



## Dietary assessment methods: dietary records

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### Abstract

Dietary records or food diaries can be highlighted among dietary assessment methods of the current diet for their interest and validity. It is a prospective, open-ended survey method collecting data about the foods and beverages consumed over a previously specified period of time. Dietary records can be used to estimate current diet of individuals and population groups, as well as to identify groups at risk of inadequacy. It is a dietary assessment method interesting for its use in epidemiological or in clinical studies.

High validity and precision has been reported for the method when used following adequate procedures and considering the sufficient number of days. Thus, dietary records are often considered as a reference method in validation studies. Nevertheless, the method is affected by error and has limitations due mainly to the tendency of subjects to report food consumption close to those socially desirable. Additional problems are related to the high burden posed on respondents. The method can also influence food behavior in respondents in order to simplify the registration of food intake and some subjects can experience difficulties in writing down the foods and beverages consumed or in describing the portion sizes. Increasing the number of days observed reduces the quality of completed diet records. It should also be considered the high cost of coding and processing information collected in diet records. One of the main advantages of the method is the registration of the foods and beverages as consumed, thus reducing the problem of food omissions due to memory failure. Weighted food records provide more precise estimates of consumed portions.

New Technologies can be helpful to improve and ease collaboration of respondents, as well as precision of the estimates, although it would be desirable to evaluate the advantages and limitations in order to optimize the implementation.

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Key words: *Dietary record method. Food intake. Energy and nutrient intakes. Diet assessment. Validity.*

### MÉTODOS DE EVALUACIÓN DE LA INGESTA ACTUAL: REGISTRO O DIARIO DIETÉTICO

#### Resumen

Entre los métodos de evaluación de la ingesta actual los métodos de registro, o diario dietético, destacan por su interés y fiabilidad. Se trata de un método prospectivo en formato abierto que recoge información sobre los alimentos y bebidas consumidos en un periodo de tiempo previamente especificado. Permite estimar la ingesta actual de individuos y de grupos de población, así como identificar grupos con riesgo de presentar ingestas inadecuadas. Se trata de un método de interés para su aplicación en estudios epidemiológicos o en el ámbito clínico.

Cuando se aplica de forma adecuada, y se considera el periodo de estudio suficiente, tiene alta validez y precisión, por lo que es un método de análisis de la ingesta considerado a menudo como referencia en estudios de validación. No obstante, está sujeto a errores y limitaciones, derivadas principalmente de la tendencia del sujeto a declarar consumos de alimentos próximos a los que considera correctos. Otros problemas son la alta demanda de colaboración, posible inducción de modificaciones en la dieta de los sujetos analizados o dificultades para describir los alimentos y/o porciones consumidas. Cuanto mayor es el número de días de observación de la dieta disminuye la calidad de los registros completados. También hay que considerar el elevado coste de procesado de la información. Entre las principales ventajas de este método destaca el registro de los alimentos y bebidas en el momento de su consumo, lo que reduce el problema de omitir alimentos por olvido. El registro por pesada permite estimaciones más precisas de las cantidades consumidas.

Las nuevas tecnologías pueden ser de gran ayuda para mejorar y facilitar el grado de colaboración de las personas estudiadas, así como la precisión de las estimaciones, aunque sería deseable evaluar sus ventajas y limitaciones para optimizar su utilización.

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## Introduction

Nutrient intake modulates the health and functional capacity, both in the short and in the long term, so the assessment of dietary intake can be of interest for different purposes in a variety of contexts. There are different methods to assess the intake of food and beverages, which can be used to analyse dietary intake from a prospective or a retrospective point of view. The dietary record (DR) highlights among the prospective methods<sup>1-4</sup>.

## Description and types of DR

A DR is a prospective open-ended assessment method where the subject records all the foods and beverages consumed over a specific period of time. Depending on the aim/hypothesis of the study it is often requested to record detailed information about food preparation methods, ingredients of mixed dishes and recipes, and even the brand name of commercial products, depending on the aim/hypothesis of the study. DR collects data by subjects' self-record at the time the food are eaten, thus minimizes reliance on a subjects' memory. To obtain accurate data, however, respondents must be trained before participating in the survey. Therefore, a high level of motivation is required and relatively large burden is passed onto the respondents<sup>3,4</sup>.

Although completely free open-forms could be used, it is very useful to apply a structured format, with additional questions for each eating occasion about name of the meal (breakfast, lunch...), time/hour, location, company, menu, menu ingredients and weight of food consumed, in order to record all details of the meals. The DR forms should be formatted so they provide adequate space for individuals to record all the data. A pocket notebook could be provided in order to record consumption away from home<sup>1</sup>.

