INDDEX Priority Technical Criteria and Review of Technology-assisted 24-hour Recall Software Programs

INDDEX Project

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Contents

Acronym List

AMPM	Automated Multiple Pass Method
ASA24	Automated Self-Administered 24-Hour Recall
CAAFE	Consumo Alimentar e Atividade Fisica de Escolares (Food Intake and Physical Activity of School Children)
CANAA-W	Children's and Adolescents' Nutrition Assessment and Advice on the Web
CAPIS	Computer-Assisted Personal Interview System (CAPIS) for Open-ended Dietary Assessments among Koreans
DIDS	Dietary Intake Data System
EARS	Estimated average requirements
FCDB	Food Composition Database
FIRRSt4	Food Intake Recording Software System
FFQ	Food Frequency Questionnaire
HELENA-DIAT	Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) Project - Dietary Assessment Tool
IARC	International Agency for Research on Cancer
IMM	Interactive Multimedia dietary recall
INDDEX	International Dietary Data Expansion
myfood24	Measure Your Food on One Day
NCC	University of Minnesota Nutrition Coordinating Center
NCI	National Cancer Institute
NDSR	Nutrition Data System for Research
NINA-DISH	New Interactive Nutrition Assistant - Diet in India Study of Health
PAC24	Portuguese self-administered computerized 24-hour dietary recall
PC	Personal computer
PC-SIDE	PC Software for Intake Distribution Estimation
PDA	Personal digital assistant
PIPS	Post-Interview Processing System
PSEA	Portion size estimation aid
SCRAN24	Self-Completed Recall and Analysis of Nutrition
SNAP	Synchronized Nutrition and Activity Program
SNAPA	Synchronized Nutrition and Activity Program for Adults
Web-DAS	Web-based Dietary Assessment Software
WHO	United Nations World Health Organization
YANA-C	Young Adolescents' Nutrition Assessment on a Computer
YCNA-W	Young Children Nutrition Assessment on the Web

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1. Introduction

Data that describe a population's food and nutrient consumption and dietary patterns are critical for achieving a wide range of policy, programmatic, and advocacy objectives. While some of these information needs can be met through national or household level data sources, many of these applications require individual-level dietary data to provide useful information for policy making. However, national investment in routine collection of individual-level dietary data in low-income countries is rare. This is due to several reasons, including capacity constraints and the cost and complexity of undertaking dietary data collection and analysis.

The International Dietary Data Expansion (INDDEX) Project[1] is intended to make strides toward rectifying these critical gaps related to dietary data scarcity that have long impaired effective food, nutrition, and agricultural policy and programming. One of the primary objectives of the INDDEX project is to standardize and streamline the collection and analysis of individual dietary data in low-income countries. To this end, INDDEX intends to develop a technology-assisted dietary assessment platform that facilitates the collection and analysis of individual dietary data in low-income countries through a standardized approach that can be readily tailored to different contexts.

In order to inform the development of this technology, INDDEX has conducted a landscape assessment of innovative approaches to dietary assessment. A number of literature reviews in recent years have surveyed the range of dietary assessment technologies available (Falomir, Arregui et al., 2012; Gavrieli, Naska et al., 2014; Illner, Freisling et al., 2012; Ngo, Engelen et al., 2009; Shim, Oh et al., 2014), including emerging approaches such as computerized and web-based 24-hour recalls and food frequency questionnaires (FFQs), mobile phone and camera-based food records, smartphone applications, and sensor-based technologies. While these reviews have detailed the relative merits and limitations of emerging tools in dietary assessment, none has evaluated the appropriateness of such technologies for use in low-income countries. Wojtusiak et al. (2014) speak to this topic, noting that the low presence of smartphones and limited network coverage limit the applicability of many web-based and smartphone-enabled methods in sub-Saharan Africa (Wojtusiak, Gewa et al., 2011). The barriers to application of such technologies in low-income country settings are further underlined by recently published research by the International Agency for Research on Cancer (IARC) (Pisa, Landais et al., 2014). The IARC conducted a multi-country survey to determine current dietary assessment tools employed by researchers in 18 African countries.[2] The results indicated that traditional, pen and paper-based food FFQs and 24-hour recalls are the main dietary assessment methods used throughout the surveyed regions. None of the surveyed researchers reported use of technology-assisted methods of dietary assessment.

INDDEX seeks to remedy this situation through the development of dietary assessment platform that will improve the feasibility of dietary data collection, analysis, and use in low-income countries. Through a combination of literature review and key informant interviews, INDDEX conducted a landscape assessment of dietary assessment technologies and their appropriateness for application in low-income

[1]The INDDEX Project, led by the Tufts University Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy, was designed in collaboration with the International Food Policy Research Institute (IFPRI) and the United Nations Food and Agricultural Organization (FAO). It is funded by the Bill and Melinda Gates Foundation.

[2] Eighteen countries from four regions of Africa were surveyed, including Algeria, Egypt, Morocco, and Tunisia (North Africa); Benin, Burkina Faso, Cameroon, Ghana, Nigeria and Senegal (West Africa); Malawi, Mozambique, Namibia, South Africa and Zimbabwe (Southern Africa); and Kenya, Sudan, and Uganda (East Africa).

countries. The landscape assessment is envisioned as the first step towards the development of an INDDEX-created dietary assessment platform.

The results of the landscape assessment are presented in three separate but related documents.[3] The first document, "INDDEX Priority Technical Criteria and Review of Technology-assisted 24-hour recall Software Programs" (abbreviated henceforth as "**Technical Criteria and 24-hour Recall Software Review**"), presents priority technical criteria for a technology-assisted 24-hour recall platform and reviews existing 24-hour recall software against these criteria. The second document in the Landscape Assessment is entitled "Portion Size Estimation Aids (PSEAs): An INDDEX Review of Validity and Feasibility of Use in Low-Income Countries" (abbreviated as "**PSEA Review**"). The process of quantifying intakes through recall introduces the most error in dietary surveys (Cypel, Guenther et al., 1997; Lazarte, Encinas et al., 2012). For this reason, the topic of improving portion size estimation deserves its own special focus.

The third document in the landscape assessment is entitled "Innovative Dietary Assessment Technology: Potential for Application in Low-Income Countries" (abbreviated as "**Innovative Technology Review**"). This Innovative Technology Review is distinct from the INDDEX Technical Criteria and Software Review in that its main focus is on technological developments that represent, in many ways, an entirely new genre of dietary assessment approaches, where it is difficult to disentangle the assessment method from the technology itself (Illner, Freisling et al., 2012). Though exciting, to date these techniques have been used primarily in small-scale pilot studies and there is relatively little available information about the validity, feasibility, and socio-cultural acceptability of some of these methods in either a high-income or low-income context. The technologies are not likely to be ready for scale-up in a low-income context in the near-term (three to five years), and would, at minimum, require an infusion of funding focused on reducing cost and adapting these approaches for low-literacy contexts. Given these constraints, at this stage we have tentatively excluded this category of technology-assisted assessment tools as candidates for the INDDEX dietary assessment platform, but have surveyed the landscape nonetheless.

1.1. Objectives

The objectives of the three different reviews comprising the INDDEX landscape assessment are listed below:

1. **Objectives of the INDDEX Technical Criteria and Software Review**
   - **1.1.** Propose a framework of priority technical criteria for a dietary assessment platform to be applied in a low-income country context.
   - **1.2.** Assess whether any available software fulfills all of INDDEX's priority technical criteria through an analysis of key features of available software applications. The aim of this objective is to determine whether INDDEX should use one of these existing platforms rather than creating a new one.
   - **1.3.** Highlight features of available dietary data collection software that might be useful to replicate in a dietary assessment platform developed by INDDEX.[4]

[3] Only the first of the two documents is presented here. The second and third documents (the **PSEA Review** and the **Innovative Technology Review**) have been completed, but are being submitted to peer-reviewed journals and therefore have not, yet, been posted to the INDDEX website.

[4] The Micronutrient Initiative is conducting a concurrent review of dietary data processing programs, that we intend to draw on to inform the data processing elements of the INDDEX dietary assessment platform; for this reason, our review touches only

2. Objective of the INDDEX PSEA Review

2.1. Assess the validity and feasibility of a range of portion size estimation aids (PSEA) in the context of low-income countries, to help inform the approach(es) that should be adopted as part of the INDDEX platform.

3. Objective of the INDDEX Innovative Technology Review

3.1. Assess the range of novel dietary assessment technologies to determine their suitability for scale-up in low-income countries and to help inform opportunities for investment.

After presenting the methods and results of the INDDEX Technical Criteria and Software Review (Methods and Results sections, respectively), this document finishes with conclusions and suggested next steps for INDDEX as it progresses with the development of its dietary assessment platform.

2. Methods for the INDDEX Technical Criteria and Software Review

2.1. Methods used to address Objective 1.1 (framework of priority technical criteria)

Dr. Rosalind Gibson, a dietary assessment expert consulting for the INDDEX Project, proposed an initial set of priority technical criteria to be considered for any dietary assessment platform designed for use across multiple low-income countries. These technical criteria were based on her familiarity with the literature and her many years of experience conducting dietary assessments in low-income countries. To examine the benefits, costs, and detailed justifications of each of these priority criteria, a literature search was conducted in July 2015 using PubMed and Google Scholar. Citation lists of relevant articles were reviewed to identify additional relevant papers.

Key search terms (alone and in combination) included: interview administered, self-administered, surveys, questionnaire, mode of administration, 24-hour recall, multiple pass, diet, dietary assessment, technology, developing countries, low-income, mHealth, eHealth, FFQ, 24, valid, validity, validation. Articles downloaded were limited to those published in English. All articles were selected initially based on the relevance of the titles and abstracts. Articles that seemed relevant were kept for in-depth review and were drawn on to explain, justify, and further modify the technical criteria as appropriate.

2.2. Methods used to address Objectives 1.2 and 1.3 (review available software against priority technical criteria, highlight useful features)

Literature search processes

A structured search for peer-reviewed and grey literature on technology-assisted 24-hour recalls was conducted in order to determine whether existing dietary assessment software meet the priority technical criteria and highlight features of available programs that could be useful to replicate in dietary assessment platform developed by INDDEX. “Technology-assisted 24-hour recalls” were defined as 24-

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lightly on a few illustrative data management and processing platforms, profiled in **Annex 1: Tools for Processing Food Intake Data.**

hour recalls that rely on a computerized method of data capture as opposed to traditional, pen-and-paper-based approaches.

To identify information on dietary collection programs, the authors used a stepwise approach beginning with a search for peer-reviewed literature using PubMed and Google Scholar. Within PubMed, Medical Subject Heading (MeSH) terms were used to increase the precision of the search. The following MeSH terms were used individually and in combination to identify relevant articles: nutrition survey; nutrition assessment; diet; dietary intake; eating; food intake; energy intake; nutrient; portion size; questionnaire; data collection; automatic data processing; computer data processing; computer; technology assessment, biomedical; innovation, diffusion of; invention; internet; and software.

In addition to MeSH terms, the authors used key search terms to identify relevant articles in Pubmed. The keyword search terms include the MeSH terms listed above as well as the following: dietary assessment, 24-hour recall, dietary recall, valid, validation, feasible, feasibility, reliable, reliability, web, digital, mobile, ehealth, and tablet.

The "Related citations in PubMed" and "Cited by ___# of articles" functions in PubMed and Google Scholar, respectively, were used if an article was deemed highly relevant to the landscape assessment's aims. Citation lists of relevant articles were reviewed to locate additional articles.

A Google search for grey literature sources such as technical manuals of 24-hour recall programs and Frequently Asked Questions (FAQs) documents supplemented information derived from peer reviewed literature. Though the search was not restricted to a specific time period or geographic region, studies conducted in the last ten years in low-income countries were of greatest interest. The World Bank's country classification system was consulted to differentiate countries by high, middle, and low income (The World Bank, 2015).

Twenty-two 24-hour recall programs were identified during the search process. Three programs were eliminated from further analysis after determining that the software was no longer in use.

Key Informant Interviews

In addition to the literature search, the authors conducted key informant interviews with individuals experienced in the development and use of the identified 24-hour recall programs. Eighteen key informants were identified via the literature search and invited to participate in an interview (one of the eighteen key informants was invited to act as a key informant for four of the dietary software programs). Of the eighteen key informants invited to interview, ten responded and were interviewed. Tufts University's Institutional Review Board's granted the key informant interviews exempt status under Exempt Category 2 as defined in 45 CFR 46.101 (b).

Data extraction and assessment process

The Landscape Assessment authors extracted information from the literature and key informant interview transcripts on the dietary software's format, functionality, portion size estimation techniques, data processing specifications, validity, reliability, resource requirements, and additional areas of research required. The data extraction categories were based on the framework of priority technical

criteria described in Section 3.1.[5] Authors also reviewed demonstration versions of the programs if they were available.

Finally, a qualitative assessment of the extracted data was performed to determine if which, if any, identified programs met all of INDDEX's criteria for dietary assessment software and to note any elements of the reviewed software that may be useful to emulate in the INDDEX platform.

3. Results

3.1. Framework of priority technical criteria (Objective 1.1)

The technical features articulated below are intended to serve as a starting point for the development of a dietary assessment platform that will be designed to meet these criteria. They are also used in this landscape assessment as a means of assessing whether or not any existing technology-assisted dietary assessment program is potentially adaptable for INDDEX purposes. This section first details the justification for the proposed use of the 24-hour recall method and is followed by a discussion of the nine priority technical criteria. Other proposed technical criteria are described in **Annex 2**: Specifications for 24-hour Recall Software for Low-Income Countries of this report.

Justification for use of 24-hour recall method

Interventions and policies that target dietary causes of malnutrition, micronutrient deficiencies, and preventable diseases require high quality individual-level dietary data because consumption patterns of particular vulnerable groups are often distinct, and appropriate targeting and action requires identification of these patterns at the individual level. Traditional methods for collecting individual-level dietary data include: 24-hour recalls, food frequency questionnaires (FFQ), which can be qualitative or semi-quantitative, and food records (Gibson, 2005), among others. Increasingly (in high-income countries), these traditional dietary assessment methods are administered using 'technology-assisted' platforms, such as the web, tablets, or smartphones, that have helped to improve ease of use and cost (Illner, Freisling et al., 2012).

