

## LOOKING AT METROLOGY CONCEPTS IN DIETARY ASSESSMENT

Aida Turrini

CREA-Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria – Centro di Ricerca per gli Alimenti e la Nutrizione [Council for Agricultural Research and Economics – Research Centre for Food and Nutrition]  
Rome, Italy, aida.turrini@crea.gov.it

**Abstract** – Dietary patterns represent the quantitative core for food-related risk management as the evaluation of the quality of the diet, i.e., adequacy, safety, environmental impact need requires the knowledge of food intake and the substances that foods bring to our body. Nutrients are structural components of foods according to its nature, contaminants occur occasionally in foods when accidentally migrate or are generated by the processing. Quantification is crucial at all stages in order to ensure the most reliable estimates. This requires the application of metrology concepts.

**Keywords:** dietary assessment, metrology, food intake, intake exposure, dietary quality

### 1. INTRODUCTION

Dietary assessment in a population represents the quantitative basis providing input for the evaluation of dietary quality, adequacy, and to estimate dietary exposure. All these information are used in the risk management and ultimately in planning food and nutritional policies.

Dietary assessment implies the availability of measures of substances carried by foods either as nourishing substances (nutrients and energy) or technical ingredients (e.g., additives), irregularly occurring substances (e.g., natural toxicants), accidentally occurring substances (contaminants, residues, food process-related substances, home treatment derivatives).

All the variables are statistically analysed to identify dietary patterns in a population group for the subsequent evaluation of dietary quality - dietary models, adequacy, safety, environmental impact, and consumer's choice factors.

Statistical analyses tackle the variability implicit in the observation of a population (each unit shows own value for a variable) and the synthesis either in

a descriptive context (non-random studies) or a probabilistic one (random selection or trial). The study design including sampling strategy, survey plan, survey forms, and tools, will ensure the reliability of the estimates. A system framework necessary to underpin this kind of studies includes databases, classification criteria, and procedures [1,2].

Uncertainty could occur at all levels and can affect the estimates in an unpredictable way as it cannot simply summed up but it could be amplified but it is not evaluable. Reliable measurements are the first brick to build good estimates when these measures are used for calculation (e.g. nutrients /100 grams of food) so we can trust the values.

In this sense a strong link between metrology and dietary assessment can be identified as «Metrology is a specialized discipline that deals with the science of measurements, irrespective of the field of application and regardless of the size of the measurement uncertainty.» [3] and dietary assessment is a complex process implying measurements of several objects (food, nutrients, other substances).

Limited publications are devoted to metrology principles along the dietary assessment process [3,4]. A need for a conceptual definition of the whole framework is required as data generation (experiments, trials, surveys) and management (collecting, cleaning, maintaining, processing, exchanging) in an open data environment demanding for meta-data and functionalities to ensure compatibility and comparability.

The present work aims at outlining the main areas where metrology is involved when processing data for dietary assessment in the context of population study.

## 2. METHODOLOGY

An exercise to identify the structure of the problem in carrying out dietary assessment was performed.

Dietary assessment at population level includes several steps and demands tools. The logical scheme can be synthesised as follow: components are all the different sources generating data that will be uploaded in various information environments to be managed using appropriate tools.

### 2.1. Components

The statistical framework ensures precision and robustness of the estimates. Accuracy is ensured by setting up a codification plan for the data, and training the fieldworkers to administer the form, measures anthropometry, collecting biological samples (when included in the study design), coding foods. The latter is a particularly difficult task as a proper statistical classification system has not yet established given the complexity of the matter [5]. An international food aggregation tool named FoodEx2 is now shared covering the majority of items collected in nationwide dietary surveys in Member states according to the EU-Menu programme [6]. This is crucial for the identification of foods and the attribution of food composition data and occurrence datasets [7]. Consequently the items can be reorganised to perform different kind of analyses, e.g., to comply with regulatory or toxicological information (additives, residues, contaminants, other migrated substances, food processing-related substances, etc.). Food classification also deal with consumers' perception [8].

Overall, dietary assessment is aimed at measuring variables in order to generate simple (single foods, nutrients, exposure to substances) or complex indicators (dietary models – Mediterranean, Nordic, etc., dietary quality, environmental impact, consumers role, etc.).

This kind of evaluation requires good underpinning databases that means input like food composition tables and occurrence data, but portions size database, yield and retention factors due to home treatments/cooking methods.

