classification performance. Participants (n=15, 11- to 18yrs, 20% female) received instruction on mpFR and were instructed to take photos before and after consuming meals and snacks (provided) over 24hr. They were monitored and all foods and beverages were weighed. At the end of the day, participants estimated portion sizes of breakfast (not beverages) with their photos. Two different aids were provided (1 to each of 2 randomised groups): multiple measure descriptors (n=7) or 2D images of plates and bowls with cubes (n=8). Automatic food identification and volume estimation was also performed, and converted to g. Data from only 1 meal was used in analyses.	• Experiment 1: 88.1% correct classification; 10% misreported nutrient information. • Experiment 2: 94.4% correct classification; 3% misreported nutrient information. • Experiment 3: 97.2% correct classificaiton; 1% misreported nutrient information. • Mean total energy estimated from automated image processing was 3588kcal (SD 180); mean total energy from weighed foods was 2723kcal (SD 51). • The known weight (g) and energy (kcal) significantly differed to automatically estimated weights and energy for the majority of foods (15/19). • Weight and energy did not significantly differ between the two methods for 'spaghetti with sauce, cheese', orange juice, strawberry jam and cheeseburger sandwich.
	Relative validity	- Schap (2010) [84]	Adolescents (n=77, 11-18yrs, 66% female) used mpFR to record intake at meals in a controlled setting for 24hr. The anticipated estimated energy intake (EEI) for each meal was calculated from percentages of total daily intake taken from a previous study (breakfast 16%, lunch 27%, dinner 33%, snacks 24%) applied to the estimated energy requirement. n=7 did not consume breakfast, n=62 did not record dinner and snacks.	• No significant difference between EER and known energy consumption over 24hr (n=15, p=0.352). • Boys consumed significantly less energy from snacks than expected (mean difference 324kcal, p=0.014); girls consumed significantly more at dinner than expected (mean diff 196kcal, p=0.044). • Those in 85th-95th BMI percentile consumed significantly less energy at lunch than expected (mean diff 88kcal, p=0.047).

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to replace traditional methods (cont'd)			
mpFR (cont'd)	Relative validity (cont'd)	- Schap (2011b) [85]	3d worth of meals and snacks in excess of EER were provided to participants: on 2d consumed in free-living environment, on 1 day meals were eaten at research facility and snacks were eaten in free-living environment. Participants received training in mpFR and asked to capture all meals and snacks consumed. Images were reviewed by research staff to estimate portions. Sample was recruited from campus community (n=12, 42% female, 20-58yr).	• The mean difference between averaged rEI and EER was -348kcal (SE 227) and was not statistically different (p=0.155).
	Acceptability	Six (2009) [86]	Volunteers (n=78, 11-18 year-olds, 65% female) participated in breakfast and lunch sessions, after receiving instruction. They photographed meals or snacks before and after eating, and provided feedback. Further training was given and feedback taken again.	• 79% participants agreed easy to use. 10% agreed taking images before snacking was easy and 19% agreed taking photos after was easy. • After more training, ease of use before and after snacking increased (significantly) to 28% and 38% respectively.
		Six (2010) [87]	The study involved 2 samples of 11-18 year-olds (mean age 14.2yr, 67% female, 70% non-Hispanic white). Sample 1 participants (n=63, 13% lost to follow-up) consumed a set lunch and returned for breakfast. Sample 2 participants (n=15) received all meals and snacks for a 24hr period, while being monitored. Participants were instructed to review images and re-take if necessary. Following the 1st meal, participants took part in an interactive session and further training.	• 80% participants took a useful image at 1st meal, 84% at 2nd meal. 71% included fiducial marker at 1st meal, 77% in 2nd meal. • 42% Sample 1 participants took >1 photo before 1st meal; 22% for 2nd meal (p=0.033). • Likelihood of taking more photos associated with sitting (vs standing). 63% participants said they would prefer to stand. • 78% agreed it would be easy to carry a credit-card sized fiducial marker; 42% a USB flash drive sized marker. • 37% participants agreed it would be easy to remember taking photos before meals, and 41% after meals. • 11% reported it would be easy to remember taking photos before snacks and 21% after snacks. This increased to 32% and 43% following additional training (p<0.0001).
		Boushey (2011)	11- to 15-year-olds were recruited from a US summer camp (46% female). Participants received brief training using iPhone 3Gs, and instructed to capture images of all meals and snacks including a fiducial marker. Participants were observed, and took part in focus groups and a questionnaire.	• 75% participants agreed it was easy to carry 2 phones. • 33% girls and 5% boys agreed the study iPhone interfered with their social interactions. • 87.2% responded positively to the suggestion of participating in another study with mpFR. On average participants would be prepared to use mpFR for 1-2 weeks.