This section details considerations regarding which dietary assessment method (24-hour recall, FFQ, food record) should form the basis of the INDDEX platform. The choice of a dietary assessment method for a given research or programmatic objective should be made in light of each method's validity, reproducibility, and suitability for a given purpose, associated resource demands, and adaptability to different contexts (Coates, Colaiezzi, Wirth et al., 2012). The comparative advantages of the various methods commonly used in dietary assessment were examined through this multi-faceted lens, leading to the conclusion that the 24-hour recall method is more adaptable, potentially more accurate, and addresses a wider range of information needs than an FFQ. Furthermore, the 24-hour recall is a lower cost and less invasive option than a weighed food record which, though considered a gold standard technique, must be conducted by a trained enumerator in the home in low-literacy populations such as those in many low-income countries, thus increasing the chance that the respondents may change their usual eating pattern during the weighed record days.

[5] A full list of the technical criteria and the data extracted for each of the 24-hour recall programs reviewed is available upon request.

Overview of Candidate Dietary Assessment Methods

The 24-hour recall is one of the most frequently used methods for collecting detailed, meal-specific, individual-level, quantitative dietary data in large-scale surveys, and if repeated statistical modeling can be applied to generate data on the usual intakes of individuals (Coates, Colaiezzi, Wirth et al., 2012). In contrast, FFQs are designed to obtain an estimate of usual intake of a population recalled over a longer time period through a single administration of the questionnaire (Thompson & Subar, 2013). Unlike the open-ended questions in the 24-hour recall, FFQs use a pre-defined food list and ask respondents to report the frequency of consumption of specific foods over a recall period that typically ranges from one week to one year. Unlike 24-hour recalls, FFQs do not often collect information on food preparation methods or the combinations of foods consumed in the meal (Thompson & Subar, 2013). Furthermore, based on experience in Africa, rural women have difficulty with the concept of reporting habitual usual food intakes over a predefined time period and find it easier to respond to specific questions related to the previous day (Gibson & Ferguson, 2008).

Food records (also called dietary records) can be estimated or weighed and provide detailed, meal-specific data that is recorded prospectively during each eating occasion in order to minimize recall errors of the types and quantities of foods consumed. Whether data should be recorded for just one or multiple days depends on the study objective. When usual intakes at the individual-level are required, then the number of measurement days per individual depends on the within-subject variation in food intake, the nutrient of interest, and the required precision of the estimate (Gibson, 2005). As with 24-hour recalls, data should ideally be recorded on nonconsecutive days to increase representativeness of the individual's usual diet (Thompson & Subar, 2013). While food records can be self-administered, due to literacy issues in low-income country contexts a trained enumerator is often present. To complete a weighed food record, enumerator-observers directly weigh all food and beverages consumed, and record detailed information describing food type, food preparation, relevant brand names, and recipes (Gibson, 2005). Weighed food records are considered the most precise method for measuring dietary intakes and, as a recognized "gold standard" (Gibson, 2005), are often used as a reference method for dietary assessment validation studies (Alemayehu, Abebe et al., 2011; Ferguson, Gadowsky et al., 1995; Thakwalakwa, Kuusipalo et al., 2012).

The key characteristics of each method are summarized in **Table 1.**

Table 1. Comparison of dietary assessment methods (adapted from Thompson & Subar, 2013).

Characteristic	24-hour recall	Food frequency questionnaire	Dietary record
Types of information about foods consumed	Detailed information; meal-specific	Provides information restricted to those foods itemized on the food list	Detailed information; meal-specific
Time frame	Short-term (e.g., yesterday)	Long-term (e.g., weekly, monthly, yearly)	Short-term (e.g., yesterday)
Adaptable for diet in the distant past	No	Yes	No
Cognitive requirements	Memory of recent consumption	Judgments of long-term diet	Recording of consumed food and drinks
Time required to complete	30-40 minutes	15-30 minutes	Continuous weighing and recording throughout the day
Suitable for cross-cultural use with minimal adaptation	Yes; only prompts must be made context specific	No, context-specific food lists are needed	Yes

Validity and reproducibility of the candidate dietary assessment methods

Validity is the extent to which a method accurately captures the phenomenon it is trying to measure for a particular purpose (Goodwin & Leech, 2003; Messick, 1995). Reproducibility is the degree to which the method offers the same results when used repeatedly, assuming the situation being measured does not change. The selection of a given dietary assessment method should be driven by the intended use of the data, while considering the relative validity and reproducibility of different methods for different types of information needs. All diet assessment methods are vulnerable to certain systematic and random errors (as discussed below); the choice of method should balance the overall objective (see **Table 2**) with the need to reduce error and bias (Gibson, 2005).[6]

Food record and 24-hour recall (administered over multiple days) methods are well-suited for a wider range of uses than the FFQ. For example, if the research objective is to measure the mean nutrient intake for a group, a single 24-hour recall or food record can be used across multiple individuals in the sample, as long as the sample is representative and all days in the week are equally represented (Gibson, 2005). If instead the objective is to determine the proportion of the population "at risk" of inadequate nutrient intakes then information on the distribution of usual intakes for the study participants is needed, requiring measures from at least two nonconsecutive days on all the participants or a subsample, using a repeated 24-hour recall or a repeated food record (Gibson, 2005). When the objective of collecting dietary data is to rank individuals within a group it is appropriate to administer multiple observations on each individual using 24-hour recalls or food records; the number of observations required depends on the within-subject variation and the required precision of the estimate. A semi-quantitative FFQ can also be used but it is considered less precise. The FFQ is often used to study the association between dietary intakes and disease outcomes and, while it is a simpler method to administer with only a single interview, quantifying errors can be difficult (Gibson, 2005). When estimating the usual food intake of individuals for correlation or regression analyses with specific biochemical or clinical measures, the 24-hour recall method is suitable, provided an estimate of the within-subject variation for each nutrient of interest is obtained, allowing the number of days of recall per subject for the desired precision of the estimate to be calculated. Alternatively, if the study takes place in a controlled setting then repeated weighed food records are an option (Gibson, 2005). Multiple 24-hour recalls or food records also allow the investigator to calculate the theoretical reduction in the absolute value of the correlation or regression, which is attenuated by the effect of within-subject variation, an added advantage when examining diet-disease relationships (Gibson, 2005). Semi-quantitative FFQs can also be used (though accuracy may be reduced) to examine relationships between diet and biochemical or clinical measures, although the correlation or regression cannot be de-attenuated because within-subject variation cannot be estimated by a FFQ.

Overall, the 24-hour recall is suitable for the widest range of study objectives, from obtaining the average food and nutrient intake of a group to assessing the usual intake of individuals, as long as the number of days for which 24-hour recall data is collected on each individual accurately reflects the study objectives.

[6] Gibson, R. S., personal communication, 2014.

Table 2. Matching information needs with dietary assessment method (adapted from Gibson, 2005).[7]

Information required	Dietary assessment method	Example of analysis
Average intake of a group	• Single 24-hour recall or dietary record • All days of the week should be equally represented • Size of the sample is dependent on precision required and between-subject variation	• Describe the usual mean or median nutrient intake for a group • Demonstrate a significant different or significant change between two groups
Proportion of target population "at-risk"	• Repeat 24-hour recall or dietary record on all or study subsample • Sampled on non-consecutive days	• Determine the distribution of usual intakes within a group to assess the proportion at-risk of inadequate intakes
Usual intakes for ranking individuals within a group	• Multiple replicates of 24-hour recalls, dietary records, or semi-quantitative FFQs • Number of replicates depends on within-subject variation and precision of estimate required.	• Rank intakes of a food group or a nutrient of respondents by terciles, for example, versus their corresponding mean level of a biomarker.
Usual intakes of individuals for correlation or regression analysis	• Multiple replicates 24-hour recalls, dietary records, semi-quantitative FFQs, or diet history • Number of replicates depends on within-subject variation and the required precision of the estimate	• Assess the interrelationship between usual nutrient intakes of individuals to other indices of nutritional status measured in the same people

All dietary assessment methods are subject to a range of systematic and random errors, though some are more accurate than others. A number of studies have assessed the relative accuracy of 24-hour recalls and FFQs against biomarkers such as doubly labeled water (which measures energy expenditure). Many of these studies have shown the 24-hour recall to be consistently more accurate than FFQs (Carroll, Midthune et al., 2012; Freedman, Commins et al., 2014; Schatzkin, Kipnis et al., 2003; Subar, Kipnis et al., 2003). For instance, Freedman et al. (2014) pooled results from five validation U.S. studies in which self-reported 24-hour recall and FFQs were compared to biomarkers for energy and protein intake. This includes the data reported by Subar et al. (2003) and Schatzkin et al. (2003). The authors found that the average rate of underreporting for energy with a single 24-hour recall was 15% and with an FFQ it was 28%. Underreporting for protein intake was generally lower than for energy intake across both methods. Another study using data from Eating at America's Table comparing 24-hour recalls and FFQs found that the 24-hour recall was superior to the FFQ (Carroll, Midthune et al., 2012), and that between two and four 24-hour recalls were sufficient to capture usual intake of commonly consumed foods for the purposes of examining diet-disease relationships. The authors suggested that even more optimal results could be obtained using a combination of multiple 24-hour recall and FFQ, though this approach is likely to be cost-prohibitive in most contexts. Studies like these have generated increased skepticism over the use of FFQs (Kristal, Peters et al., 2005; Schatzkin, Kipnis et al., 2003) leading many researchers to caution against continuing to use the FFQ in epidemiological studies given its relatively lower accuracy compared to 24-hour recalls.

Reproducibility is a function of measurement errors as well as true variation in intake and, because these two sources of variability in a repeated measure cannot be easily disentangled, reproducibility can only be estimated by minimizing error and confounding to the extent possible during a test-retest assessment (Gibson, 2005). The weighed food record yields the most reproducible results, followed by the 24-hour recall when used to measure average nutrient intake (for most nutrients) across a population group. Reproducibility is lower for individual level 24-hour recall measurements (Gibson,

[7] Gibson, R. S., personal communication, 2015.

2005). Qualitative FFQs are less reproducible, particularly when foods assessed are consumed at a relatively low frequency. The reproducibility of semi-quantitative FFQs is very specific to the design of the questionnaire and the nutrients being captured; when the questionnaire design limits reporting of variability in food consumed over time, nutrient intake is naturally likely to appear less variable (Gibson, 2005).

Resource requirements for the candidate dietary assessment methods

These three methods – 24-hour recall, FFQs, and food records – vary in terms of the time required to develop and adapt the instrument for a new setting and administer the instrument to respondents (Gibson, 2005; Thompson & Subar, 2013). Other factors, aside from method choice, affect resource requirements. These include the uniqueness of a given context and related survey design, the technical capacity of the researchers, and the specific design decisions for a given method (Gibson, 2005), for example, if it is administered via a tablet or using pen and paper (Thompson, Subar et al., 2010). Generally speaking, the FFQ requires the most time to develop and the least amount of time to administer; the 24-hour recall requires a moderate amount of time to develop and administer, and a food record, if interviewer-administered and weighed, requires the least amount of time to develop but the most time to administer (Gibson, 2005). All three methods must be validated prior to use when the study settings are not comparable to those used in earlier validation studies.

When considering these factors collectively, the 24-hour recall method appears to offer the best balance in terms of validity, reproducibility and cost. Along with the food record, which is generally unsuitable for low-literacy populations, the 24-hour recall method is also the most flexible with relatively fewer adaptation requirements for new contexts compared to the FFQ.

The standardization of data collection and assessment through INDDEX is expected to further reduce the cost of the 24-hour recall relative to the closest gold standard, the weighed food record. Given that other promising new innovative technologies using sensors, image recognition, or other approaches are not yet ready for scale-up (see **Innovative Technology Review** the INDDEX team anticipates that the 24-hour recall method will best fulfill the core technical criteria of the dietary assessment software program discussed below.

Technical criteria for 24-hour recall

Use the multiple-pass format

The program should follow a standardized 24-hour recall multiple-pass format. The multiple-pass technique aims to reduce cognitive burden and improve reporting accuracy by encouraging respondents to report the foods that they consumed in stages, with increasing detail and opportunity to review and probe for potentially forgotten or misreported items. The multiple-pass method has been in use since the 1960s (Slimani, Freisling et al., 2015), when in 1965 the USDA began using the 24-hour recall method in periodic nationwide surveys (Raper, Perloff et al., 2004)

The original USDA version had three stages – a quick list, detailed description, and review. This approach evolved into the five-stage format, used in USDA's Automated Multiple-Pass Method (AMPM) for large-scale surveys, including the dietary interview component of the National Health and Nutrition Examination Survey, What We Eat In America (USDA ARS, 2015). The five-stage format increased and re-ordered the passes, added more memory cues and prompts for aiding respondents to remember and report foods (Raper, Perloff et al., 2004). **Table 3** describes each stage of the five-stage multiple-pass method used by the USDA.

In a separate but largely parallel endeavor (Gibson & Ferguson, 2008), developed a four-stage multi-pass format for use in low-income countries. This method requires the interviewer to guide the respondent to first recall the foods and drinks consumed, describe the foods and drinks consumed, estimate the portion sizes, and then review the interview data. **Table 4** provides a description for each stage of the four-stage multiple-pass method.

Table 3. Five-stage multiple-pass method (USDA/ARS, 2013; Raper et al., 2004).

Stage	Purpose
1. Quick list	Collect food consumed by the respondent in a 24-hour period the day before the interview.
2. Forgotten foods list	Collect foods that may have been forgotten during the quick list. Probe by commonly forgotten categories of foods/beverages: nonalcoholic beverages, alcoholic beverages, sweets, savory snacks, fruit, vegetables, cheeses, breads and rolls, and any other foods.
3. Time and occasion	Collect information on the time at which the respondent ate each food and the name of the eating occasion.
4. Detail cycle	Collect a detailed description of each food reported, including additions to the food, amount eaten, its source, and whether it was consumed at home.
5. Final probe	Provide a final opportunity to recall any other foods.

Table 4. Four-stage multiple-pass method (Gibson & Ferguson, 2008).

Stage	Purpose
1. Recall the foods and drinks consumed	List all of the foods and drinks (including water) consumed during the preceding 24-hour period.
2. Describe the foods and drinks consumed	The interviewer should go over, in chronological order, each of the responses made by the respondent in stage 1, probing for more specific descriptions of food and drink consumed, including cooking methods and brand names.
3. Estimate portion sizes	A variety of different methods can be employed for estimating the portions size.
4. Review the recall interview data	The interviewer reviews the recall to ensure that the items have been recorded correctly.

Research conducted for this landscape assessment did not identify any studies that compared the validity of using a four- versus five-stage multiple pass method. However, with literature suggesting that the multi-pass approach is cognitively easier and more accurate than a single-pass or less-structured approach (Gibson & Ferguson, 2008), the INDDEX dietary assessment platform will be based on the four- or five-stage multiple pass method, as the exact number of stages and the content of each stage still to be determined.