Close-ended forms have been developed also. These included a specific list of foods so that the interviewee indicates which food has been consumed<sup>5,6</sup>. Additionally, a check list can be developed to assess particular "corefoods" that contribute substantially to intakes of some nutrients, or to track food contaminants. Estimates of portion size can also be asked, either in an open-ended manner or using categories<sup>5,7</sup>.

The DR can also be filled in by someone else. This procedure is often used in the case of children, or in the case of people with trouble scoring/recording the food consumed<sup>5</sup>. Theoretically, the food is recorded at the time of each eating occasion, but it is not always necessary to be performed in a paper form. Dictaphones have been used and hold special promise for low literacy groups<sup>4</sup>. Also camera and mobile telephone technology have been used to capture food and meal images, especially in disabled people<sup>8</sup>.

## Training of interviewees

The interviewee should receive a specific training to be able to describe in a proper way all the foods and the quantities used, including the name/brand of the consumed food, recipes of dishes, method of preparation or cooking, and also the portion sizes. In some studies this training is reinforced with a subsequent contact with the interviewee after the first day of registration, in order to check the registered data and resolve any doubts. At the end of the recorded period, again a trained interviewer should review the DR with the respondent, to clarify any doubts and to probe the possible consumption of forgotten foods<sup>5</sup>.

## Description of consumed portion sizes

The amount of food consumed should be recorded as precisely as possible. The amounts of each food can be measured with a kitchen weighing scale or using household measures (e.g., bowls, cups, and glasses). Alternatively, portion sizes can be estimated in reference to standard household measures, or using three-dimensional food models, or two-dimensional aids such as photographs<sup>5</sup>.

When interviewee uses common household measures to describe the quantities consumed, it is important that coders receive a specific training to transform those amounts described in grams of consumed food. Some software commonly used to process DR (such as DIAL)<sup>7</sup> includes a comprehensive database with information on weight of common household measures or each food (tablespoon, cup, cup, plate...) which facilitates the DR processing (Fig. 1).

In the subsequent revision of DR, and to clarify questions about the amounts described, it may be useful to employ food models representing dishes or foods of different sizes. In this case the interviewee points out which is the closer model to the portion size consumed.

## Length of the DR

It is important to establish the number of days to be monitored in the DR and also whether they must be consecutive or not. Ideally the controlled period should be long enough to provide reliable information on usual food consumption (a minimum of 3 days is required), but this has to be balanced against the likelihood of poor compliance if the recording period is too long<sup>1,2</sup>.

Traditionally the most common DR monitors the diet for 7 consecutive days. This time period allows for collecting information about the diet minimizing bias related to the day of the week. It also helps collect information about those foods eaten less often.

However, it was found that recording periods of more than 4 consecutive days are usually unsatisfac-