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to replace traditional methods (cont'd)			
mpFR (cont'd)	Acceptability (cont'd)	Schap (2011a)[82]	This study used data from the samples described in Six et al (2010). Sample 1 was asked to write down food names at the time of the meal. Sample 2 was asked to identify names of foods and portion sizes 10h after lunch and 14.5hr after dinner using their photos. 14hr after breakfast they were prompted with food names and asked to estimate portion sizes, using either of two aids ('multiple descriptors estimation aid' or standardized 2D images) in a randomised crossover order.	• Sample 1: 30/38 foods identified correctly. Misidentifications were within same food group. 22 food items were misspelt at least once. • Sample 2: 11/13 food items identified correctly. Every food was misspelt at least once. • Using the 2D portion size estimation aid, 2/6 food items were significantly different in estimated and actual grams and kJ (margarine and jam). Using the MDes, 2/12 were significantly different (toast and chocolate chip cookie).
		Boushey (2012)[73]	To compare the perceptions of mpFR between two samples (n=103, 21-65yrs, 67% female) under controlled feeding and free-living conditions. Participants in the controlled condition attended a meal in a metabolic kitchen, in which they used the mpFR. Participants in the free-living condition received similar instruction and were asked to use the mpFR over 7d. Questionnaires were administered after training and after use.	• The groups responded equally to 'remembering to take an image before my meals would be easy' before and after use. • For snacks, free-living participants adopted a more favourable response after 7d (67% after training, increasing to 90% after 7d, compared to 50% of controlled condition. • 91% of participants in controlled group responded favourably to carrying a fiducial marker, 98% of free-living participants.
		Daugherty (2012) [75]	The study used 3 samples: 2 of adolescents (see Six et al, 2010) and 1 of adults. Adults (n=57, 68% female, 21-65yr, 79% non-Hispanic white) used the mpFR for a meal in the research centre and returned for a 2nd meal another day. They gave feedback prior to recording and after meal 1. 58% adults were lost to follow-up.	• 87% adults owned a digital camera and 49% frequently used it. 100% owned a mobile, but only 16% used it for photos. • 95% adults were able to include all food items in before and after images of meal 1, 96% for meal 2. For adolescents, the proportions were 78% (p=0.008 vs adults) and 84%. • There were no significant differences between adolescents and adults in ability to include the fiducial marker: 69% and 79% respectively for meal 1, and 76% and 75% for meal 2. • A significantly higher proportion of adults than of adolescents needed to take multiple images before (42% vs 55%, p=0.03) and after (25% and 65%, p=0.008) meal 1 but no significant difference was apparent for meal 2. • 91% adults agreed the software was easy to use. Adults were more likely than adolescents to agree that carrying a USB flash drive sized fiducial marker would be easy (67% agreed). Adults preferred to sit whilst taking photos.

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to replace traditional methods (cont'd)			
mpFR (cont'd)	Resources	None		

RFPM	Validity	++
		Martin (2009) [69]
			Pilot study 1: Photographs were taken of 16 example meals, comprising 31 foods, each food represented in 2 different portions. Plates and simulated plate waste were weighed. 2 dietitians estimated EI from the images with and without standard portion photos.
			Main study: Participants (n=52, mean age 32.4yr (SEM 1.5), 54% female, 70% Caucasian, 30% African American) were provided all food and randomized to consume this in the lab or at home (lunch consumed at lab). Participants took photos of food consumption and plate waste, using a telescoping pen to standardize distance and a 45deg angle, labelled photos and sent them over cellular network. They received 4-6 automated prompts (email & texts). They also recorded EI using paper and pen or voice recording, and were interviewed afterwards. Plate waste was weighed. Intakes were measured for 3d, 2 to 7 days apart.
				• Pilot study 1:
				  • With no standard portion size photo aids, ICC 0.93 for food selection, 0.94 for plate waste and 0.91 for EI.
				  • With standard portion size photo aids ICC 0.95 for food selection, 0.92 for plate waste and 0.92 for EI.
				  • The difference between the mean estimated and weighed EI was significant without standard portion size photos (p=0.01) and for energy intake (p=0.03).
				• Main study:
				  • Response rate to prompts delivered on time was 98.3%.
				  • In 'dine-in' group, 3/150 meals could not be analysed due to protocol error, 4/150 due to poor quality or missing images. In the take-out group, 9/150 meals had protocol error, 9 had poor quality or missing images.
				  • ICC for inter-rater reliability 0.99 for food selection, 0.91 plate waste and 0.88 for EI.
				  • In dine-in group, mean difference was -368kJ (RFPM - weighed intake). In take-out group, mean difference for lunch was -151kJ, and for dinner -406kJ.
				  • No significant association between body weight or age and RFPM error. Error was larger for women in the take-out group than for men.