Mode of administration

The software program should be designed to be interviewer-administered. There are several reasons why, in low-income country contexts, interview-administered surveys are preferable to those that are self-administered. Most significantly, low-income countries tend to have low literacy rates[8], which limits the applicability of self-administered survey modalities for complex questionnaires (Thompson, Subar et al., 2010). Even if literacy were not a concern, many self-administered surveys are traditionally carried out over the internet or through the mail, and most low-income countries lack the necessary infrastructure (i.e., postal service and internet) for these to be feasible options for producing a representative set of survey results. Furthermore, web-based options require a high-level of computer proficiency and literacy (Thompson, Dixit-Joshi et al., 2015), making them infeasible options for many countries in the world at this time.

While self-administered surveys tend to be less expensive to implement per sample achieved, interviewer administration yields its own benefits. In general, interviewers have the opportunity to build rapport and motivate respondents, pause to encourage responses, and clarify questions that might arise in the course of the survey (Bowling, 2005). This is especially relevant when interviewers are equipped with specific probes to help respondents recall details of meals and snack items that may not otherwise have been reported initially (Thompson & Subar, 2013). Interviewer-administered surveys can increase the item response rates if the interviewer is able to maintain motivation during "longer questionnaires, probe for responses, clarify ambiguous questions…and control the order of questions" (Bowling, 2005, p. 2). For example Campbell and Dodds (1967) found that respondents with interviewer probing reported 25% higher dietary intakes than respondents without probing (as cited in Thompson & Subar, 2013). Another study in Denmark comparing interviewer-administered and self-administered health surveys found that the non-response rate was higher in self-administered surveys (37.9%) compared to interview-administered surveys (23.7%) (Christensen, Moller et al., 2014).

With that said, interviewer-administered surveys can also introduce random and systematic errors that differ from those that result from self-administered approaches. Some of the general potential issues with interviewer-administered surveys include social desirability bias, 'yes-saying' bias, (Bowling, 2005) and inter-interviewer variation, which can affect data collection consistency and accuracy (Coates, Colaiezzi, Fiedler et al., 2012; Gibson & Ferguson, 2008). Inter-interviewer variation can be mitigated to some degree by using computerized survey methods that aid in standardizing the interview process (Ngo, Engelen et al., 2009).

Despite the potential drawbacks and biases of both self-administered and interviewer-administered 24-hour recalls, these two approaches have been shown to achieve similar results among literate populations (Kirkpatrick, Subar et al., 2014; Thompson, Dixit-Joshi et al., 2015). For example a study by Kirkpatrick et al. in 2014 compared the performance of the Automated Self-Administered 24-hour (ASA24-hour recall) to the interviewer-administered Automated Multiple-Pass Method (AMPM) using random assignment in a feeding study in which the true intake and plate waste for three meals was known. The authors found that respondents completing the ASA24-hour recall reported 80% of the items truly consumed compared with 83% in the interviewer-administered AMPM (p=0.07), though the number of intrusions (i.e., the number of foods not consumed but reported) was significantly higher in

[8] According to the CIA World Factbook there are approximately 781 million illiterate adults (>15 years) and more than three-quarters of them live in South Asia, West Asia, and sub-Saharan Africa. Women comprise almost two-thirds of all of the illiterate adults in the world (Central Intelligence Agency, 2015)

ASA24-hour recall (p<0.01). For both methods, ingredients in multicomponent food and drinks were omitted more often than main foods or drinks. There were, however, very few differences by recall mode between true and reported energy, nutrient, and food group intakes and portion sizes (Kirkpatrick, Subar et al., 2014).

Based on the greater feasibility and at least equivalent accuracy of interviewer-administered approaches, INDDEX recommends that the dietary assessment platform be interviewer-administered.

Digital display of food photographs for food identification and portion size estimation

The program must allow the display of simultaneous graduated food photographs to aid in food identification (e.g., species of fish) and portion size estimation. These portion size estimation photographs should be readily customizable to specific countries or population groups.[9] An overview of the evidence that informed this recommendation is provided in the portion size estimation aid literature review (see **PSEA Review**).

Links to food composition database

The software program should be linkable to a contextually appropriate food composition database (FCDB) *during* the data collection process.[10] The reasons for incorporating this feature are to: ensure that interviewers elicit sufficient detail from respondents to be able to match reported food items and mixed dishes to those in the FCDB, reduce the task of post-coding, and ensure that the survey implementers think about the completeness and quality of their food composition data while preparing for the survey, rather than after the data are collected.

The food list within the software should be comprised of single item foods and mixed dishes with accompanying recipe information. When a respondent reports a food or mixed dish the interviewer will consult the food list to select the most closely corresponding item. Each item on the food list should be pre-coded; and the selection of an item should prompt the interviewer to ask the respondent a number of standardized, follow-up questions about the type of food item, its preparation method, and whether any foods were added to the item before consumption.

Though ideally each of these food items will be pre-linked to accompanying food composition data, the data capture software should also allow text entry of foods and items in recipes not contained in the food composition database.[11] Harrison (2004) includes some thoughtful suggestions about the ideal front-end software, specifying that it should "provide for data entry in the local language; allow creation of new, locally appropriate portion-size models and terms; allow entry and open-ended querying for new or unknown foods; and provide for recipe modification, including changes in fat and water retention and retention/loss factors in nutrient content with cooking" (Harrison, 2004, p. 4). These features have been integrated into many 24-hour recall software programs in use in high-income countries but have so far received insufficient attention in low-income countries.

[9] Gibson, R. S., personal communication, 2015.
[10] Gibson, R. S., personal communication, 2015.
[11] Gibson, R. S., personal communication, 2015.

Finally, to be useful for a range of contexts, the software must allow users to easily upload or link to the most contextually appropriate food composition database. This issue is further discussed under the "contextual adaptability" criterion.

Data collection modality

The software should be able to run offline on a laptop/tablet but should also be compatible with pen/paper data capture. Advancements in technology-assisted dietary assessment (e.g., using PCs, laptops, PDAs, tablets, and smartphones) have led to significant changes in the collection of dietary data in high-income countries. Investments in using technology-based platforms have largely been driven by a shared objective of reducing costs for both the collection and processing of dietary intake information and increasing accuracy (Thompson, Subar et al., 2010). These technology-assisted approaches have also reduced researcher and participant burden, automated and standardized coding, and upgraded data quality (Illner, Freisling et al., 2012; Sharp & Allman-Farinelli, 2014). Ultimately the goal of the INDDEX dietary assessment platform is to incorporate these types of features to reduce the barriers associated with dietary-related research in low-income settings.

In a review of the USDA's dietary intake data system, one of the main advantages noted by Raper and colleagues was that the automated interview system maintained consistency across all interviews since each question had to be answered before moving to the next one, and responses outside a plausible range were flagged in real time (Raper, Perloff et al., 2004). The use of computer-assisted interviewing techniques can help reduce inter-interviewer variability (Illner, Freisling et al., 2012) while maintaining the same standard of results as conventional recalls (Ngo, Engelen et al., 2009). A systematic review of projects in Africa that use mobile phone technology for healthcare (mHealth) found that mobile phones reduced data losses, improved data quality monitoring, reduced delays in reporting, lowered replication costs, improved adaptation to new cultural contexts and scale up, and improved acceptance and satisfaction by both respondents and staff (Aranda-Jan, Mohutswiwa-Dibe et al., 2014). In addition, a review of four mHealth projects in Malawi reported that fieldworkers preferred using the electronic data capture devices (smartphones and personal digital assistants) instead of carrying paper and pen-based systems, which can be tiresome and were deemed to be "easier to carry, control, and work with" (King, Hall et al., 2014). Furthermore respondents reported liking the use of the electronic data capture devices in the interview process (King, Hall et al., 2014).

Box 1: Advantages and disadvantages of using digital instruments for 24-hour dietary recall

Advantages of digital instruments:

- Reduces interviewer bias;
- Reduces the time and cost during fieldwork;
- Data collection and codification in real time;
- Automatic calculation of daily intake; and
- Highly economic options of capturing food intake: online (e.g., computers, tablets, and smartphone) tools.

Disadvantages of digital instruments:

- Potentially high cost of program design in the initial phases;
- High costs related to the acquisition of technology (e.g., computers, tablets, and smartphones) but savings related to data entry;
- Requires additional enumerator training as many enumerators may not be accustomed to using a computer, tablet or touch screen;
- Potentially requires access to internet;
- The method still depends on the subject's recall capacity;
- Risk of theft or breakage.

Source: Adapted from Salvador Castell, Serra-Majem et al. (2015).

Despite the many advantages of new technologies, errors and bias related to retrospective dietary intake assessment will not be entirely resolved through an automated approach to 24-hour recall (Illner, Lachat et al., 2014). See **Box 1** for a summary of key advantages and disadvantages of using digital instruments for 24-hour recall assessments.

The data collection software that INDDEX intends to use should probably be designed to run on a small laptop or a large tablet, as most smartphones do not currently have a large enough display to adequately portray multiple side-by-side graduated photographic aids for estimating portion size.[12] The smaller screen size of smartphones also limits the number of response options that can be displayed without necessitating scrolling through results, which may make the procedure more cumbersome for interviewers and reduce accuracy of dietary data collected (Kirkpatrick, Subar et al., 2014). Small screen size can also be problematic during translation of the software since other languages may require more text and thus more space on the screen.[13]

The *processing* components of the platform will also be automated and directly linked to the data capture software, but should also be compatible with pen and paper data capture/manual data entry for contexts where technology-assisted options are not feasible or desired. A number of practical issues often crop up in field survey contexts, such as the varied battery life and options for recharging in the field, forms freezing or not appearing, and difficulty saving the survey (King, Hall et al., 2014). Given the challenging conditions in which this technology will likely be used, the pen and paper back-up option is needed in case the technology stalls or fails.

Data able to be collected offline

The data capture software on the tablet/laptop must be able to function offline, in settings with only occasional internet access. This technical criterion is driven by the 'global digital divide', a term used to explain the uneven provision and development of internet services in the world, with the African continent lagging far behind Asia and the Americas (Internet Live Stats, 2014). Globally, over 3.1 billion people have access to the internet and roughly 4.2 billion do not, with usage growing only 9% per year (West, 2015). In addition to the possible total lack of internet access, when internet does exist two additional critical issues must be considered when designing the software program for use in low-income countries: low bandwidth and intermittent access due to lack of electricity (Khanal, Burgon et al., 2015). Users of this dietary assessment software program could face these types of challenges and, to ensure the program is flexible for multiple types of contexts, users must be able to collect data offline and upload when an internet connection becomes available.

Contextual adaptability

The dietary assessment platform must be designed to be adaptable across different contexts in order to promote uptake and comparability of data. Ideally, the software will guide users through the adaptation process in a structured way, in order to ensure a balance between standardization, flexibility, and contextual appropriateness across countries.

The protocol for conducting multiple-pass 24-hour recall assessments is essentially the same in every context, though certain aspects, such as names of local foods and dishes, eating occasions, context-

[12] Gibson, R. S., personal communication, 2015.
[13] Subar, A. F., ASA24 – Key Informant Interview, 2015.

appropriate prompts, and portion size aids must be adapted for a given setting. To enable adaptation, several technological qualities need to be built into the software including the ability to:

- Allow translation into multiple languages within the program;
- Embed country-specific food composition databases;
- Insert country specific foods and recipes;
- Allow for locally appropriate portion size models and terms;
- Include customized portion size estimation photographs for specific countries or population groups; and
- Include alphanumeric codes for each food and ingredient consumed, with food descriptions from the planned FAO international food database (using FoodEx2 coding system).[14]

Scalable and appropriate for use during national surveys

Given that one of the main objectives of creating this software is to increase the frequency of national level dietary data collection in low-income countries**, the technological aids adopted as part of the INDDEX platform must be usable on a large scale.** This means, for instance, that tablet-based software should have the capacity to collect and process the large number of records common to sample sizes of nationally representative surveys and should facilitate collation of data from multiple data collectors within a country and possibly across multiple countries. In other words, multiple users should be able to simultaneously collect and upload data without encountering bottlenecks or technological inefficiencies. Other innovative technology-based methods of diet assessment, such as wearable cameras, are not yet at a stage of development where they can be scaled up for large sample sizes, for reasons related both to accuracy and cost-efficiency (see **Innovative Technology Review**).

Easy to use

For this dietary assessment software to gain traction with users it must be easy to use.[15] Interviewers are likely to have limited to no expertise with the software tool and potentially limited exposure to working with touch screen tablet/laptop technology. However it is worth noting that young people, those most likely to be engaged as interviewers, are often considered 'first adopters' of new technology (Halewood & Kenny, 2008), and recent research from Malawi shows that despite the majority of fieldworkers never having used a smartphone or PDA, gaining proficiency was not a barrier to use (King, Hall et al., 2014) The software should be designed in a very intuitive manner, with a clear and appealing interface, that allows relatively novice interviewers to learn the technology quickly. This design requirement may result in forgoing certain desirable advanced features (or making them optional) in order to keep the product as streamlined as possible.

Not only must consideration be given to creating compelling and user-friendly training materials, but also to optimizing technical support for the process of adaptation and implementation. A systematic review of telemedicine programs in low-income countries found that ensuring easily accessible local expertise for trouble shooting technical issues was an invaluable investment (Khanal, Burgon et al., 2015). Another, probably less desirable, possibility is for the product developer to provide remote support, with the option of purchasing additional support time as needed (King, Hall et al., 2014).

[14] Gibson, R. S., personal communication, 2015.
[15] Gibson, R. S., personal communication, 2015.

The software should not only be easy to use, but relatively rapid to implement. Pen and paper-based 24-hour recalls take an average of 30-45 minutes to administer (Thompson & Subar, 2013). Ideally this software should take at least the same amount of time and, preferably, less.

Low-cost to adapt and use

For the software to be successful with users it must require limited time and costs when adapting the tool to new settings (Gibson, 2015). As noted earlier, using mobile technology for healthcare in Africa has demonstrated low replication costs with significant potential to be scaled-up easily (Aranda-Jan, Mohutswiwa-Dibe et al., 2014). Similar benefits of a universally adaptable dietary assessment platform must be realized within the INDDEX Project.