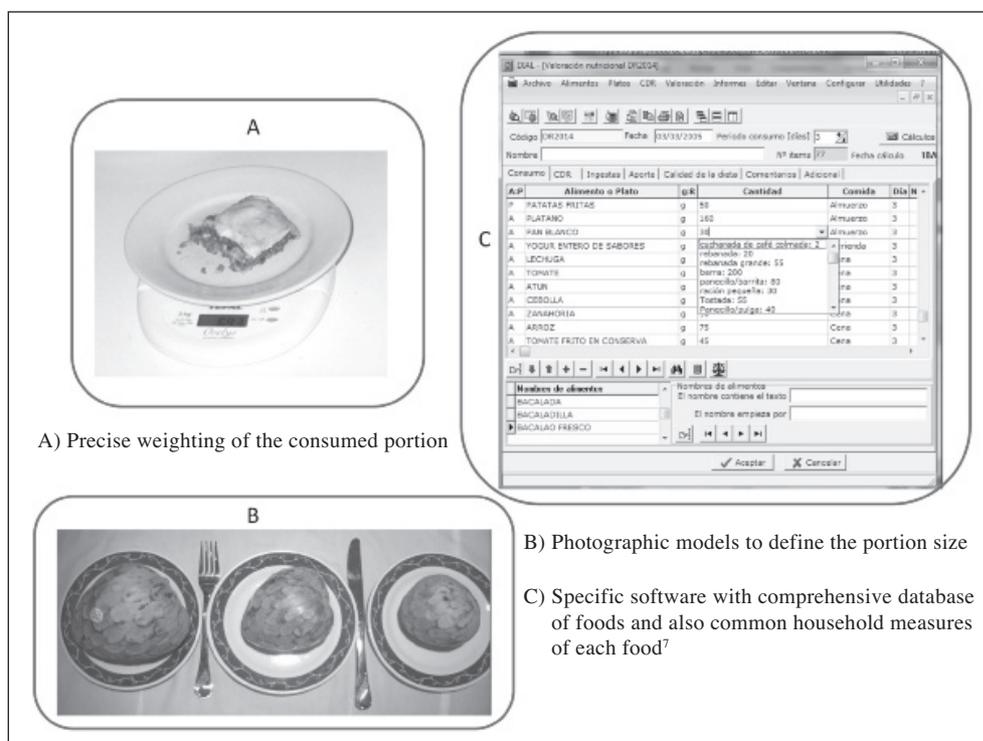


Fig. 1.—Some useful aids in obtaining accurate information and tabulation of DR.

tory, as reported intakes decrease due to respondent fatigue, and individuals who do comply may differ systematically from those who do not. Additionally, it has been noted that many respondents develop the practice of filling out the record retrospectively rather than concurrently<sup>5</sup>, so the validity of the collected information decreases in the later days of a 7-day recording period, in contrast to collected information in the earlier days<sup>2,5</sup>.

Because of these limitations, shorter DRs are often used<sup>1,2</sup>. The optimal number of days to collect more reliable data depends largely on the nutrient subject of attention or the sample size of the study. As a general rule, the smaller the number of individuals, the greater must be the number of controlled days. When the aim is to have an overview of a group, the main interest is that the sample is large enough to be representative, instead of increasing the number of monitored days. However, it is likely that foods eaten less than once or twice a week may not be captured in 3-4 days DR. In these cases it may be useful to supplement the collected information with a brief Food Frequency Questionnaire (FFQ) or a propensity questionnaire.

On the other hand, because the foods and amounts consumed on consecutive days of reporting may be related (e.g., leftovers and eating more one day and less the next day), it may be advantageous to collect non consecutive single-day records in order to increase representativeness of the individual's diet<sup>5</sup>.

Regardless of the length of the DR, it is desirable to control both working and weekend days, in order to get a better picture of the overall diet. In some studies it is also required to collect information in different

seasons, bearing in mind that the availability and preparation of food changes with the season. For these reasons, the date of every single day included in the DR should be recorded<sup>1,2,5</sup>.

### Strengths of DR

The main advantage of DR is its potential to collect accurate quantitative information on individual foods consumed during the registration period<sup>5</sup>. Because of the quality of the dietary data, the DR is considered to be the gold standard of the dietary methods, and is often used as a reference in calibration or validation studies using other less involved and less expensive methods.

The weighed DR provides more precise estimates of intakes for individuals which can be related to health indices, such as nutritional status measured by blood analytes.

As foods are recorded as consumed, it is less likely to omit / forget food items and moreover, the description thereof is more accurate. Also, as the amount consumed is recorded when eaten, valuable and accurate information about **exact portion size** is provided, and therefore it does not rely on portion size estimation. In this sense, the weighed DR remains an invaluable tool for estimations of actual portion sizes, which are needed for estimated methods.

When the DR uses open-ended questions, **abundant information can be collected** and analyzed in various aspects. For example, if sufficient days are recorded, **day-to-day variation** can be studied. Also

detailed descriptions of the foods consumed and all eating occasions are provided.

It can be easily applied to diverse groups with a **wide range of eating** habits and may be used to estimate the average intake of a certain population<sup>3,5</sup>, since provides excellent estimates for energy, nutrients, foods and food groups.

DR is **suitable in metabolic and intervention studies**. In the latter case, the weighed DR is very useful for knowledge of dietary habits and change<sup>5,9</sup>. Recording, by itself, is an effective weight loss technique<sup>5</sup>.

### Disadvantages of the method

The diet is highly variable from day to day, so that the recorded data can represent the **current diet** but not the **usual diet**. But usual intake can also be estimated if repeated.

Those who have to fill in DR (interviewees or caregivers) must be both motivated and literate (if done on paper), which potentially limits their application in some population groups (people with low literacy, immigrants with low language skills, children, elderly, people with difficulty writing ...). Because the DR require high cooperation limits the type of population that can be applied, and this could compromise the generalizability of the results to the wider population<sup>5</sup> (table I).