		+ Martin (2012) [70]	Study 1: TEE was measured using DLW over 2wk. Participants used RFPM for 6d, either in 1st wk or 2nd wk of DLW. Participants were assigned to 1 of 2 groups (non-randomly): n=22 received EMA (ecological momentary assessment) messages 2 or 3x per day and were contacted approx every other day if failed to respond; n=13 received enhanced 'EMA+' of 3-4 message per day and contact w/in 24hr in the case of non-response. The sample (n=40) comprised overweight/obese individuals, 77% female, 75% Caucasian, mean age 43yr (SD 14.3)).	• RFPM underestimated EI by 8.8% (270kcal/d, SD 748kcal, p=0.22) in the EMA+ group and by 34.3% (895kcal/d, SD 770kcal, p<0.0001) in EMA group. • Underestimation was significantly smaller using EMA+ than EMA (p<0.05).

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to replace traditional methods (cont'd)			
RFPM (cont'd)	Validity (cont'd)	+ Martin (2012) [70]	Study 2: Participants used the RFPM during 2 lab-based buffet meals, then completed a 2wk DLW period with 1wk RFPM as Study 1 (only EMA+). User satisfaction was assessed with 6-point Likert scales. The sample (n=50) was 88% female, 62% Caucasian, mean age 41yr (SD 12.8).	• EI across 6d of RFPM was reliable, ICC 0.74. • EI estimates of RFPM and DLW did not significantly differ (p=0.16). The difference was -152kcal/d (SD 694) (RFPM underestimated). • EI from lab-based RFPM and weighed plates did not significantly differ (p=0.67). The difference was -4kcal (SD 73) (RFPM underestimated). • Regression indicated RFPM error did not differ by body weight, BMI or age.
		- Martin (2014) [71]	The paper described 2 studies amongst pre-school children enrolled in the Head Start program in the US. In Study 2 (n=12), personnel used smartphone to capture images of foods at Head Start centre (same day). Other personnel weighed food selection and leftovers both at Head Start and at home.	• At home, the mean difference between RFPM and weighed was 35g (ns).

	Relative validity	- Martin (2014) [71]	The paper described 2 studies (see above) amongst pre-school children enrolled in the Head Start program. Study 1 (n=12): Mothers used smartphone to capture images of foods consumed by child in the home over 24hr.	• RFPM significantly overestimated food intake by 9.9g (13%).
				  • Problematic foods were canned fruits/veg in liquid, condiments, mixed meals, layered foods, beverages and foods with inedible portions.
				  • The correlation between RFPM estimated weight and measured weight was 0.95 (significant).

	Acceptability	Martin (2009) [69]	Pilot study 2: Participants (n=42, 79% female, mean age 33.9yr (SEM 1.6), 67% Caucasian, 28% African American) were asked to photograph foods and calorific beverages over 4 consecutive days, and label photos.
			Main study: procedure described above.
				• Pilot study 2:
				  • Participants occasionally forgot to take photographs
				  • Systematic mistakes not corrected until data upload
				  • Lighting was sometimes problematic
				  • Descriptions were sometimes poor due to time taken to type.
				• Main study:
				  • 85.7% (30 of 35) rated comfort level as 4 or 5 (out of 5).
				  • 78.8% (37 of 47) rated satisfaction as 5 or 6 (out of 6).
				  • 40 (85%) rated satisfaction with sending photos as 5 or 6.
				  • 44 (93.6%) rated ease of use as 5 or 6.
				  • 93.6% preferred RFPM over paper record.

Exemplar	Domain	Reference*	Study description	Findings
	Non-automated cameras to replace traditional methods (cont'd)			
RFPM (cont'd)	Acceptability (cont'd)	Martin (2012) [70]	Procedure described above (Study 2).	• 82% participants rated satisfaction with overall method as 5 or 6. • 85% rated satisfaction with sending food images via phone as 5 or 6. • 93% rated 5 or 6 satisfaction with training. • 96% found a run-in period useful (rated 5 or 6). • 93% rated ease of use of RFPM as 5 or 6. • 89% were satisfied with EMA methods (5 or 6).
		Martin (2014) [71]	The paper described 2 studies amongst pre-school children enrolled in the Head Start program in the US (n=12 for both studies). Study 2 followed a similar procedure to Study 1 described above), with the addition of post-study interviews with mothers.	• 80% participants reported RFPM was easy or very easy to complete. None reported it was difficult. • 92% said they would not change the procedures, training or EMA prompts. • 100% thought it would not be difficult to use when eating out.
	Resources	None		
Nutricam	Validity	+ Rollo (2012)[94]	2 studies described: both involved adults with type 2 diabetes in Australia. In 'study 4', subjects (n=10, 40% female, age range 48-69yr, mean age 61.2yr (SD 6.9)) underwent DLW procedure for 14d. Nutricam was used on days 2, 4 and 6, and a weighed food record kept on days 9, 11 and 13. Questionnaires were administered at the end. Subjects were called the day after each Nutricam recording day to ensure recording complete. Written records were also reviewed for completeness.	• EI was significantly under-reported by Nutricam by -0.6MJ/d (SD 0.8, $p<0.05$).
	Relative validity	+ Rollo (2012)[94]	'Study 4' described above	• 50 items reported in the food records were not captured by Nutricam images. Beverages constituted 50% of these, followed by snacks (n=17). • 8 items in Nutricam were not recorded in the written records.