Specifically related to 24-hour recalls, the costs associated with standard pen and paper methods can be high. One study estimated the cost of a traditional pen-and-paper 24-hour recall to be approximately USD $247 per household, given a sample of 480 households in Sub-Saharan Africa (Fiedler, Martin-Prével et al., 2013). The authors' cost categories include sample-related work and materials development such as translation of documents and identification of common recipes for mixed dishes, ensuring completeness of a locally-relevant food composition database and portion size estimation aids, possible laboratory work, data entry, data analysis, report writing, and dissemination of results (Fiedler, Martin-Prével et al., 2013). Many of these steps take a long time to complete when first done. Additionally, because many countries do not archive dietary assessment data and related externally-linked databases in a readily accessible way, each time a diet survey is conducted, even in the same setting, users often end up 're-inventing the wheel' and recreating the work, which contributes to this high cost. The authors also considered the geographic coverage of the survey, the number of days of training, and the average number of interviews to be conducted per day in determining the total cost per household, which also speaks to the need to reduce time-per-interview and training requirements.

Research using four different data capture systems[16] in Malawi determined that, for recurrent use, electronic data capture is cheaper than pen and paper methods, as capacity develops and the hardware costs are gradually amortized. This is especially true when factoring in the 'effectiveness' side of the equation, including high returns associated with the improved data quality and reduced error (King, Hall et al., 2014).

By absorbing all of the initial costs of developing the platform, INDDEX aims to significantly reduce recurrent user costs. While the necessary hardware will have to be purchased by the users, the software will contain built-in features to streamline adaptation to new settings and facilitate data collection, cleaning, processing, analysis and reporting of information. A feasibility assessment of the beta version of the platform will be carried out in two countries: as part of this process, an economic costing comparison will be conducted of pen-and-paper versus the technology-assisted method in order to assess the degree of resource savings derived from the platform approach.

[16] The four data capture tools include two Android devices (CommCare and ODK Collect, one for PALM and Windows OS (Pendragon), and a custom built application for Android (Mobile InterVA – MIVA)

3.2. Results of assessment to determine whether existing 24-hour recall software programs meet all technical criteria (Objective 1.2)

This section offers an overview of the technology-assisted 24-hour recall programs identified in the literature review and analyzes them to determine how well they fulfill INDDEX's priority technical criteria.

Overview of technology-assisted 24 hour recall programs

Table 5 lists the twenty-two 'technology-assisted' programs used for 24-hour dietary recalls were identified during the landscape assessment. The majority of these were designed for use in high-income countries, with just three programs designed for middle-income contexts[17]: 1) CAAFE (Brazil), 2) GloboDiet (Mexico and Brazil) (World Health Organization International Agency for Research on Cancer, 2015), and 3) DietPal (for Malaysia, which is technically an upper-middle income country).

Just one of the programs, NINA-DISH, was designed for a lower middle-income country, India (Daniel, Kapur et al., 2014). NINA-DISH was created for use during the India Health Study, a multicenter pilot study of a range of different economic, ethnic and urbanization patterns, intended to determine the feasibility of establishing a diet and cancer cohort in India (Daniel, Kapur et al., 2014). This review produced no record of technology assisted 24-hour recall programs designed for, or used in, any African country on a large-scale, echoing findings previously reported by Pisa, Landais et al. (2014).

Many of the dietary assessment programs identified in this review have evolved over time, and some assumed new names. SCRAN24 (used in the United Kingdom) has been adapted and improved and renamed Intake24.[18] FiRRSt4 has evolved into ASA24-Kids, the U.S. National Cancer Institute's version of ASA24 adapted for use with children.[19] Finally, YCNA-W has been replaced by CANAA-W as software for the measurement of dietary intake among young Belgian children. SCRAN24, FiRRSt4, and YCNA-W are presented with the other platforms in Table 5 but, since they are considered obsolete[20], the subsequent discussion of findings considers only the nineteen 24-hour recall programs that are believed to be currently in use.[21]

[17] Per the World Bank's classification system (The World Bank, 2015)
[18] Foster, E., Intake24 – Key Informant Interview, 2015.
[19] Baranowski, T., eButton, FiRRST4, CAAFE, and PAC24, 2015.
[20] As implied by the literature.
[21] There was no response to requests for key informant interviews on the following programs: CANAA-W, CAPIS, AMPM, DietPal, HELENA-DIAT, IMM, NINA-DISH, SNAP, SNAPA, and YANA-C. Some of the aforementioned programs may no longer be in use but confirmation of the program's status could not be obtained from key informants or the available literature.

Table 5. List of 24-hour recall programs identified.

Name	Responsible organization	Target population	Country of application	Reference
AMPM[22]	US Department of Agriculture	Adults	United States	McDowell, Warren et al. (1997); Moshfegh, Rhodes et al. (2008); Raper, Perloff et al. (2004)
ASA24[23]	National Cancer Institute	Adults, children (10y+)	United States	Kirkpatrick, Subar et al. (2014); National Cancer Institute (2011, 2014a, 2014b); Subar (2010); Subar (2015); Subar, Crafts et al. (2010); Subar, Thompson et al. (2007); Thompson, Dixit-Joshi et al. (2015); Zimmerman, Hull et al. (2009); Zimmerman, McNutt et al. (2006); Zimmerman, Potischman et al. (2015)
CAAFE[24]	Federal University of Santa Catarina	Children (7-10y)	Brazil	CAAFE (2013a, 2013b); da Costa, Schmoelz et al. (2013); Davies, Kupek, de Assis, Engel et al. (2015); Davies, Kupek, de Assis, Natal et al. (2015); Universidade Federal de Santa Catarina (2013)
CANAA-W	University of Ghent	Parents of pre-primary and primary school-aged children	Belgium	Vereecken, Covents et al. (2014)
CAPIS	Seoul National University	Adults	Republic of Korea	Shin, Park et al. (2014)
DietDay[25]	University of California, Los Angeles	Adults, children[26]	United States	Arab (2013); Arab, Tseng et al. (2011); Arab, Wesseling-Perry et al. (2010)
DietPal	Universiti Kebangsaan	Adults	Malaysia	Noah, Abdullah et al. (2004); *Visual Informatics: Bridging Research and Practice* 2009)
FIRRSt4[27]	Baylor College of Medicine	Children (8-9y)	United States	Baranowski, Islam et al. (2012)

[22] The USDA's Automated Multiple-Pass Method (AMPM) is a computerized 24-hour recall data collection program that is integrated into a larger dietary assessment system called the Dietary Intake Data System (DIDS). Two other supporting programs, the Post-Interview Processing System (PIPS) and Survey Net also comprise DIDS. PIPS reformats the data and assigns food codes, while Survey Net is used for final coding, quality review, and nutrient analysis. Any references to DIDS should therefore be understood as encompassing this three-part system.
[23] Subar, A. F., ASA24 – Key Informant Interview, 2015.
[24] Baranowski, T., eButton, FiRRST4, CAAFE, and PAC24 – Key Informant Interview, 2015.
[25] Arab, L., DietDay – Key Informant Interview, 2015.
[26] DietDay has also been used in dietary assessment of infants (Arab, L. Diet Day – personal communication, 2016).
[27] Baranowski, T., eButton, FiRRST4, CAAFE, and PAC24 – Key Informant Interview, 2015.

Table 5. (cont'd). List of 24-hour recall programs identified.

Name	Responsible organization	Target population	Country of application	Reference
GloboDiet[28]	International Agency for Research on Cancer	Adults	Various[2]	Crispim, Nicolas et al. (2014); de Boer, Slimani et al. (2011); Diethelm, Huybrechts et al. (2014); GloboDiet (2012); González-Gross, de Henauw et al. (2013); Huybrechts, Casagrande et al. (2011); Huybrechts, Geelen et al. (2011); Ocke, Slimani et al. (2011); Park, Park et al. (2015); Pisa, Landais et al. (2014); Slimani, Deharveng et al. (1999); Vereecken, Covents et al. (2008); World Health Organization (2014)
HELENA-DIAT	Universidad de Zaragoza	Adolescents (13-17y)	Various[3]	Diethelm, Huybrechts et al. (2014); González-Gross, de Henauw et al. (2013); Vereecken, Covents et al. (2008)
IMM	Virginia Tech	Adults	United States	Zoellner, Anderson et al. (2005); Zoellner, Anderson et al. (2006)
Intake24[29]	Newcastle University	Children and young adults (11-24y)	United Kingdom	Food Standards Agency Scotland (2014); Food Standards Agency/Newcastle University (2013); Foster, Delve et al. (2014); Mauerhoefer, Kawelke et al. (2014)
myfood24[30]	University of Leeds	Adolescents (11-18y), adults (19-64y), older adults (≥65y)	United Kingdom	Carter, Albar et al. (2015)
NDSR[31]	University of Minnesota	Adults, children	United States	Nutrition Coordinating Center (2014); Nutrition Data System for Research (2014)
NINA-DISH	U.S. National Cancer Institute, Indian Council of Medical Research	Adults	India	Daniel, Kapur et al. (2014)
PAC24[32]	University of Lisbon	Children (7-10y)	Portugal	Carvalho, Baranowski et al. (2014); Carvalho, Santos et al. (2014)
SCRAN24	Newcastle University	Children (11-16y)	United Kingdom	Foster, Hawkins et al. (2014)
SNAP	Durham University	Children (7-15y)	United Kingdom	Moore, Ells et al. (2008); Moore, Hillier et al. (2014)

[28] Slimani, N., GloboDiet – Key Informant Interview, 2015.
[29] Foster, E., Intake24 – Key Informant Interview, 2015.
[30] Carter, M., Measure Your Food On One Day (myfood24) – Key Informant Interview, 2015.
[31] Harnack, L., Nutrition Data System for Research (NDSR) – Key Informant Interview, 2015.
[32] Baranowski, T., eButton, FiRRST4, CAAFE, and PAC24 – Key Informant Interview, 2015; Carvalho, A., PAC24 – Key Informant Interview, 2015.

Table 5. (cont'd). List of 24-hour recall programs identified.

Name	Responsible organization	Target population	Country of application	Reference
SNAPA	Durham University	Adults	United Kingdom	Hillier (2010)
Web-DAS[33]	University of Denmark	Adults, children[34]	Denmark	Biltoft-Jensen, Bysted et al. (2013); Biltoft-Jensen, Hjorth et al. (2013); Biltoft-Jensen, Trolle et al. (2014)
YANA-C	University of Ghent	Adolescents (11-14y)	Belgium	Vereecken, Dohogne et al. (2010); Vereecken, Covents et al. (2005)
YCNA-W	University of Ghent	Parents of primary school-aged children	Belgium	Vereecken, Covents et al. (2009)

[33] Biltoft-Jensen, A., Web-DAS – Key Informant Interview, 2015.
[34] WebDAS has also been used in dietary assessment of infants (Biltoft-Jensen, A. Web-DAS – personal communication, 2016).

Table 6. Summary of priority technical criteria met by the 24-hour recall software.[35]

Priority Criteria	AMPM	ASA24	CAAFE	CANAA-W	CAPIS	DietDay	DietPal	GloboDiet	HELENA-DIAT	IMM
Runs on a laptop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Runs on a tablet	Unknown	Yes	No	Unknown	Unknown	Yes	Unknown	No	Unknown	Unknown
Interviewer-administered (or capable of being interviewer-administered)	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No
Follows a multiple-pass format	Yes	Yes	No	No	Yes	Yes	Unknown	Yes	No	Yes
Data collected offline (or capable of offline data collection)	Yes	No	No	No	No	No	No	Yes	Yes	Yes
Scalable and appropriate for use during national surveys	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unknown
Linked to a FCDB	No	Yes	No	Yes	Yes	Yes	Yes	Yes[36]	Yes	Yes
Allows free text entry of foods not found in food list	Yes	Yes	No	Yes	Unknown	No	No	Yes	Yes	Unknown
Designed to facilitate adaptation to new settings	No	Yes	No	No	No	No	No	Yes	Yes	No
Digital display of food photographs for portion size estimation	No	Yes	No	Yes	Yes	Yes	Unknown	Yes	Yes	Yes
Total 'Yes'	6	9	2	5	5	7	4	9	7	5
Total 'No'	3	1	8	4	3	3	3	1	2	2
Total 'Unknown'	1	0	0	1	2	0	3	0	1	3

[35] A "Yes" indicates that the program meets the criterion, a "No" indicates that it does not, and "Unknown" implies that there is not enough information in the available literature to determine if the program meets the criterion.

[36] GloboDiet provides limited food composition information on macronutrients (energy, protein, and fat) of consumed foods. This limited database functions as a quality control mechanism, allowing researchers to identify extreme outliers. GloboDiet does not automatically generate comprehensive food composition data.

Table 6 (cont'd). Summary of priority technical criteria met by the 24-hour recall software.

Priority Criteria	Intake24	myfood24	NDSR	NINA-DISH	PAC24	SNAP	SNAPA	Web-DAS	YANA-C
Runs on a laptop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Runs on a tablet	Yes	No	No[37]	Unknown	No	No[38]	Unknown	Yes	Unknown
Interviewer-administered (or capable of being interviewer-administered)	No	Yes	Yes	Yes	No	No	No	Yes	No
Follows a multiple-pass format	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Data collected offline (or capable of offline data collection)	No	No	Yes	Yes	No	No	No	No	Yes
Scalable and appropriate for use during national surveys	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unknown
Linked to a FCDB	Yes	Yes	Yes	Yes	Yes	Unknown	Yes	No	Unknown
Allows free text entry of foods not found in food list	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Designed to facilitate adaptation to new settings	No	Yes	No	No	No	No	No	Yes	No
Digital display of food photographs for portion size estimation	Yes	Yes	No	No	Yes	No	No	Yes	Yes
Total 'Yes'	7	7	7	7	6	3	3	7	4
Total 'No'	3	3	3	2	4	6	6	3	3
Total 'Unknown'	0	0	0	1	0	1	1	0	3

[37] Though no mobile application has been developed for NDSR, the program can be used on a Microsoft Surface Pro (which is a laptop-tablet hybrid); Harnack, L., Nutrition Data System for Research (NDSR) – Key Informant Interview, 2015.
[38] A mobile version of SNAP is currently in development (Moore, Hillier et al., 2014).

Do any of these 24-hour recall programs meet the INDDEX priority technical criteria?

Table 6 depicts the extent to which the nineteen 24-hour recall programs meet INDDEX's priority technical criteria for a technology-assisted dietary assessment program suitable for low-income countries. The criteria related to cost and ease of use were not included in the table due to lack of available information in the literature, but will be assessed through additional key informant interviews to be conducted at a later date.

None of the software programs reviewed meets all of the priority technical criteria put forth in the INDDEX framework. ASA24 and GloboDiet meet nine of the 10 INDDEX priority criteria, followed by seven programs that have seven of the priority features (DietDay, HELENA-DIAT, Intake24, myfood24, NDSR, NINA-DISH, and Web-DAS).