The method could be **complex for some individuals**, particularly for those who do not cook regularly and are not familiar with weighing foods (table I).

The knowledge that foods and amounts must be recorded and the demanding task of doing it may **alter the dietary behaviors** the tool is intended to measure. Previous studies have found some respondents may improve their dietary habits unintentionally through self-reflection. However, some respondents may alter their diet intentionally to avoid a burden on responses or even choose to not report actual intake<sup>3</sup>. This can affect both the types of food chosen and the quantities consumed<sup>5,10,11</sup>. This effect is a weakness when the aim is to measure typical dietary behaviors<sup>5</sup>.

In weighing DR a kitchen scale must be used, and this could bias the study because:

- The subject has to have a scale (participation bias).
- If researcher provides scales, the study may become more expensive (scales must be purchased) and the interviewee has to be specifically trained in the use of the scale and how to record clearly the food consumed (if the weight is just food, or dish, if the weight is complete food or edible part ...).
- The interviewee has to spend more time (in addition to completing the registration he/she must weigh), and always carry with him/her the scale (problem with meals outside the home).
- Can modify further dietary habits and food choices can be more influenced by the fact the subject is more conscious his/her diet will be analyzed.

Unless electronic devices are used to carry out the DR, the coding of an open-ended format requires a considerable effort of data collection, entry and analyses. Each DR requires a careful review by a trained research staff. All food and mixed dishes consumed according to the detailed description of the respondent must be coded and matched with the most appropriate food of the food composition database. Portion size must be converted in its actual weight. These processes tend to be time-consuming, laborious, and highly expensive to implement<sup>3</sup>. In this regard it is of great interest to use software enabling enter information using common spellings of foods, as it helps to save time in the coding of food<sup>5</sup>.

Given that it is a method that requires significant personal and economic resources, and the substantial individual burden on the participant, the DR is **not practical for large population studies**.

As DR measures the current intake, and is mainly focused on short-term intake, it cannot be used in studies looking at associations of **past diet** with health outcomes, or when **long-term dietary** exposure is of interest, as when chronic diseases are investigated. In this latter case, to measure average intakes, multiple DRs are needed. Then, the repeated measurement not only requires a lot of resources and time but also the survey repetition can also influence a respondents' diet.

<b>Table I</b> <i>Characteristics, strengths and limitations of dietary record</i>	
<i>Method</i>	<i>Subjective measure using open-ended, self-administered questionnaires</i>
Collected data	Actual intake information throughout a specific period
Strengths	Provides detailed intake data; no interviewer required; no recall bias
Limitations	Relatively large respondent burden (literacy and high motivation required, possible under-reporting); expensive and time-consuming; multiple days required to assess usual intake; possible changes to diet if repeated measures
New techniques	Required technology: Software, internet, PDA, mobile phone, application, etc.
Strengths of new techniques	Standardized, real-time data collection possible; likely reduce time and cost; improve feasibility
Limitations of new techniques	Inherent bias related to self-report; requires participant training on how to use the technology

Modified from Shim et al.<sup>3</sup>.

**Table II**  
*Overall methodological drawbacks of dietary records*

<i>Topic</i>	<i>Issue detected</i>
Type of foods	Addition /omission of foods influenced by social desirability
Amount of food	Underestimation increases as consumed portion sizes increase Overestimation increases as consumed portion sizes decrease Personal views on specific food items can affect reported portion sizes above or under real intake
Age of the studied population	<i>Elderly:</i> Inadequate cognitive function Ignoring food ingredients / difficulties to describe portion sizes Cultural and physical difficulties to write down the food items and portion sizes consumed.  <i>Children:</i> Ignoring what they consume or the ingredients in food preparations Difficulty to write down the food items consumed
Problems affecting individuals or groups in the studied population	<i>Obese people, ill people, sport people:</i> May avoid reporting the consumption of foods being advised not to eat or those considered to help them in their success (sport people)

### Sources of error

In DR, and in prospective methods in general, the respondent can voluntarily modify his/her diet because is aware of being studied, so the main source of error is the tendency to declare foods and portion sizes closer to those considered to be socially desirable (table II)<sup>1,2</sup>.

Some of the sources of error due to the respondent are:

- Motivation, memory, communication skills.
- Perception (type and amount): over or underestimation.
- Forgetting of certain foods (bread, fats, oils, liquids, snacks, alcohol).
- Personal characteristics (age, sex, obesity).