Exemplar	Domain	Reference*	Study description	Findings
Nutricam (cont'd)	**Non-automated cameras to replace traditional methods (cont'd)**			

	Acceptability	Rollo (2012)[94]	In 'study 2', participants (n=10, 40% female, age range 59-70yr , mean age 64.7yr (SD 3.8)) completed questionnaires, then took photos of foods and leftovers along with a voice recording of details for 3 consecutive days (2 weekdays, 1 weekend). Written food records were concurrently kept. Post-recording, participants completed usability questionnaire.
			'Study 4' is described above.
				• Study 2
				  • 100% agreed Nutricam was easy to use and were confident in their ability to use Nutricam to record all items for a set time.
				  • 7 subjects reported it was easy to use outside the home (3 responded 'neutral').
				  • 2 participants admitted not recording all foods and drink using Nutricam, but none reporting forgetting to photograph leftovers.
				  • 6 participants found Nutricam took less time than the written record, 2 said it took about the same time, 1 that it took longer.
				  • 5 participants said they would be prepared to use Nutricam for 30d. 1 stated 3d was the maximum time they would use it.
				  • 70% participants preferred Nutricam, 30% preferred written records.
				• Study 4:
				  • 100% reported they found the Nutricam easy or very easy to use. Only 3 participants reported the weighed food record as being easy.
				  • 6 participants found the prompt card useful.
				  • 1 participant reported changed habits due to Nutricam method, 4 with weighed record.
				  • All subjects preferred the Nutricam to weighed record, due to 'convenience', 'ease of use' and 'portability'.
				  • Participants were prepared to record for longer periods with Nutricam than weighed records.
				  • Mean 2.9 items required clarification with Nutricam.

	Resources	None		

* References of validation studies are accompanied by the symbol '++', '+' or '-' to indicate the study quality (see Appendix J for full quality appraisal of each study)

Appendix I: Quality checklist for validation studies

Study identification *Include author, year, ID*			
Checklist completed by:			
SECTION 1: STUDY DESIGN			
Criterion		Criterion is met:	
1	The sample size is adequate.	Y	N
2	The sample used is representative of the population in which the tool is to be used.	Y	N
3	The study had an acceptable response rate and follow-up/drop-out rate.	Y	N
4	The comparator is appropriate.	Y	N
5	The outcome(s) on which the tools are compared are appropriate and selected a priori.	Y	N
SECTION 2: DATA COLLECTION			
Criterion		Criterion is met:	
6	The timing of data collection using each tool was appropriate.	Y	N
7	The study also addressed repeatability or reliability of the method.	Y	N
SECTION 3: ANALYSIS AND INTERPRETATION			
Criterion		Criterion is met:	
8	The study adhered to an a priori list of outcomes and analyses.	Y	N
9	Data were analysed appropriately, assessing agreement or misclassification.	Y	N
SECTION 4: CONFLICTS OF INTEREST			
Criterion		Criterion is met:	
10	There was no conflict of interest.	Y	N

Using the checklist

In the checklist, the term ‘dietary assessment tool’ is used to refer to the tool, method, approach, equipment or measure that is being validated. The term ‘comparator’ will be used to signify the tool, method or measurement that the new tool is being compared against, the reference measure.

Each of the criteria in the checklist addresses an aspect of validation study methodology that has been shown to affect study conclusions. The more criteria a study meets, the more likely it is that the reported conclusions reflect the validity of the dietary assessment tool being assessed.

1. **The sample size is adequate.**
   To assess agreement, the sample size should be large enough to allow the estimation of limits of agreement. The size of the sample will affect the width of these limits, with smaller samples showing wider limits. A minimum sample size to accept as adequate should be stated in the review protocol.

2. **The sample is representative of the population in which the tool is to be used.**
   A study will meet this criterion if it specifies the intended purpose of the dietary assessment tool, details the methods used for recruitment and comments on how the validation sample relates to the intended population. For example, if the dietary

assessment tool is designed for population surveys, efforts should be made to recruit a sample representative of the population; if the tool is intended for use amongst elderly adults, the sample should represent the elderly population in the country/region/city in which it is intended to be applied. Reviewers should note that losses to follow-up and attrition may impact on the representativeness of the sample also: if there are systematic differences evident between responders and non-responders or between completers and non-completers, the sample may not be representative and the study will fail to meet this criterion.