Most programs reviewed (12 of 19) use digital photographs as portion size estimation aids and are linked to a FCDB[39] (14 of 19). Slightly less than half (9) of the programs are designed to be interviewer-administered (or capable of being interviewer-administered), as newer, self-administered, web-based platforms are driving much of the innovation in 24-hour recall technology in high income countries. Tablet-compatibility and offline data collection were not common among the assessed software; only ASA24, DietDay, Intake24, and Web-DAS are currently tablet-compatible. Only five programs, ASA24, GloboDiet, HELENA-DIAT, myfood24, and Web-DASC are designed to be adaptable to multiple countries.

The 24-hour recall programs are described in greater detail below with respect to each of the INDDEX priority technical criteria.

Laptop and tablet compatibility

All of the assessed programs appear capable of running on a laptop. On the other hand, tablet compatibility could not be determined for nine of the programs and of those programs for which information was available, only ASA24, Dietday, Intake24, Web-DAS are designed to be administered on tablets. Mobile[40] applications for SNAP are in development. Software that is originally designed to run on a desktop or laptop computer requires a mobile application ('app') to operate and display optimally on a tablet or smartphone.[41] Several key informants expressed a desire to develop a mobile app but perceived the expense to be prohibitive.

Administration format

A total of nine of the 19 software programs are designed to be administered by an interviewer or capable of interviewer-administration (AMPM, ASA24, DietDay, DietPal, GloboDiet, myfood24, NDSR, NINA-DISH, and Web-DAS). Three of the 9 (ASA24, DietDay, and Web-DAS) were originally designed as self-administered, web-based programs but have been adapted to an interviewer-administered format for use in populations with low literacy and computer skills. Four programs are used solely as an

[39] "Linked with a food composition database" is defined as software that contains an internal FCDB that automatically generates food composition data for foods or recipes reported during the 24-hour recall.
[40] "Mobile" refers to smartphone and tablet technologies.
[41] A software application (or 'app') is distinct from system software. "A mobile application is a computer program running on a mobile device and presenting value to the mobile user." (Rupnik, 2008)

interviewer-based 24-hour recall (AMPM, GloboDiet, NDSR, NINA-DISH) while one program (myfood24) allows researchers to select the administration format. Dr. Emma Foster and her research team at Newcastle University are exploring the possibility of adapting Intake24 to an interviewer-based format.[42]

Several programs that target children and adolescents (CAAFE, PAC24, HELENA-DIAT, and YANA-C) used a mixed administration format. The ages of children to whom these programs are administered range from seven to 17 years. Children complete the 24-hour recall in a classroom setting while a research assistant is present. The research assistant provides a short introduction to the software and then the children are expected to complete the 24-hour recall themselves and they may request assistance if they encounter difficulties.

Multiple-pass format

The majority of the assessed programs (11 out of 19) adhered to a multiple-pass format. Lack of adherence to the multiple-pass format was common among self-administered dietary software, particularly among the self-administered programs that targeted children for whom detailed descriptions of foods and portions consumed is cognitively challenging.

One program, myfood24, contains an optional quick list feature. When using myfood24 researchers can either select a four-pass (quick list, description of foods, portion size estimation, and final review) or a three-pass option with the quick list omitted. During feasibility testing respondents stated that they preferred to enter all data on foods consumed (food type, additions to foods, and portion sizes) in one instance, hence the decision to make the quick pass feature optional. Myfood24 researchers at the University of Leeds have not yet compared intakes estimated with the quick pass feature to those estimated without it.[43]

The interface of interviewer-administered 24-hour recall software programs must allow the interviewer to easily reference the quick list as he or she progresses with the recall. INDDEX researchers intend to test a number of the 24-hour recall programs in August 2015, which will help inform the optimal design of the quick list feature.

Offline data collection

Given that the major technological developments in 24-hour recall software have occurred in high-income countries, it is not surprising that most (12 out of 19) of the identified programs use a web-based data collection format. Online data collection programs use the internet for multiple purposes: to permit researchers to register a study, select study parameters, manage study logistics (e.g., create accounts for respondents to use when logging on to complete the recall), and obtain dietary analyses. Although currently only capable of collecting data online, ASA24 could be adapted to support offline data collection fairly easily – it would take approximately three months of work.[44] The seven offline data collection programs identified during the landscape assessment are AMPM, HELENA-DIAT, IMM, GloboDiet, NDSR, NINA-DISH, and YANA-C. Based on available information, it does not appear that any of the offline data collection programs use an internet server for data storage and manipulation.

[42] Foster, E., Intake24 – Key Informant Interview, 2015.
[43] Carter, M., Measure Your Food On One Day (myfood24) – Key Informant Interview, 2015.
[44] Subar, A. ASA24 – personal communication, 2016.

Interviews with key informants suggested that one of the advantages of a web-based program is its flexibility (i.e., the online questionnaire can easily be updated and made available to all users). Though the INDDEX software will be an offline data collection platform, the INDDEX project should devise an efficient system for troubleshooting bugs and rolling out software updates to users.

Scalable and appropriate for use during national level surveys

All but two of the 24-hour recall programs appear capable of being used at national scale (i.e., the programs allow concurrent operation by multiple users and appear capable of collection and management of large datasets). A number of the programs assessed were either designed for or are currently being used in large-scale survey research. For instance, AMPM is used for data collection in What We Eat in America, the dietary interview component of the National Health and Nutrition Examination Survey (NHANES). GloboDiet is the data collection tool used in support of the IARC-WHO Global Nutrition Surveillance initiative, which collects standardized, national-level dietary risk factors on non-communicable diseases, primarily in Europe but increasingly in other mid-to upper-income settings. Feasibility testing is currently ongoing to determine whether Intake24 is appropriate for use in the national Scottish Health Survey.[45] There was not enough information available to determine whether IMM and YANA-C are scalable.

Linkage with food composition database

Linkage with a food composition database, which we have defined as software that contains an internal FCDB that generates food composition data for foods or recipes reported during the 24-hour recall, is a common feature among 24-hour recall software. Fourteen of the 19 programs are linked to a FCDB and provide some level of food composition data for food items and mixed dishes (ASA24, CANAA-W, CAPIS, DietDay, DietPal, GloboDiet, HELENA-DIAT, IMM, Intake24, myfood24, NDSR, NINA-DISH, PAC24, and SNAPA). With this feature, nutrient data files are conveniently available immediately following completion of the interview, generally in either a CSV or Excel file format. GloboDiet is a unique case in that it contains a simplified nutrient database that is used solely for identification of extreme outliers. This database provides information on energy composition of the foods and is used to compare reported energy intakes with energy and macronutrient requirements based on the subject's age, sex, weight, and height (Crispim, Nicolas et al., 2014). GloboDiet does not automatically generate comprehensive food composition data.

There was not enough information to determine if SNAP and YANA-C are linked to FCDBs. CAAFE is not linked to a FCDB. AMPM, Web-DAS, and GloboDiet all require an external procedure for linking foods reported by respondents with comprehensive food composition data (Raper, Perloff et al., 2004).[46] Foods and mixed dishes within these three programs are pre-coded with codes from the FCDB, which facilitates the eventual calculation of nutrient intakes when the data are externally linked to the FCDB. In the case of GloboDiet, the main reason for separating the comprehensive FCDB from the data collection software relates to its aim to be flexible for implementation in new country contexts. According to Slimani, an integrated FCDB would reduce this flexibility and increase the costs associated with adapting the tool to new settings.[47]

[45] Foster, E., Intake24 – Key Informant Interview, 2015.
[46] Biltoft-Jensen, A., Web-DAS – Key Informant Interview, 2015; Slimani, N., GloboDiet – Key Informant Interview, 2015.
[47] Slimani, N., GloboDiet – Key Informant Interview, 2015.

For those programs that are linked to an internal FCDB, the number of foods included varies widely from program to program. SNAPA includes 120 fully coded food and beverage items whereas myfood24 contains food composition data for approximately 45,000 UK-branded and generic foods (Carter, Albar et al., 2015; Hillier, Batterham et al., 2012). The specific search modalities used for foods, beverages, and mixed dishes within the system are discussed in Section 3.3.

Allows free text entry of foods not found within the food list

Twelve of the 19 programs assessed allow respondents or interviewers to create free-text entries for foods not found within the food list (AMPM, ASA24, CANAA-W, GloboDiet, HELENA-DIAT, Intake24, NDSR, NINA-DISH, PAC24, SNAP, Web-DAS, and YANA-C). Generally, users may create temporary records for food items not found within the system. These records are then either automatically coded by the system (termed "autocoding") or manually assigned codes after being reviewed by researchers.

ASA24 provides an example of the first scenario (i.e., autocoding of new records for foods not found within the food list). The ASA24 respondents who cannot find a food or drink within the food list can provide details in the "unfound food" field. The system will then ask a series of general questions to attempt to identify the food (Zimmerman, Potischman et al., 2015). There is also an "other, specify" field for respondents to provide food details, such as brand name or cooking method, that differ from the responses offered by ASA24 (Zimmerman, Potischman et al., 2015). In both cases, the software assigns default food codes to answers provided by respondents. Foods that are entered by text and then autocoded by the system are flagged in the output files. This feature allows researchers the opportunity to correct discrepancies later if they so choose.[48]

GloboDiet and NDSR rely on review and manual coding for new entries to the food list. GloboDiet automatically flags all new temporary records created by interviewers when a food not found within the food list is reported. This is a quality control mechanism that prevents the creation of duplicate records. Duplication may occur if, for instance, an interviewer cannot not find a food in the food list and suggests to software administrators that this food should be added when in fact the food is already listed, perhaps under a category the interviewer did not check. This situation is a problem because errors may be introduced if duplicate foods are coded differently. In the case of GloboDiet, all temporary records for new foods, recipes, or supplements are flagged and reviewed by researchers. If, upon review, the record is determined to be unique then a new record is subsequently created and entered into the food list (Crispim, Nicolas et al., 2014). NDSR Interviewers use the "Missing Food" window and fill out details about the food. A New Food request form is later filled out and sent to the Nutrition Coordinating Center, the organizational home of the NDSR. Administrators periodically add foods to the NDSR food list and food composition database.

Myfood24 and DietDay do not allow free text entry of items not found within the food list. Respondents must select from pre-defined food and beverage options. Intake24 currently contains a free text field for entry of foods that respondents cannot find in the food list but the eventual goal is to make all responses in the system pre-defined and autocoded.[49] Generally, the prevention of open-ended text fields is a means of quality control, but it also limits flexibility and may result in data being lost.

[48] Subar, F. ASA24 – personal communication, 2016.
[49] Foster, E., Intake24 – Key Informant Interview, 2015.

Designed to facilitate adaptation to new settings

The vast majority of 24-hour recall software that exist has been developed for application in highly-specific contexts, meaning they are not readily adaptable to new settings. ASA24, GloboDiet, HELENA-DIAT, myfood24, and Web-DAS are the five programs assessed that have been designed for application across multiple countries. The features that facilitate adaptation are described in Section 3.3.

Digital display of food photographs for portion size estimation

Twelve of the assessed programs used digital photos as portion size estimation aids (ASA24, CANAA-W, CAPIS, DietDay, GloboDiet, HELENA-DIAT, IMM, Intake24, myfood24, PAC24, Web-DAS, and YANA-C). In addition to use of digital photos, dietary assessment software commonly provide a number of alternative options for estimating quantities of foods consumed. For example, GloboDiet allows respondents to report foods consumed using six different quantification methods: digital photos of foods or shapes, household measurements, standard units (e.g., small, medium, large), standard portions, direct reporting of known gram or volume amounts consumed, and an 'unknown' method to provide a standardized option when the amount consumed is unknown (Slimani, Deharveng et al., 1999).

None of the software reviewed relied on digital photos as food identification aids; in every instance photos were used exclusively as portion size estimation aids. The literature review on portion size estimation describes the validity and feasibility of a range of portion size estimation aids, including digital photos, in low-income countries (see **PSEA Review**).

Straightforward to use (develop, adapt, train to use, and use during an interview)

Though the development of a tool that is straightforward to use and straightforward to train others to use is an essential criterion for the INDDEX platform, results data for this criterion do not appear in **Table 6** due to the scarcity of published information addressing this issue and the challenge that key informants had in quantifying their answers. Some key informants were able to report the time required per respondent to complete the 24-hour recall interview using the software. Time requirements varied widely from 10 to 45 minutes and did not appear to be longer or shorter depending on the administration mode.

GloboDiet is the only software for which information could be found on the total time required to develop the software for use in a dietary survey, from the preparation to the analysis phase. Research by Ocke et al. detailed the time required to adapt and use GloboDiet in a new country setting (Ocke, Slimani et al., 2011) (see **Table 7**). The authors state that the "requirements to use [GloboDiet] in terms of number of personnel, expertise and time needed for all steps of a survey are high. This is partly because [GloboDiet] collects dietary information with a lot of details and partly because the steps of processing of the consumption data cannot be fully automated yet." The INDDEX Project will need to consider whether these high adaptation and usage requirements are feasible for low-income country contexts.

Table 7. GloboDiet: Indications of time spent on preparation of databases, conducting interviews, cleaning and linkage with nutrient databases (Ocke, Slimani et al., 2011).

Task	Time needed
Preparation of GloboDiet databases for a new project	**10-15 person-months** for a new country-specific GloboDiet version; **2-6 person-months** for an update of a country-specific GloboDiet version
Conducting interviews	25-45 minutes per interview
Data cleaning	30-50 minutes per interview
Merge with nutrient database and extension of nutrient database	2 person-months for 200 interview; 12 person-months for 2500 interviews (if not done before)

The published literature offers few details on the time and cost of training requirements for interviewer-administered software. Two interviewer-administered programs have information available on training needs and approaches: NDSR and GloboDiet. The Nutrition Coordinating Center (NCC), the organizational home of the NDSR software, offers a two-day, on-site training and certification workshop. The workshop content includes individual and group practice using the software, an orientation to the NCC Food and Nutrient Database, and dietary recall quality assurance.

The International Agency for Research on Cancer (IARC) has developed an extensive e-training infrastructure to orient users to its GloboDiet software. The e-trainings are comprised of basic modules to introduce new users to GloboDiet and refresher modules for experienced users. Countries that are beginning the process of adapting the software receive in-depth training lasting between two to three weeks, depending on the degree of technical capacity within the country.[50] The initial trainings focus on how to prepare the country specific food and recipe databases.