Other sources of error are linked to the field workers:

- Insufficient training to instruct individuals on undertaking a DR.
- A non-deep check of the DR when collected.
- Mistakes in DR tabulation and food codification.

Other possible sources of error must be considered, such as errors in the food database regarding to the nutritional composition of foods, or the recommended intakes, etc.

### Validation of DR data

DRs are often regarded as the “gold standard” against which other dietary methods could be assessed<sup>4</sup>. But, anyway, and considering that the DR has drawbacks as other dietary methods, DR must be validated using a more precise method with a different source of error.

Compared to other methods, like FFQ or 24-hour recall method, that are more practical and cost-effective for application in large epidemiological studies, a 4-day DR provides a stronger estimate of energy and protein intake, as has been shown using doubly labelled water method and 24-hour urinary nitrogen<sup>12</sup>. In the EPIC-Norfolk cohort a 7-day DR showed closer data than FFQs to biomarkers for protein, potassium, and sodium consumptions<sup>13</sup>, at least for absolute intakes<sup>14</sup>.

Biochemical markers (measured in blood / urine) are helpful to analyze the relationship between a derived DR nutrient intake and the corresponding biochemical index of nutritional status. A positive correlation between the nutrient intake and the serum data helps to validate the DR as reliable. But this correlation is more expected when the nutrient intake is inadequate and the likelihood for reaching optimal blood levels is lower. When the nutrient intake is adequate, a higher intake not always is related to increased blood levels. In this scenario (higher intakes) urine parameters could be more useful if a correlation between the dietary intake and the output of water-soluble nutrients or nitrogen catabolites is expected. Another possibility to test the validity of the DR, is to find significant differences in biochemical parameters between subjects with lower or higher intakes than those recommended<sup>1,2</sup>.

Specific biochemical markers have been used as a surrogate to measure the dietary intake of selected nutrients or dietary components in epidemiological studies<sup>3,15-17</sup>. Previous studies have found these markers to be highly correlated with dietary intake levels, free of a social desirability bias, independent of memory, and not based on subjects’ ability to describe the type and quantity of food consumed<sup>3,18</sup>. Thus, these biochemical markers may provide more accurate measures than dietary intake estimates do. However, a number of biomarkers have been known to provide integrated

measures reflecting their absorption and metabolism after consumption, and they are also affected by disease or homeostatic regulation, thus their values cannot be translated into the subject's absolute dietary intake. Moreover, the results based on biomarkers cannot provide dietary recommendations to modify a subject's dietary habit. Thus, direct assessment of dietary intake may be more informative than biomarkers are<sup>3,18,19</sup>.

Comparing energy intake (EI) to energy expenditure (EE), measured or estimated, in people with stable weight, also helps to identify those subjects more prone to under/overestimation of energy intake. The discrepancy between EI and EE, measured with the formula:  $(EE - EI) \times 100 / EE$ , provides a percentage of probable underestimation (with positive values) or overestimation (with negative values)<sup>20-22</sup>.

Using IOM equations<sup>23</sup> for estimating EE, and EI estimated with DR, some studies found a low discrepancy ( $-0.64 \pm 10.5\%$ )<sup>24</sup>. But this mean figure, that suggests that EI is very close to EE, also highlights that a significant percentage of the studied population underestimated their energy intake<sup>2,20</sup>.

There is a general tendency to declare foods and amounts closer to those considered as more correct, and some of the factors that can contribute to this discrepancy may be mentioned:

- **Being overweight or obese:** the underestimation of energy intake increases with increasing weight<sup>20,21</sup>.
- **Concern about the body weight/shape:** those people who wish to lose weight, even without excess body weight, show a tendency to underestimate their energy intake to a greater extent than people who do not have this concern about weight, regardless of actual BMI<sup>20,22</sup>.

Studies that follow individuals for 30 days to see if their weight was stable<sup>22</sup>, show that the underestimation of energy intake was higher in those individuals who reported a desire of losing weight, and this discrepancy

increases as BMI does. On the other hand, in those who didn't want to lose weight, a slight overestimation of the intake was observed, which increased as BMI decreases, especially when a weight deficit was observed<sup>22</sup> (Fig. 2).

Having in mind that a high percentage of the population suffer from overweight / obesity<sup>25</sup> or are concerned with the control of body weight (even being normalweight)<sup>26</sup>, these data must be taken into account when conducting dietary studies, in order to improve the accuracy of the data.