3. **The study had an acceptable response rate and follow-up/drop-out rate.**
   Indicate 'No' if there is no mention of the response rate, follow-up or drop-out rate in the results, where applicable. Reviewers should agree an acceptable rate in the protocol. In addition, the response and follow-up/drop-out rates should only be judged acceptable if adequate sample size is preserved (see above).

4. **The comparator is appropriate.**
   The comparator should have been previously validated itself. The choice of an appropriate comparator will depend upon the dietary assessment tool being validated, as well as the selected outcomes on which they are to be compared. Reviewers should state a priori which types of comparator will be accepted as appropriate.

5. **The outcome(s) on which the tool is compared to the comparator are appropriate and selected a priori.**
   Appropriateness will depend on the purpose of the new measure. For example, for an FFQ developed to measure consumption of dairy, comparing estimates of vitamin C intake is unlikely to be useful. The timescale of dietary assessment will also determine appropriateness of outcomes. Estimates of energy or nitrogen intake are usually appropriate in that they provide an indication of completeness of reporting. Reviewers could choose to select specific outcomes as appropriate depending on the purpose of the review.

6. **The timing of data collection using the dietary assessment tool and the comparator was appropriate.**
   This criterion applies both to the timing of data collected with each tool (the assessment tool being validated and the comparator) by itself and in relation to each other. The criterion is met if the study: takes into account a balance of weekdays and weekend days, or compares like with like; takes into account seasonal variation, or compares like with like; if using daily records/recalls, takes an average of several days; and acknowledges in the study design the potential for learning effects (for example, using a cross-over design).

7. **The study addressed repeatability or reproducibility of the dietary assessment tool.**
   This criterion is met if the new dietary assessment tool is re-administered to participants to gauge within-person variability in findings. Alternatively, assessing repeatability of researcher coding would count as meeting this criterion.

8. **The study adhered to an a priori list of outcomes and analyses.**
   Indicate 'no' where the results presented do not match the proposed analyses and/or aims in the methods. However, the criterion could be met where there are valid reasons for conducting post hoc unplanned analyses, clearly stated and justified.

9. **Data were analysed using tests for agreement or misclassification.**
   Indicate 'yes' where methods to examine agreement, such as a Bland-Altman plot, are used. If the dietary assessment tool is intended to be used to classify individuals (and not give a continuous estimate of intakes), an assessment of misclassification would also be appropriate. The criterion is not met if a measure of difference, correlation or regression is used in the absence of measures of agreement and misclassification.

10. **There was no conflict of interest.**
    The study meets this criterion if a statement of conflict of interest is made or the sources of funding acknowledged.

For the purposes of the current review, the following specific criteria were set:

Criterion 1. Sample size
A sample size of 50 is judged the bare minimum (the confidence interval of samples smaller than this are likely to be wider than the standard deviation of normally distributed observations [97]).

Criterion 3. Response/follow-up/completion rates
Although thresholds of acceptable response rates or loss to follow-up are recognised to be arbitrary and fail to take into account the actual threat of bias [98], large losses will increase the risk of bias. For this review, an arbitrarily selected cut-off of 20% lost to follow-up/non-completers was chosen on the basis of historical precedence [98, 99] .

Criterion 5. Comparator
As the scope of the current review is broad (particularly in terms of the types of dietary assessment tools being validated), selecting one appropriate comparator is not feasible. Therefore, all forms of comparator will be considered, as long as previous attempts at validation or calibration of the comparator exist. The appropriateness of comparators will need to be judged on an individual study basis.

Criterion 9. Data analysis
For this review, in which eligibility criteria specified that data collected by dietary assessment methods be fully quantified and suitable for nutrient analysis, tests for misclassification would not be as useful as assessments of agreement. Therefore, only validation studies in which an assessment of agreement (such as Bland Altman plots or intra-class correlation (ICC)) was performed will be judged as high quality.