After the country-specific software has been prepared, a five-day training of trainers, defined as a training of individuals who will conduct and facilitate the local trainings, is held. The trainers receive all the materials needed to conduct the training of local interviewers, who are usually dietitians or nutritionists (Huybrechts, Casagrande et al., 2011; Ocke, Slimani et al., 2011). Due to the large amounts of information disseminated during the training period, the trainings are broken up into separate sessions. The first training consists of an online module and practice session. This session is followed by a 3-day onsite training at IARC headquarters and concludes with a one-day training in the trainers' home countries.

Though difficult to systematically rate the software reviewed as either straightforward to use or not, several features that appear to improve usability are listed in Section 3.3. After INDDEX researchers are able to test the demonstration versions of the software in August 2015 they will have a better understanding of the ease with which the software may be used by interviewers in low-income countries.

Low cost

There is little published information on the costs associated with the development, adaptation, and application of technology-assisted 24-hour recall programs. Key informants stated that activities required to adapt the software to new settings were particularly time-intensive and thus represent a significant cost in terms of labor requirements. These activities include development of country-specific

[50] Slimani, N., GloboDiet – Key Informant Interview, 2015.

portion size estimation aids (e.g., creation of digital photos for country-specific foods and mixed dishes) and, most notably, updates to the software's food composition database. Key informants also emphasized that the resources needed for adaptation of any given software to a new setting are heavily dependent on the baseline capacity of countries to adapt the tool.

3.3. Specific Features of Available Software for Consideration by INDDEX (Objective 1.3)

Elaborating on additional features of the software programs reviewed during the landscape assessment may help to inform the design choices for the INDDEX dietary assessment platform. These features have been grouped into five main categories – adaptation features, quality control features, data entry time-savers, search features, and troubleshooting features – and are listed below.

Adaptation features

As mentioned in Section 3.2, only five of the 19 assessed programs (ASA24, HELENA-DIAT, GloboDiet, myfood24, and Web-DAS) are specifically designed to be adaptable to different country contexts. The section below presents an overview of each program's features that facilitate adaptation.

ASA24 adaptation features

- ASA24 has been designed for database and language adaptation[51]. In order to translate ASA24, the script for the interface text is replaced with a translated version. The program is available in the U.S. in both English and Spanish versions. A Canadian version of ASA24 is available in English and French. An Australian version of the program is also in development.
- Currently, when researchers log into the ASA24 Researcher website to register a study, they have the option to use the English or Spanish versions of the American ASA24 or the English or French versions of the Canadian ASA24. Once the Australian version is complete, it will be added to this list of options.
- In order to create a country-specific version of ASA24, researchers must create and upload their own context-specific food list, nutrient database, probe database. Portion sizes of foods listed within the nutrient database must be adapted to the given context and coded appropriately. If not currently available, appropriate photographic portion sizes estimation aids should be developed and uploaded.

HELENA-DIAT[52] adaptation features

- HELENA-DIAT is especially formulated to be translatable to multiple languages. It contains an open translation engine, which permits 10 countries and languages to participate. The program is described as "easy-to-handle" and has an "easily maintainable definition system was developed using standard XLS-files for definition of the different screens, menu structure and food items" (Vereecken, Covents et al., 2008).
- A protocol for the creation of country-specific food lists and food photographs to use as portion size estimation aids was created and disseminated to partners.

[51] Subar, A. ASA24 – Personal communication, 2016.
[52] HELENA-DIAT was created for use during the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) Project. It is not clear whether the software will continue to be used now that the HELENA Project has concluded.

- All 10 countries that participated in the HELENA Project were able to access and contribute to a central database of generic and country-specific food photographs. The photos were used as portion size estimation aids. Vereecken, Covents et al. (2008) do not provide any further details on the protocol used to create the food photographs.
- HELENA-DIAT does not provide the option to link to a variety of country-specific FCDBs. Instead the software contains one FCDB: the German Food Code and Nutrient Database. The current iteration is BLS (Bundeslebensmittelschlüssel) version II.3.1, 2005. To calculate energy and nutrient intakes "culture-specific composite dishes were disaggregated into their basic food components, all of which were available in the German database" (Vereecken, Covents et al., 2008). This approach is advantageous in that it removes the need for the FCDB to contain a number of country-specific mixed dishes; however, all ingredients for culture-specific food dishes must already be in the FCDB for the advantages of this approach to be realized. The disadvantage is that the amount of each ingredient in mixed dishes is usually estimated incorrectly which introduces errors. Furthermore, this approach precludes analysis of food consumption patterns of mixed dishes and only allows analysis of consumption patterns for individual ingredients (Gibson, 2015).

GloboDiet adaptation features

- Originally developed for use in the European Prospective Investigation on Cancer (EPIC) Study, GloboDiet has recently been adapted for application outside of Europe. It is in the process of being adapted for use in Mexico and Brazil and has recently been adapted for use in Korea (Park, Park et al., 2015).
- GloboDiet is a highly standardized data collection tool. Each country-specific version of GloboDiet is comprised of approximately 70 different common and country-specific databases. The databases cover foods, recipes, dietary supplements, basic food composition data (e.g., energy, protein, carbohydrate, and fat), quantification methods, and coefficients used to convert the amount of reported foods or recipes to the net quantity consumed (e.g. cooked without edible part) (Crispim, Nicolas et al., 2014).
- Ocke et al. have outlined the features of GloboDiet that are common across countries and those that are country-specific and therefore require adaptation for use in a new country where it has not been used before (Ocke, Slimani et al., 2011). These features are summarized in **Table 8**.

Table 8. Standardized and country-specific features of GloboDiet (adapted from Ocke, Slimani et al., 2011).

Aspects in GloboDiet that are standardized across countries within a given project	Aspects in GloboDiet that are country specific
Steps in which interview is conducted.	---
Types of products considered to be foods; types of products considered to be recipes.	Recipes that can be changed/adapted and which cannot, and ingredients that can be changed/substituted.
Standardized food and recipe grouping system.	Lists with available foods, recipes, dietary supplements and their numeric coding.
A standardized level of detail in which foods that belong to the same food group are described using facets (a series of questions) and descriptors (their pre-entered possible answers).	Applicability and necessity of assigning a facet to a food.
The available six types of portion size estimation (photo series, bread shapes, household measures, standard units, standard portions, grams and milliliters), and an additional 'portion of whole-known recipe' proposed only when the recipe is known.	The assignment of the available quantification methods to foods and recipes, the amount for each unit, bread shapes and household measures.
Standardized food photographs to estimate portion sizes for selected foods.	The choice of photographs.
Standardized algorithms to calculate grams as consumed and grams of raw food from the provided information that may be expressed differently.	Coefficients used in the algorithms (raw to cooked, edible part, fat absorption, density, percentage fat/sauce/sweetener added after preparation).
Standardized handling of fat used for food preparation	Fat-absorption coefficients
Possibility to export data in grams of foods in consumed state or as raw (with and without inedible part).	---
Systematic quality controls.	Maximum quantities of foods that are checked, list of potentially forgotten foods to be checked.
Algorithms to calculate too high or too low energy intake and macronutrient intake.	---
Data storage and export according to a common format.	
---	Face-to-face or telephone administration.

myfood24 adaptation features

- Myfood24 is a recently developed online 24-hour dietary assessment tool originally designed for use in the UK population.
- The key feature that facilitates adaptation is its ability to incorporate a range of different national food composition databases (Carter, Albar et al., 2015). This feature allows "the researcher to determine which food composition databases will be displayed in the myfood24 food search (i.e., the accompanying food list) so that databases for different countries can be made available with relative ease" (Carter, Albar et al., 2015).
- Currently, the program contains three FCDBs – two for the UK and AusNut, Australia's national FCDB.
- Myfood24 contains a very flat interface, meaning the program includes minimal text and prompts. Usability testing revealed that respondents preferred a flat interface design as opposed to a multi-layered format.[53] The interface design therefore facilitates adaptation to new contexts since there is limited amount of text to adapt/translate. Though this interface design may ease the process of adaptation, it may not be appropriate for the INDDEX platform,

[53] Carter, M., Measure Your Food On One Day (myfood24) – Key Informant Interview, 2015.

which favors a multilayered question format and use of a number of prompts, which would need to be translated and adapted for the consumption patterns of different settings.

Web-DAS adaptation features

- Web-DAS permits researchers to easily create a new food list or modify an existing list. The food list can be created in Excel, saved as a text file, and then imported into the program using the administration module[54].
- The administration module allows researchers to set up new projects (i.e., new dietary assessment surveys). From here researchers can import new food lists, the list of respondents to be surveyed, context-specific portion size images, and set the design of the interface, registration days, and reminder emails.
- The program allows for text display in a range of languages. For instance, the program has been used in Danish, Norwegian, and English.

Quality control features

The different programs reviewed in the landscape assessment adopted a range of quality control features that may be useful to the INDDEX platform:

- The program's time stamp of the start time and completion time of the 24-hour recall can be used for quality control purposes. Researchers can compare the average length of recall interviews across interviewers and flag unusually short interviews for follow-up. An unusually short interview may indicate that the interviewer is rushing through the recall with respondents.
- The program can be designed to prevent users from progressing to next stage of the recall unless all necessary information has been entered (AMPM, ASA24).
- Alternatively, the program can display a warning message if an interviewer attempts to move on to the next question without providing all necessary information (GloboDiet and NDSR have this feature). NDSR indicates foods with insufficient descriptive information with a blue question mark to the left of the food. Once an interviewer has completely described a food, NDSR replaces the question mark with a green check mark to the left of each completed item (Nutrition Data System for Research, 2014).
- Prompts are used throughout the 24-hour recall interview to ensure completeness of data collection. Prompts are used in the following situations:
    - When food entries with no beverage are reported (CANAA-W, HELENA-DIAT, YANA-C).
    - When a food commonly eaten in combination with other foods is reported as eaten alone (ASA24, CANAA-W, HELENA-DIAT, Intake24, myfood24, YANA-C).
    - When a long gap of time without eating is reported (ASA24).
    - When commonly forgotten foods are not reported by the last pass of the 24-hour recall (ASA24, HELENA-DIAT, Intake24, myfood24, SNAPA, Web-DAS, YANA-C). During the final review, HELENA-DIAT searches entries for frequently forgotten items. A prompt then appears on the screen asking the user if they forgot to report any commonly omitted items.

[54] Biltoft-Jensen, A. Web-DAS – Key Informant Interview, 2015.

Data entry time savers

The landscape assessment identified four types of features that are used by 24-hour recall software to reduce data entry requirements: pre-fill, copy and paste, drag and drop, and favorites. Pre-fill and drag and drop features seem to improve the efficiency of data entry without introducing large potential sources of error. On the other hand, copy and paste and favorites features may introduce errors by masking variation in foods consumed or quantities of foods consumed. Skilled interviewers can mitigate the risk of error by determining whether there was any discrepancy in the food's preparation method, added ingredients, or quantity before an entry is copied. Alternatively, the program can minimize error by prompting interviewers or respondents to re-enter portion sizes and any added ingredients to the food.

Pre-fill

- AMPM contains a pre-fill feature to reduce interviewer and respondent burden: "'Pre-fills' are based on the descriptive detail implied in the food name. In the example for juice, when a respondent reports consuming ''juice'' during step 1, the question ''What kind was it?'' is asked during step 4. However, if ''orange juice'' is reported during step 1, the answer to the question ''What kind was it?'' is pre-filled with ''Orange'' and that question is not asked" (Raper, Perloff et al., 2004).

Drag and Drop

- If a user realizes that he/she has reported a food consumed during the wrong mealtime they can use the "drag and drop" feature in myfood24 and drag the item to the appropriate time slot.

Copy and Paste

- A number of software programs contain a copy and paste feature (AMPM, ASA24, CAPIS, DietDay, GloboDiet, Intake24, myfood24, NDSR, Web-DAS).
- The programs differ according to whether the portion size information is also copied. GloboDiet and ASA24 require that users re-enter portion size information when an item is copied. In some programs, such as myfood24, the food and portion size are copied but the user must re-enter accompaniments.

Favorites

- The "favorites" feature is similar to copy and paste. It allows a user to create a list of commonly consumed foods or beverages, accompaniments, and portion sizes. It is most commonly found in self-administered programs and is especially useful if multiple recalls are collected per respondent or if a respondent consumes a similar meal or beverage several times a day.
- DietDay contains a "Fast Track meal" option (Arab, 2013). This option allows respondents to customize and pre-record meals for speedy daily entry, for example one cup of coffee with two tablespoons of cream and one teaspoon of sugar.
- ASA24, myfood24, and Intake24 also contain "Favorites" features (called "Recently used" in myfood24 and "Same as before" in Intake24).

Search features

A number of different search features were identified during the landscape assessment of 24-hour recall programs:

- Most of the assessed software allows users to search and browse by food group or recipe category. Programs containing large numbers of brand name foods, such as AMPM and myfood24, also allow users to search by brand. Search results typically display in the same search window; however, AMPM displays lengthy search results in a separate pop-up window to make it easier to scroll through items.
- Myfood24 contains a search feature built into the quick list. Called “Make a List,” this feature allows users to list everything consumed in the previous 24 hours using free text. Once completed, the search function works its way through this list to find the appropriate food item in the database (Carter, Albar et al., 2015).
- Several programs contain correction algorithms to automatically recognize misspelled search terms (Intake24, NDSR, PAC24, Web-DAS).
- HELENA-DIAT allows users to search for foods without typing in the full name of the food item in the search bar. For example, a search for “pine” will return “pineapple” as a search result (González-Gross, de Henauw et al., 2013).
- Over time Intake24 has improved its food lookup system to refine the precision of search results. The result of these improvements has meant that the system is more tolerant to searches that contain unnecessary information (e.g., “a plate of chips” instead of just “chips”), misspelled words and synonyms including regional food names (Food Standards Agency/Newcastle University, 2013). As part of the Intake24 food lookup system:
    - A large number of combinations of word interpretations is analyzed (including various combinations of synonyms);
    - The word ordering and the inter-word distance are taken into account to show the foods whose descriptions are most similar to the user input;
    - The limitations on the number of possible combinations, number of possible word interpretations, etc. are not fixed and can be changed to fine-tune the performance of the system;
    - Phrases that look like multiple foods are automatically split (e.g., for "fish and chips" the system will suggest two separate dishes: “fish” and “chips,” rather than suggesting only one; and
    - Look up results are sorted based on popularity of individual foods rather than their alphabetical ordering. This results in the more popular foods always being towards the top of the search result list (Food Standards Agency/Newcastle University, 2013).
- The Intake24 system logs terms that are entered into the search bar.[55] This log is useful for identifying new foods that should be added to the FCDB and for identifying regional terms for foods.

[55] Foster, E., Intake24 – Key Informant Interview, 2015.