Another point to consider is that people tend to report food intakes close to those they consider more appropriate or healthy. Sometimes misconceptions and preconceived ideas can make that some foods considered unhealthy (rightly or wrongly) were recorded/declared in lower amounts than true intakes, while higher amounts of top rated foods can be declared/recorded (like fruits, vegetables ....)<sup>27</sup>.

### New Technologies and DR

In recent years, new technologies have been developed in order to increase feasibility of DR in large epidemiological studies. Their main purposes are to reduce the respondents' burden, improve accuracy and making multiple self-administrations possible. Several reports have discussed their use and implications in clinical and research settings<sup>3,28,29</sup>.

Although many of these techniques are still under development, they have made great strides. Admittedly, the development of both software and hardware implies a great investment in the early stages of the research. But once developed, these new technologies can reduce costs and resources. Collecting and handling data are easier, consistency of data improves, and the collection of data and calculation of dietary intakes in real-time allows respondents to focus on dietary assessment<sup>3</sup> (table I).

Some of the applications developed allow the user to use their mobile phone to enter his/her dietary intake.

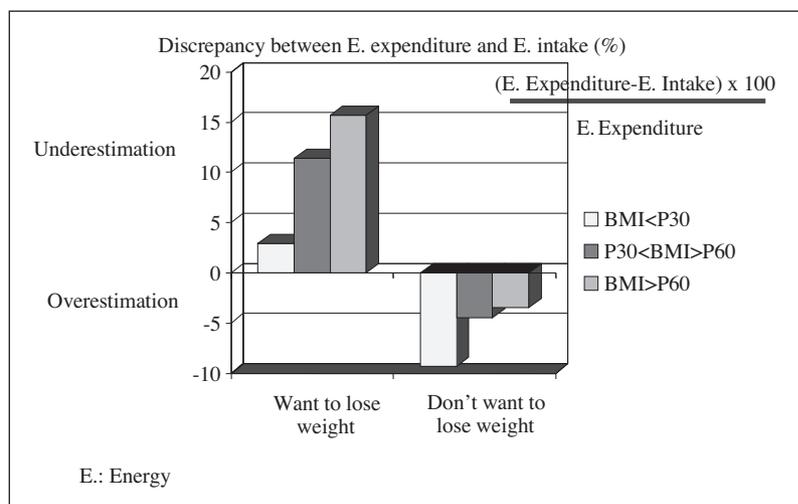


Fig. 2.—Influence of BMI and concern about body weight on discrepancy between Energy intake and Expenditure with DR<sup>22</sup>.

The subject can record the diet by matching each food from a predefined list of foods and beverages, and the amount consumed can be recorded choosing pre-defined portion sizes<sup>3,30</sup>. In other studies the subject's camera and mobile phone were used to report everything that was consumed by sending images before and after eating to the research staff<sup>3</sup>. Specific software can be used to estimate the weight of portion sizes. Some internet-based technologies include online tutorials, digital images for food identification and portion-size estimation, and audio files. Thus, those with low literacy can easily complete the survey, and researchers can collect real-time data<sup>3</sup>.

While the feasibility of multiple DRs in epidemiological studies has considerably improved with the help of these new technologies, there are still some limitations. First, these methods may be difficult to apply to certain populations who are not familiar with innovative technologies or new devices: Training subjects on how to use these technologies and use a computer including accessing the internet is also required<sup>3</sup>. Second, technical problems in data transfer, storage, battery life, and other concerns must be improved. And third, these new methods do not seem to overcome the methodological problems related to self-report. Subjects still had difficulties in recalling and reporting their diet, underreported in repeated assessments, and altered their food intake when they knew the survey date in advance<sup>28</sup>. For these reasons, open-ended methods with new technologies have not yet been widely implemented as the primary assessment tool in epidemiological studies<sup>3</sup> (table 1).

## Conclusions

Dietary intake is difficult to measure, and any single method cannot assess dietary exposure perfectly. But DR is one of the most reliable methods of dietary assessment. However it is important to consider some aspects such as the length of the study ( $\geq 3$  days,  $\leq 7$  days), the format of the questionnaire, the motivation of participants, their training in completing the questionnaire, and the need of trained staff. New technologies are very promising and probably in a near future will facilitate the implementation of DR in large epidemiological studies. Some interviewee's factors must be considered as they can influence the accuracy of DR: The BMI, weight/shape concerns, or the subject's perception of certain foods can be useful to detect / fix bugs. Despite being a reliable method, it is always advisable to validate the DR results with biochemical markers or analyze the discrepancy between intake / energy expenditure.

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