Appendix J: Quality appraisal results

Study	Adequate sample size	Representative sample	Acceptable response/follow-up/drop-out rate	Appropriate comparator	Appropriate outcomes	Appropriate timing of administration	Repeatability or reliability	A priori analyses	Appropriate analyses	No conflict interest	Overall
Baranowski et al (2012)	Y	Y	Y	Y	N	Y	N	Y	N	Y	+
Bjorge-Schohl et al (2014)	N	N	N	Y	Y	Y	N	Y	Y	Y	+
Carter et al (2013)	N	N	Y	Y	Y	N	N	Y	Y	Y	+
Ettienne-Gittens et al (2013)	N	N	N	Y	Y	N	N	Y	Y	Y	+
Foster et al (2013)	N	N	N	N	Y	Y	N	N	N	Y	-
Foster et al (2014)	Y	N	N	Y	Y	Y	N	Y	Y	Y	+
Frankenfeld et al (2012)	Y	N	N	Y	Y	N	N	Y	Y	Y	+
Hutchesson et al (2013)	N	N	N	Y	Y	Y	N	Y	Y	Y	+
Kirkpatrick et al (2014)	N	Y	Y	Y	Y	Y	N	Y	N	Y	+
Lee et al (2012)	N	N	N	Y	Y	Y	N	Y	N	Y	+
Martin et al (2009)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	++
Martin et al (2012) (Study 1)	N	N	Y	Y	Y	Y	N	Y	Y	Y	+
Martin et al (2012) (Study 2)	N	N	N	Y	Y	Y	Y	Y	Y	Y	+
Martin et al (2014)	N	N	Y	Y	N	Y	N	N	N	Y	-

Study	Adequate sample size	Representative sample	Acceptable response/follow-up/drop-out rate	Appropriate comparator	Appropriate outcomes	Appropriate timing of administration	Repeatability or reliability	A priori analyses	Appropriate analyses	No conflict interest	Overall
McClung et al (2009)	N	N	Y	Y	Y	Y	N	Y	Y	Y	+
Neve et al (2009)	N	N	N	Y	Y	N	N	N	N	N	-
Newcastle (2013)	N	Y	N	Y	N	N	N	N	N	N	-
Rollo (2011)	N	Y	N	Y	Y	N	Y	Y	N	N	+
Schap et al (2010)	N	N	N	N	Y	N	N	N	N	Y	-
Schap et al (2011)	N	N	N	N	Y	N	N	Y	N	Y	-
Subar et al (2010)	N	N	N	Y	Y	Y	N	Y	N	Y	+
Subar et al (2014)	Y	Y	Y	Y	Y	Y	N	N	N	N	+
Timon (no year)	N	Y	Y	Y	Y	N	N	Y	Y	Y	+
Touvier et al (2011)	Y	N	Y	Y	Y	N	N	Y	Y	Y	+
Vergne et al (2011)	Y	N	N	Y	Y	Y	N	N	N	N	-

++ Good quality - all or most (≥8) of the criteria fulfilled, conclusions of study unlikely affected by bias; + Moderate quality - some criteria fulfilled, criteria not met unlikely to affect conclusions; - Poor quality - few (≤4) or no criteria fulfilled, conclusions are likely to alter.

Appendix K: Qualitative research material

Focus groups with the general public: topic guide

Aim of the study To inform the Department of Health of the range of new technologies currently available and in development internationally that have the potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme.
Focus group objectives To gather perspectives from members of the public who have not (recently) participated in the National Diet and Nutrition Survey on the potential use of one or more of the following new technologies in the survey: entering dietary information into an electronic device (tablet, mobile phone or laptop/desktop computer) using an app or website taking photographs of what they eat and drink.

▪ Introduction

- Introduce self and NatCen
- Briefly explain study
    - Funder – Department of Health
    - Lead research team – University of Leeds
    - Aim of the study
    - Objectives of the discussion
- Explain details about participation
    - Voluntary – participants do not have to answer questions if they do not want to
    - Incentives – check these have been received (or explain they will be paid afterwards)
    - Confidentiality – information to be used for research purposes only, will include research report
    - Anonymity – individuals will not be named in the report and no information will be included which could lead to individuals being identified, anonymity also depends on participants so don't use names outside the room
    - Nature of discussion – please contribute, no right or wrong answers, don't interrupt
    - Length of discussion – up to 90 minutes
    - Permission to record?
- Check whether they have any questions and are happy to go ahead
- START RECORDING

1. Background

- *Invite participants to introduce themselves, including:*
  - Name
  - What they're doing at the moment (e.g. working, studying)
  - Any electronic devices they use: home computer with internet access, tablet (e.g. iPad), smartphone

2. Participants' use of new technologies

Ask about devices mentioned by participants

- What they use the devices for
  - Internet?
  - Email?
  - Photos?
  - Social media?
  - Banking?
- How often they use them
- Context
  - Work?
  - Personal?
- Examples of apps they use
- Confidence with new technologies
  - How confident?
  - What do they find easy? Hard?
  - If they need help what do they do?
- Enjoyment of new technologies
  - Enjoy gadgets?
  - Why? Why not?
  - Try to stay up to date?

3. Participants' experience of recording what they eat and drink

- Have participants ever tried to keep a record of everything they eat and drink?
  - Why?
  - How did they do it? (e.g. on paper, electronically)
  - For how long?
  - Experiences and views of doing this?