Troubleshooting

The following is a list of troubleshooting features that INDDEX may wish to consider for its dietary assessment software:

- Include links to the user manual and Frequently Asked Questions (FAQs) in the data collection tool. ASA24 contains a "Help" button visible on the top right corner of the screen. When selected, a list of FAQs loads.
- Consider mouseovers and hover text in places where additional clarifying information may be beneficial to interviewers.
- Make accessible a telephone number that interviewers can call for troubleshooting assistance. This feature proved very useful during data collection using the Web-DAS.[56] Though logistical issues such as time zone differences and mobile phone network coverage may render this approach impractical, interviewers may prefer to make a quick phone call rather than browse through a document in order to resolve technological issues.
- Publicize known bugs in the program and possible workarounds. The NCI website on ASA24 includes a link to information on "Known Issues and Workarounds," NCI also maintains a list of known database errors with corresponding notifications when the issue has been corrected.
- Ensure that autosave can be enabled. GloboDiet contains an automatic procedure whereby previously entered data are saved and recoverable in the event of a computer crash. The interviewer can then resume the data collection with the recovered data.[57]

4. Conclusions and Next Steps

This document reviewed available 24-hour recall programs against priority technical criteria for low-income country contexts and highlighted details of certain technical features, including those related to quality control, troubleshooting, efficiency of data entry, and searching of the food composition databases, that that are worth further consideration as INDDEX progresses with the development of a technology-assisted dietary assessment platform.

The review of available technology-assisted 24-hour recall programs highlights a gap in programs designed for the needs of low-income countries. Most of the programs reviewed were created for application in high-income countries and none meets all of INDDEX's priority technical criteria. Technical features that facilitate adaptation to a range of country contexts are noticeably absent among most available programs; only ASA24, GloboDiet, HELENA-DIAT, myfood24, and Web-DAS have the flexibility to be used across multiple countries and thus far, they have been applied only in high- and middle-income countries. Though GloboDiet meets more of the priority criteria than most of the other programs (except ASA24, which also met nine out of the ten criteria evaluated in **Table 6**), initial information about the time-cost of adaptation and flexibility of the program suggests that it may not be a preferred option for use in low-income country contexts.

[56] Biltoft-Jensen, A., Web-DAS – Key Informant Interview, 2015.
[57] Slimani, N., GloboDiet – Key Informant Interview, 2015.

Next steps in the process are expected to include:

1. Confirm with the INDDEX technical advisory group (TAG) that INDDEX should proceed according to its priority technical criteria.
2. Test the demonstration versions of the software programs, where possible, to better assess user-friendliness for the context of a low-income country and to identify potentially useful features.
3. Determine, with input from the full INDDEX team and the TAG, whether INDDEX should aim to develop a new dietary assessment platform that meets all criteria or modify or adapt one that already exists.
4. Solicit feedback from the TAG regarding additional features and specifications that should be included in the platform.
5. Identify potential trade-offs in desired criteria and prioritize accordingly.
6. Consult the Micronutrient Initiative review for additional information on useful features of diet data processing platforms and consider how data collection and processing can be seamlessly integrated.
7. Determine what additional information (e.g., food habits, activity levels) should be collected alongside the 24-hour recall.
8. Consider how the Food and Agriculture Organization of the United Nations, the preferred institutional home for the platform, should shape the design of the platform (process and product).
9. Develop and issue a request for proposal to identify a suitable information technology partner to collaborate in developing the dietary assessment platform.

Annex 1: Tools for Processing Food Intake Data

Introduction

Food intake processing tools are a critical link in the dietary assessment process. Tools developed for processing food intake data, when designed well, allow for efficient transformation (and sometimes subsequent analysis) of the food intake data into the nutrient equivalent and the production of key food and nutrient-related variables. Currently the Micronutrient Initiative is conducting a comprehensive review of tools for processing and analyzing food intake data. The INDDEX Project team will carefully review their findings when they become available and incorporate them into plans for the INDDEX dietary assessment and processing platform. Though the primary focus of this landscape assessment is on dietary data *collection* programs, a brief review of existing tools for processing food intake data was necessary in order to provide a sense of the possible processing elements to eventually include in the INDDEX software. Illustrative examples of three specific tools for processing food intake data are described below and will be further augmented by the results of the Micronutrient Initiative's review. The TAG is invited to provide feedback on any additional processing and analysis platforms that would be worthy of consideration as INDDEX develops the processing components of its dietary assessment platform.

Results: Processing Tools

The three food intake processing programs that are discussed here, as demonstrative examples, are CSDietary, Lucille, and IMAPP. These processing programs were chosen as illustrative examples of different types of nutrient data processing tools. CSDietary and Lucille are largely designed to manage 24-hour recall dietary assessment data and allow the user to clean the data and prepare them for analysis. In addition, CSDietary contains some data analysis functionality. IMAPP on the other hand is designed to assess dietary adequacy, implementation, and evaluation of fortification programs.

CSDietary (v1.11)

CSDietary, developed by HarvestPlus of the International Food Policy Research Institute (IFPRI), is a computer software program designed to manage 24-hour recall data. The software simplifies the entry and management of individual dietary data by automatically cleaning and processing the data in order to quickly return reliable nutrient intake information. Five external datasets support the software: a food composition table, standard recipes, retention factors, food groups, and measurement conversion factors. The software comes pre-installed with Excel templates for each of the five datasets, which must be updated with information relevant to the context and specific dietary assessment procedures prior to entering the 24-hour recall data. The datasets must be in comma separated value (CSV) format and follow the same format as the templates. Once these files are updated and loaded into the software, data can be entered and reports immediately generated. The software generates two reports: the short-report provides the averaged nutrient intake of total foods consumed for each subject and the long-report provides the nutrient content from each individual food consumed. Several key features of the program include: the ability to integrate most food composition tables and portion size estimation methods; quality checks to ensure data are correctly entered; and an immediate report of nutrient intakes upon completion of data entry with percent of nutrient intakes from

pre-coded food groups (International Food Policy Research Institute, 2011). CSDietary is free to use and is designed to run on a personal computer. The software can easily be transferred to a computer via a thumb drive or downloaded from the web via a 9MB installer file. Version 2 of CSDietary is currently under development. Version 2 will attempt to eradicate known bugs, improve the performance of the software and user interface, and explore ways in which the software can be used on tablets with the goal of having a fully functional program that will allow users to collect data on a tablet. Currently, a challenge to collecting the data via the CSDietary software is that the software is designed for data entry and proceeds horizontally. In order to accommodate data collection (not just data entry) using the multi-pass 24-hour recall method, the software would need to flow vertically. A further challenge to running the software on a tablet is that the software requires many databases to be open at one time, which tablets often cannot support. Efforts are under way to address these challenges (International Food Policy Research Institute, 2011). [58] The current software can be downloaded at ftp://ftp.cgiar.org/ifpri/MouradM/DietaryInstallJan142010.zip. The INDDEX team plans to contact Dr. Moursi to remain apprised of updates to version 2 and any additional plans for modifications to the software.

Lucille

Lucille, developed at the University of Ghent, was designed to process quantified food intake data primarily from 24-hour recall surveys and weighed food records. The software is designed for the user to upload and define his/her own food composition table and does not impose any criteria on the number or type of nutrient information available for each food. Lucille is strictly a data management program; unlike CSDietary it does not generate any indicators of food or nutrient intake within the program itself (Universiteit Gent Department of Food Safety and Food Quality, 2014a).

The Lucille software was developed for Mozilla Firefox but runs on all major browsers (e.g., Internet Explorer, Google Chrome). There are two versions of Lucille. One version is made to run online, and all data is secure, stored and backed-up on the University of Ghent server. This version requires users to have a reliable Internet connection. The other version can be used offline, and in this case all data is stored on the user's personal computer. There are important differences between the offline and online versions of the software, in terms of users' ability to share and edit the data. The online version, housed at the University of Ghent, allows multiple users to enter data at the same time and to see real-time updates of the other users' work on that same data, while the offline version, housed on the user's personal computer, only allows the person using the computer to access the modified data. It is therefore more difficult to share the data and ongoing edits with others (e.g., colleagues). However, it is possible to set-up a local network with the offline version, which allows the computer with the Lucille program to essentially operate as a server for other users of the database, thus allowing multiple users to access the database at once (Universiteit Gent Department of Food Safety and Food Quality, 2014b).

Once all information has been entered, the program generates a raw data file in a CSV format, which is designed to enable users to specify additional variables in a food intake survey (e.g., place of preparation of each food consumed, price). Therefore further processing of the data

[58] Moursi, M., personal communication, 2014.

and related analyses, such as generating summary statistics, need to be carried out in another software program such as Stata, SPSS, or Excel. Lucille is still evolving; however, it is fully operational and has been used to manage data from large food intake studies. While the software is specifically designed to manage quantified food intake data derived mainly from 24-hour recalls and weighed food records, with some modifications it might be able to process food frequency data (Universiteit Gent Department of Food Safety and Food Quality, 2014a). To navigate the software with a guest account, or for other related questions, contact Carl.Lachat@UGent.be.

IMAPP

The World Health Organization (WHO) developed the Intake Monitoring, Assessment and Planning Program (IMAPP) software with researchers from Iowa State University, University of Hawaii and the University of California Davis (Iowa State University, 2015). IMAPP has three main uses: 1.) to assess group intake data in terms of the prevalence of inadequate and excessive intakes; 2.) to estimate whether a given fortification strategy will be safe and effective for all population groups consuming a fortified food vehicle; and 3.) to enable practitioners to choose between different fortification strategies on the basis of safety (i.e., proportion of people with usual intakes below the upper intake level) and efficacy (World Health Organization, 2011).

IMAPP uses the PC-SIDE (Software for Intake Distribution Estimation) engine, which was developed by researchers in the Department of Statistics at Iowa State University in 2001. IMAPP can do everything that PC-SIDE does including remove the within-person variance from the daily intakes; adjust the daily intake for the effects of the day of the week, seasonality, other factors that affect nutrient intakes; estimate usual intake distributions; estimate prevalence of inadequate or excessive intakes of nutrients; and use survey weights to produce unbiased estimates of means, variances, and percentiles. IMAPP requires individual level data to be available for: 1.) daily dietary intake (e.g., from 24-hour recalls or food records); 2.) age, gender and reproductive status (e.g., pregnant, lactating, or neither); 3.) nutrient intakes as well as daily intakes of potential food vehicles for each person[59]; 4.) two or more days of dietary data for at least a representative subsample (otherwise default values are suggested for day-to-day variance estimates); 5.) body weight (in kilograms) to assess protein intake (otherwise default weight values are suggested); and 6.) bioavailability factors for iron and zinc supplied by user (otherwise default values are suggested) (Carriquiry & Osthus, 2012).

IMAPP uses average nutrient requirements based on the USA and Canada's estimated average requirements (EARs) and the WHO/FAO recommended nutrient intakes (World Health Organization, 2011). The upper nutrient levels are based primarily on the upper tolerable intake level from dietary reference intakes. The user can adopt these default values (developed for each gender, age, reproductive status group) or can input values. The beta version of IMAPP became available in December 2010 (World Health Organization, 2011). More information on the program can be found by contacting micronutrients@who.int and the software can be downloaded here: http://www.side.stat.iastate.edu/imapp.php.

[59] The user can select, for example, the bioavailability of dietary iron and of iron used to fortify, the form of the nutrient (e.g., folate or folic acid), the DRIs for the nutrient, if different from the default.

Annex 2: Specifications for 24-hour Recall Software for Low-Income Countries (Rosalind Gibson)

General Prerequisites of an Interviewer-Administered 24-Hour Recall Interview Program

- The application must operate offline on a laptop or large tablet.
- The interview should follow the four-stage multiple-pass method:
    - Pass 1: Record a quick list of foods and dietary supplements consumed;
    - Pass 2: Record a complete description of each food and beverage;
    - Pass 3: Record the amount of each food; and
    - Pass 4: Review the whole day and allow changes and additions of any forgotten items.
- The program should use language accessible to a general audience and avoid using professional names for foods (e.g., poultry, fats).
- The program should have a single-user interface with all activities (including but not limited to free text entry, identifying foods in a database, portion size estimation) occurring within a single screen to enhance consistency. Intake24 uses a flat user interface design without overlapping windows, which enhances its usability and reduces the amount of time it takes to complete the recall.
- Foods should be entered sequentially as they were consumed: starting at 0:00 hours, one food at a time and with each food as a single record. Foods should be identified by the time of day instead of meals. The record ends at 23:59 hours.
- A navigation panel easily seen on one-side of the interface should map the progress of the interview (i.e., identify at which stage the interview is).
- The program must include an ‘undo’ function and allow the addition of foods in non-sequential order.
- The program should include ‘copy’ and paste’ functions for food entry. This is useful if the same food items are consumed over the day.
- The program should use the planned FAO international food composition database.
- Implementers should be able to customize portion size estimation photographs for contexts specific to countries or population groups (for example, Intake24 used a database tool in Java to facilitate this).
- Misspelled words should be automatically recognized without further user input by using correction algorithms (e.g., metaphone algorithm, GoogieSpell).
- The overall framework of the program should be in the English language; however, translation to other languages must be integral to program.
- The program should use food descriptions from the planned FAO international food composition database; the link will be via an alpha-numeric code for each food and ingredient consumed.
- After the interviewer has completed data collection for one subject, the data should be stored on the device. The program should allow re-initialization and the collection and saving of multiple recalls.
- A program function to transfer the stored multiple recalls to a centralized database through an internet connection must be available.

Preliminary information to be obtained and recorded at "start-up"

- Interviewer name.
- Respondent name, sex, ID number, and household GPS location.
- Day and date of interview (day/month/year).
- Record if the recall is for a weekday, a weekend day, a market day, or a feast day.
- Record whether the day's consumption is representative or not in relation to the amount of food consumed (e.g., below average, average, and above average); the options should be accessible from a drop-down menu; space to write text to provide reasons for choice.
- Record dietary supplement use and dosage from drop-down menu of photos of locally available products.
- Record frequency of supplement use (e.g., daily, weekly, monthly, or never).
- Record medication use from a drop-down menu of locally available medications (e.g., for malaria).
- Record source of drinking water from a drop-down menu of options.

Pass One: Quick List

- Quickly record a list of foods consumed by the subject. This quick list should start with the first food or beverage that the subject consumed, followed by others in chronological sequence.
- The time of each eating event should be recorded using 24-hour clock convention. Location of each eating event should also be recorded using a drop-down menu with options such as home, garden, field, neighbor, and other).
- The program should display the quick list in a window on one side of the screen and update it in real-time, so the interviewer and subject can review.