- Have they ever used calorie counting/fitness websites or apps?
  - Why?
  - Which ones?
  - For how long?
  - Experiences and views of them?

4. Introduction to NDNS

- *Explain how NDNS works at the moment. Show **Food and Drink Diary** and explain that everything the person eats and drinks needs to be recorded in it for 4 days, including quantity, brand, and cooking/preparation method for every item of food. Example – for a sandwich you have to say what kind of bread, how thickly sliced, any butter or margarine added and if so, what kind etc. Show **NDNS diary – example of completed page** and **NDNS diary – example of badly completed page with corrections**.*

- Participants' views on this method
    - How would they feel about doing this?
    - Potential problems with this method?

5. Entering information into an electronic device

- **Tablet computer**
  *[Show **tablet**.] Explain how this works – participant is given a tablet for four days, enters information about everything they eat and drink for four days, including types and quantities.*

  *Show screenshot of existing app (**App screenshot – My Meal Mate**) but explain that this is just an example of the kind of thing they would be using (NDNS would probably have its own bespoke app).*

    - How would they feel about using this?
        - Advantages and disadvantages compared with written food diary
        - Any issues with internet access? *(n.b. assume that the app would not require constant internet access)*

    - Would they carry the tablet with them?
        - Why?
        - Why not?

    - Would they enter the information after every meal?
        - After every snack?
        - After every drink, including water?
        - Why?
        - Why not?
        - If not, when would they enter the information?
        - How would they keep track of what they ate and drank in the meantime?

    - How would they feel about getting email reminders to enter the information?
        - At mealtimes? In the morning? In the evening?

    - (If they already have a tablet) Would they prefer to download an app to use on their own tablet?

- **Mobile smartphone**

*Explain how this works – participant is asked to download an app on their phone, enters information about everything they eat and drink, and gives the researcher permission to access their records. Refer to screenshot (**App screenshot – My Meal Mate**)*

- How would they feel about using this?
  - Compared with tablet?
  - Compared with written food diary?

- Would they carry the phone with them?
  - Why?
  - Why not?

- Would they enter the information after every meal?
  - Every snack? Every drink, including water?
  - Why?
  - Why not?
  - If not, when would they enter the information?
  - How would they keep track of what they ate and drank in the meantime?
  - Would they have problems getting a signal?

- How would they feel about getting text reminders?
  - At meal times? In the morning? In the evening?

- **Laptop/desktop computer**
  *Explain how this works – participant is asked to register for website using their own computer, enters information about everything they eat and drink, and gives the researcher permission to access their records. Show screenshot (**Website screenshot – ASA 24**)*

  - How would they feel about using this?
    - Compared with mobile phone?
    - Compared with tablet
    - Compared with written food diary?

  - How often would they enter the information?
    - How would they keep track of what they ate and drank in the meantime?

  - How would they feel about getting email reminders?
  - Would they have problems accessing the internet?

6. Taking photos

- **Taking photos manually**

Explain how this works – participant is given a digital or disposable camera – or uses their mobile – to take photos or videos of everything they eat and drink. Marker is used to give indication of quantities.

- How would they feel about doing this?

        - Compared with using an electronic device?
        - Compared with keeping a written diary?

    - Would they take photos of everything they eat and drink?
        - Why?
        - Why not?
        - In which circumstances would they/wouldn't they take photos? (What about snacks and drinks – tea, coffee, alcohol, water?)

    - Would they prefer to use their mobile or a camera provided by researchers?
        - Why?

    - How would they feel about getting text reminders to take photos?

7. Final thoughts

- Overall thoughts about the technologies discussed

- Discuss how they might feel if given choice between new methods and existing paper-based approach – more likely to take part?

- Any other suggestions for collecting information about what people eat and drink

Close

- Thank the participants
- Check whether they have any questions about the research
- Reassure them about confidentiality and anonymity
- Pay incentives if not already paid

Telephone interviews with previous NDNS participants: topic guide

Aim of the study
To inform the Department of Health of the range of new technologies currently available and in development internationally that have the potential to improve, complement or replace traditional methods of dietary assessment in the National Diet and Nutrition Survey Rolling Programme.

Telephone interview objectives
To gather perspectives from recent participants of the National Diet and Nutrition Survey on the potential use of one or more of the following new technologies in the survey:
entering dietary information into an electronic device (tablet, mobile phone or laptop/desktop computer) using an app or website
taking photographs of what they eat and drink.

▪ Introduction

- Introduce self and NatCen
- Briefly explain study
    - Funder – Department of Health
    - Lead research team – University of Leeds
    - Aim of the study
    - Objectives of the discussion
- Explain details about participation
    - Voluntary – participant does not have to answer questions if they do not want to
    - Incentives – explain they will be sent in post
    - Confidentiality – information to be used for research purposes only, will include research report
    - Anonymity – individuals will not be named in the report and no information will be included which could lead to individuals being identified
    - Nature of discussion – no right or wrong answers
    - Length of discussion – up to 30 minutes
    - Permission to record?
- Check whether they have any questions and are happy to go ahead
- START RECORDING

8. Background

- Occupation (e.g. working, studying)
- Any electronic devices they use: home computer with internet access, tablet (e.g. iPad), smartphone

- Check when they took part in NDNS

9. Participants' use of new technologies

Ask about devices mentioned by participants

- What they use the devices for
    - Internet?
    - Email?
    - Photos?
    - Social media?
    - Banking?
- How often they use them
- Context
    - Work?
    - Personal?
- Examples of apps they use
- Confidence with new technologies
    - How confident?
    - What do they find easy? Hard?
    - If they need help what do they do?
- Enjoyment of new technologies
    - Enjoy gadgets?
    - Why? Why not?
    - Try to stay up to date?

10. Participants' experience of recording what they eat and drink

Remind participant / or check they remember how NDNS works at the moment – paper based, 4 day food diary, recording quantity, brand, and cooking/preparation method for every item of food. Example – for a sandwich you have to record what kind of bread, how thickly sliced, any butter or margarine added and if so, what kind etc.

- As an NDNS participant, when did they enter food/drink information into the diary?
    - After every meal/ every snack /every drink, including water?
    - At the start / end of each day?
    - How would they keep track of what they ate and drank in the meantime?
    - Same approach for all 4 days or different each day?
    - Reasons for this approach?

- Participants' views of using the food diary on NDNS
    - How did they feel about completing the diary?
    - What worked well?
    - Problems/issues?
    - Any help received from interviewers?

- Outside of NDNS, have they ever used calorie counting/fitness websites or apps?
    - Why?
    - Which ones?
    - For how long?
    - Experiences and views of them?

11. Entering information into an electronic device

- **Tablet computer**
  Explain how this works – participant is given a tablet for four days, enters information about everything they eat and drink for four days, including types and quantities.

    - How would they feel about recording food/drink information on a tablet?
        - Advantages and disadvantages compared with written food diary

    - Would they carry the tablet with them?
        - Why?
        - Why not?

    - Would they enter the information after every meal?
        - After every snack?
        - After every drink, including water?
        - Why?
        - Why not?
        - If not, when would they enter the information?
        - How would they keep track of what they ate and drank in the meantime?

    - How would they feel about getting email reminders to enter the information?
        - At mealtimes? In the morning? In the evening?

    - (If they already have a tablet) Would they prefer to download an app to use on their own tablet?

- **Mobile smartphone**
  Explain how this works – participant is asked to download an app on their phone, enters information about everything they eat and drink, and gives the researcher permission to access their records.

    - How would they feel about using this?
        - Compared with tablet?
        - Compared with written food diary?

    - Would they carry the phone with them?
        - Why?
        - Why not?

    - Would they enter the information after every meal?

        - Every snack? Every drink, including water?
        - Why?
        - Why not?
        - If not, when would they enter the information?
        - How would they keep track of what they ate and drank in the meantime?

    - How would they feel about getting text reminders?
        - At meal times? In the morning? In the evening?

- **Laptop/desktop computer**
  Explain how this works – participant is asked to register for website using their own computer, enters information about everything they eat and drink, and gives the researcher permission to access their records.

    - How would they feel about using this?
        - Compared with mobile phone?
        - Compared with tablet
        - Compared with written food diary?

    - How often would they enter the information?
        - How would they keep track of what they ate and drank in the meantime?

    - How would they feel about getting email reminders?

12. Taking photos

- **Taking photos manually**

Explain how this works – participant is given a digital or disposable camera – or uses their mobile – to take photos or videos of everything they eat and drink. Marker is used to give indication of quantities.

    - How would they feel about doing this?
        - Compared with using an electronic device?
        - Compared with keeping a written diary?

    - Would they take photos of everything they eat and drink?
        - Why?
        - Why not?
        - In which circumstances would they/wouldn't they take photos? (What about snacks and drinks – tea, coffee, alcohol, water?)

    - Would they prefer to use their mobile or a camera provided by researchers?
        - Why?

    - How would they feel about getting text reminders to take photos?

13. Final thoughts

- Overall thoughts about the technologies discussed

- Explore whether if they had been given a choice when they did the previous NDNS survey between paper-based and electronic methods which they might have opted for and why

- Any other suggestions for collecting information about what people eat and drink

Close

- Thank participant
- Check whether they have any questions about the research
- Reassure them about confidentiality and anonymity
- Gift card will be sent in the post

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