Pass Two: Detailed description of each food or beverage consumed

- The interviewer should prompt the subject to describe in detail the foods from the quick list, starting from the first food consumed, and match each item on the quick list to a description drawn from the planned FAO international food composition database. It is important to note that this database will likely have hundreds of food items indexed. Preparation and cooking methods should be included in this description. Some mixed dishes and complex foods (e.g., bread, biscuits, cakes, soup, and drinks) are considered single food items and should not be broken down to the ingredient-level. Other foods, such as "egg on toast" should be entered as discrete items ("egg" and "toast").
- The search tools that query the planned FAO international food composition database should allow the interviewer to search and browse an organized list (in alphabetical or categorical order) in case a recalled food item is not found in the database and an approximate match needs to be found.
- To ensure that the user includes all foods consumed, commonly-associated foods (e.g., relishes, spreads, milk on cereals and added to tea and coffee) should be linked to some food items and prompt the interviewer to ask if they were also consumed.
- The search tools should be tolerant to queries that contain irrelevant information (e.g., "plate of chips" instead of "chips"), misspelled words, and local food names and synonyms.

- The program should allow the user to record food items not found in search results; a decision on adding the food item to the database or substituting a generic food could be made later. However, the program should discourage recording food items not found by prompting the user to review.
- The program should be able identify food items that look like multiple items (e.g., fish and chips) and prompt the user to split them into discrete items.
- The program should allow the user to choose how search results are displayed: by popularity, alphabetical order, or food groups.
- The program should include a "same as before" function to enter foods consumed several times in one day.
- The program should prompt the user to record drinks with a meal. The program should also prompt the user to review long-periods of time during which no food items are recorded.

Pass Three: Portion size estimation

Estimations of food quantity depends on food type. The deployed method should depend on a variety factors: whether the food is liquid, solid, or amorphous; raw or cooked; with or without an inedible part. The quantity estimation method should be specified for every food in the planned FAO international food composition database.

Photographic methods of estimating portion sizes of foods

- Professionally taken photos of food items should be used in conjunction with age-specific portion sizes based on national survey data, when available. Many food items will need photographs specific to the regional context.
- Vertical aerial photos with a scale, rather than angled photographs, should be used to estimate portion size.
- Photographs of food items should depict the food as it may be served to the subject (i.e., in a bowl, glass, or plate) to increase accuracy.
- The program should simultaneously display photos of different portion sizes (seven in total), rather than sequentially. One portion size should be displayed with the weight in grams; thumbnail images with different portion sizes arranged by increasing size (UKIntake24 used seven) should be located at the side of bottom of the screen for the user to choose.
- Sizes of different portions should range from fifth to 95th percentile of served weights. This should be based on data collected from specific age and sex groups during a national survey, when available.
- Sizes should be calculated in equal increments on a logarithmic scale.
- All seven food photographs should depict the same food preparation styles; not different preparation styles.

Photographic methods of estimating portion sizes of foods using household measures, cans, and packets.

- For foods usually served or sold as pre-packaged or in predetermined amounts (e.g., yogurt, cooking oil, bags of chips), food photographs should represent a variety of commonly available local portion sizes. These photos are termed 'guide photographs.'
- For spreads (e.g., jam) and condiments (e.g., MSG, salt, sugar), photos should use country-specific spoons with thumbnail images of them filled to various levels.

- For beverages, use country-specific household measures (e.g., cups, mugs, glasses) with the various sizes and shapes in seven thumbnail images. Provide the user a dynamic function to "fill" the cup to estimate the exact volume and weight consumed.
- For canned foods, use photos featuring a range of country-specific can shapes, colors, sizes, and food types. The featured varieties can be featured altogether in a single image.
- For takeaway cups, photos of both hot and cold drinks and seven different cup sizes should be included.
- For foods rarely consumed, photos of household measures should be used.
- For mixed dishes (e.g., salads, sandwiches, fried rice, stir fried Asian foods), incorporate a subroutine during which the user is asked a series of questions to list out the dish components. The questions must then guide the user through estimating each component portion. If component portion sizes are unknown, a generic option should be available and selected.
- For young children, consider estimating the served portion size, as well as the leftovers, instead of the portion consumed. If incorporated, consider how the size of the leftovers will be addressed (see UK SCRAN24 for an example). An alternative prompt could use the question "Did you leave any of your food?"

Pass four: Display of overall intake for checking

- The program should generate a summary of consumed foods with missing information on quantities highlighted to allow corrections during the interview.
- Food quantities should have predefined ages to prompt the user to check on outlier values.
- The program should check for proportionate energy intake with the subject's age, sex, and weight.

Saved information for each 24-hour recall

- The program should save the preliminary information on the subject collected at the start of the 24-hour recall in an XLS format file.
- For each food consumed, the spreadsheet in which the information is saved should contain the following fields: subject ID, the time of consumption, the food group to which it belongs, the corresponding food code from the planned FAO food database, the food description, and the amount consumed in milliliters or grams. There should be no fields left empty except in the case of user-specified foods (the corresponding food code will be absent).
- Every subject should be recorded on a discrete XLS file.

Offline, post-data collection processing. Conversion to gram equivalents and link to nutrient database.

Instructions must be provided to the national representatives to facilitate and standardize post-data collection processing. Following are notes on specifications:

- The program should use common algorithms to adjust for raw to cooked edible parts.

- The program should include algorithms to calculate fat absorbed by foods during cooking.
- The volume to weight conversions must be done using standardized conversion factors specific to each food (e.g., food density).
- Nutrient contribution calculations for mixed foods recipes should be done using nutrient yield and retention factors.
- Each food code used by the program must be linked to a country-specific nutrient database food code.
- Food group codes should be standardized across countries. A standardized method to assign food group codes to mixed recipes must be used; this is usually based on the principal ingredient in the recipe.
- Maintenance and update of food composition databases should be centralized.

Once the post-data collection processing is complete, including conversion from volume to mass (milliliters to grams), the instructions to the national representatives should allow them to calculate the amount of food and nutrients consumed by food item and food group. The instructions should also allow the national representatives to calculate these measures by meal and day for each user. From these, food frequency and dietary diversity can be generated. Nutrient and food group information for individual subjects and groups of subjects can be generated using a statistical analysis packages (e.g., SAS, SPSS, Stata); an add-on built into the program to do this is not required so long as post-data collection processing is completed carefully.

Data on intra-household food allocation, anthropometry, and physical activity could also be collected, but these measures are not specified in this document.

The above specification is based on the features in the UK Intake24 and EPIC SOFT programs: standardizing the interview using four-stage multiple-pass 24-hour recall, standardizing food descriptions, and portion size estimation using graduated photographs. The primary disadvantages of using such a sophisticated and exact procedure include increased level of difficulty, the time duration of the procedure, and the cost to generate. As noted, the graduated photographs must be country-specific, although the planned FAO international food database may allow use multiple countries.

Alternative Specification for a Simpler 24-Hour Recall Interview Program

An alternative interviewer-administered four-stage multiple-pass 24-hour recall interview would follow a more traditional pattern, but would use a standardized desktop computer, laptop, or tablet to replace paper forms.

General prerequisites of a simpler 24-hour recall Interview program

- The program must operate offline on a laptop or tablet.
- The interview should follow the four-stage multiple-pass method:
    - Pass 1: Record a quick list of foods and dietary supplements consumed;
    - Pass 2: Record a complete description of each food and beverage;
    - Pass 3: Record the amount of each food; and

    - Pass 4: Review the whole day and allow changes and additions of any forgotten items.
    - The program should use language accessible to a general audience and avoid using professional names for foods (e.g., poultry, fats).
- An in-country dietary assessment research should be responsible for compiling a local food composition database appropriate for the study group. The initial source of the local food composition database could be the planned FAO international food composition database; however, it must be bolstered using information collected through focus group discussions and literature review. The local database must include a detailed description of each food item, including preparation and cooking methods.
- Recipes for mixed dishes should be collected using conventional methods; however, the local food composition database should incorporate as many mixed dishes as possible to minimize the need to collect mixed dish data during recalls.

Preliminary values to be obtained and recorded at "start-up"

- Interviewer name.
- Respondent name, sex, ID number, and household GPS location.
- Day and date of interview (day/month/year).
- Record if the recall is for a weekday, a weekend day, a market day, or a feast day.
- Record whether the day's consumption is representative or not in relation to the amount of food consumed (e.g., below average, average, and above average); the options should be accessible from a drop-down menu; space to write text to provide reasons for choice.
- Record dietary supplement use and dosage from drop-down menu of photos of locally available products.
- Record frequency of supplement use (e.g., daily, weekly, monthly, or never).
- Record medication use from a drop-down menu of locally available medications (e.g., for malaria)
- Record source of drinking water from a drop-down menu of options.

Pass One: Quick List

- Quickly record a list of foods consumed by the subject. This quick list should start with the first food or beverage that the subject consumed, followed by others in chronological sequence.
- The time of each eating event should be recorded using 24-hour clock convention. Location of each eating event should also be recorded using a drop-down menu with options such as home, garden, field, neighbor, and other).

Pass Two: Detailed description of each food or beverage consumed

- At the beginning of Pass Two, the program should display the quick list generated during Pass One and prompt the user to review it for completeness (i.e., ask the subject if the list includes *all* food and drinks consumed during the 24-hour).
- The interviewer should then go through the quick list with the subject and ask for details for each of the foods consumed.
- The interview should then match each food item with the corresponding entry in the local food composition database and enter the food code into the record with the

description. It is recommended that the interviewer have a complete list of food codes on hand during Pass Two.

Pass Three: Portion size estimation

- During Pass Three, the interviewer should consider each food and, with the help of the subject, estimate the volume and weight of the consumed portion and add this to the entry.
- Portion size estimation should be performed by the interviewer in the subject's home using a variety of methods: weighing salted replicas of main cereal staples, weights of selected foods brought by the interviewer, household utensils calibrated with water and measuring cylinders, and estimating the volume of irregularly-shaped items using water displacement.
- An atlas of photographs featuring country-specific food items should also be used during Pass Three. Each photograph should show seven graduated portion sizes per food item per A4 page. The sizes of portions should range from fifth to 95th percentile of served weights. This should be based on data collected from specific age and sex groups during a national survey, when available.
- Sizes should be calculated in equal increments on a logarithmic scale.

Pass four: Recall of overall intake for checking

- The program should generate a summary of consumed foods with missing information on quantities highlighted to allow corrections during the interview.
- Food quantities should have predefined ages to prompt the user to check on outlier values.
- The program should check for proportionate energy intake with the subject's age, sex, and weight.

Saved information for each 24-hour recall

- The program should save the preliminary information on the subject collected at the start of the 24-hour recall in an XLS format file.
- For each food consumed, the spreadsheet in which the information is saved should contain the following fields: subject ID, the time of consumption, the food group to which it belongs, the corresponding food code from the planned FAO food database, the food description, and the amount consumed in milliliters or grams. There should be no fields left empty except in the case of user-specified foods (the corresponding food code will be absent).
- Every subject should be recorded on a discrete XLS file.

Offline, post-data collection processing. Conversion to gram equivalents and link to nutrient database.

Instructions must be provided to the national representatives to facilitate and standardize post-data collection processing. Following are notes on specifications:

- The program should use common algorithms to adjust for raw to cooked edible parts.
- The program should include algorithms to calculate fat absorbed by foods during cooking.

- The volume to weight conversions must be done using standardized conversion factors specific to each food (e.g., food density).
- Nutrient contribution calculations for mixed foods recipes should be done using nutrient yield and retention factors.
- Each food code used by the program must be linked to a local nutrient database food code.
- Food group codes should be standardized across countries. A standardized method to assign food group codes to mixed recipes must be used; this is usually based on the principal ingredient in the recipe.
- Maintenance and update of food composition databases should be conducted by the local national representative.

Once the post-data collection processing is complete, including conversion from volume to mass (milliliters to grams), the instructions to the national representatives should allow them to calculate the amount of food and nutrients consumed by food item and food group. The instructions should also allow the national representatives to calculate these measures by meal and day for each user. From these, food frequency and dietary diversity can be generated. Nutrient and food group information for individual subjects and groups of subjects can be generated using a statistical analysis packages (e.g., SAS, SPSS, Stata); an add-on built into the program to do this is not required so long as post-data collection processing is completed carefully.

Data on intra-household food allocation, anthropometry, and physical activity could also be collected, but these measures are not specified in this document.

The above specification is based on the features in the UK Intake24 and EPIC SOFT programs and the methods outlined Ferguson & Gibson, 2008: standardizing the interview using four-stage multiple-pass 24-hour recall, standardizing food descriptions, and portion size estimation using graduated photographs. The primary advantages of this simpler approach include cheaper costs and shorter development time for use in low-income countries.

Testing the 24-hour recall application

No matter which program design is selected, the following characteristics should be assessed in two low-income country settings in Africa and Asia:

- Feasibility and ease of use.
- Accuracy of portion size estimations.
- Reproducibility of the design to measure food and nutrient intakes.
- Relative validity of design to measure food and nutrient intakes compared to weighed records.
- Validity of system to measure energy intakes compared with energy expenditure using doubly-labeled water.

Annex 3: Key Informant Interviews and Personal Communications

Table 9. Key informant interviews.

Interviewee	Year	Program(s)	Interviewer
Lenore Arab	2015	DietDay	Brooke Colaiezzi
Tom Baranowski	2015	eButton, FiRRST4, CAAFE, and PAC24	Brooke Colaiezzi
Anja Biltoft-Jensen	2015	Web-DAS	Brooke Colaiezzi
Michelle Carter	2015	Measure Your Food On One Day (myfood24)	Brooke Colaiezzi
Maria Ana Carvalho	2015	PAC24	Brooke Colaiezzi
Vanessa Davies	2015	CAAFE	Brooke Colaiezzi
Emma Foster	2015	Intake24	Brooke Colaiezzi
Lisa Harnack	2015	Nutrition Data System for Research (NDSR)	Brooke Colaiezzi
Nadia Slimani	2015	GloboDiet	Brooke Colaiezzi
Amy Subar	2015	ASA24	Brooke Colaiezzi

Table 10. Personal communications.

Author	Year	Title	Recipient
Mourad Moursi	2014	CSDietary information	Cathleen Cissé
Rosalind Gibson	2014	24-hour recall presentation	Brooke Colaiezzi
Rosalind Gibson	2015	Program specifications	Brooke Colaiezzi
Lenore Arab	2015, 2016	DietDay	Brooke Colaiezzi
Anja Biltoft-Jensen	2015, 2016	Web-DAS	Brooke Colaiezzi
Amy Subar	2015, 2016	ASA24	Brooke Colaiezzi

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