Measurement issues in dietary assessment regard survey and pre-survey factors. Survey

factors concern food intake (actual or habitual), energy expenditure (physical activity and metabolic requirements), nutrients requirements by age/gender. Pre-survey factors include all necessary inputs like food composition and occurrence data and several other information. Managing pre- and survey factors allows for considering the reliability of the results. This is particularly important taking into account that data are also analysed joined to socio-economic, cultural and motivational variables in order to outline consumers' dietary behaviour.

Mis-evaluation at early stages are likely to be propagated in the subsequent steps of the dietary assessment process. Tracking the path and the critical points facilitate the identification of sources of uncertainty sources to enhance the interpretation of the results.

### 2.2. Information environment and tools

This topic was considered by EFSA in the preparation of the Eu-Menu programme to promote harmonised individual dietary study at national level [7].

In general, the creation of meta-data explaining the structure and the content of the data in environment are shared where big data are released [see e.g., 9]. Standard procedures are greatly helpful in performing multi-participant and transnational activities like in the system of European Food Information Resources [10]. These developments need also to take into consideration the usual international standards like the European Committee for Standardisation (CEN) and the International Standardisation Organization (ISO).

The analysis of dietary assessment component can be used in the development of tools for managing the collection of data. Particularly but not only, the software for individual surveys build either to guide the surveyor in face-to-face interview (e.g., 24h recall, or the data entry of paper-recorded information (e.g., food diary).

Moreover, currently several web and mobile phone applications uses food information so the precision and accuracy need to be carefully treated [11].

## 3. RESULTS AND DISCUSSION

The dietary assessment process requires appropriate actions using data provided by different

sources: primary collected food intake (main aim) and population characteristics (breakdown) data [].

Collecting good, i.e., accurate and complete micro-data following a correct study design (validated methods/protocols) and taking all provisions to reduce uncertainty (training and standardisation), will allow for building reliable data matrices for statistical evaluation. Often recording technique (food record, 24hr recall, etc.) is considered synonym of “dietary assessment” [see e.g., 12] but this is rather the core of a complex process to determine dietary patterns. Several components are necessary to this purpose [13].

If not, an unknown error due to unpredictable imprecision could be added without the possibility to evaluate its magnitude or statistical distribution. This makes uncertainty different from variability.

Overall, we have

- natural variability statistically treated as nature of the phenomenon, in this case food intake with its intra- and inter-variability
- uncertainty due to lack of precision/accuracy in the recording food intake data and other variables (e.g. anthropometric, physical activity, etc.);
- uncertainty due to imprecision in data used in combination with food intake data.

The importance of having reliable food composition data is internationally recognised [14] and the link with the metrological concepts was also discussed [15]. Having good quality composition data means to minimize the possibility of a propagation effect of the original uncertainty related to analytical instruments when the data are used in nutritional assessment [3,4].

However, the concept of the goodness of measurement must be extended also to variables not obtained using instruments, but measured through observational methods like the registration of food intake amounts and the subsequent dietary evaluations. Procedural provisions to ensure high level of accuracy and prevent imprecision are crucial for data reliability considering the three pillars of metrology, i.e., traceability, uncertainty and comparability [4].

The formula (1) expresses the calculation of the intake of nutrient  $n$  ( $Nut_n$ ) from the food  $f$  ( $Nut\ intake_n^f$ ) multiplying the eaten amount of food  $f$  in grams ( $g\ intake_n^f$ ) divided by 100 and the amount

of nutrient that 100 g of edible food product  $fp$  associated to the food  $f$  contains ( $Nut_n^{100g(f)}$ )

$$Nut\ intake_n^f = \frac{g\ intake_n^{fp}}{100} \times Nut_n^{100g(f)} \quad (1)$$

Examining this simple formula a series of critical points are found in building it.

Identifying the right food product with all the associated characteristics is the first issue to tackle. Nutrients composition and occurrence of other substances vary according to several factors like treatments, preservation methods, packaging, cooking method applied to the same food. Shared validated food description and food classification systems help to perform this task limiting the possibility to make mistakes in classifying the item [5,6].

Once the food product  $fp$  is well defined, the second problem is to match the eaten food  $fp$  and the right composition item as food composition data - often refer to the average content of a composite sample representing the item  $f$  [16]. Therefore food matching requires a detailed knowledge both of consumed foods and composition data [17].

The third uncertainties could affect the eaten amount indicated as  $g\ intake_n^{fp}$  in (1). It derives from the possible lack of accuracy in quantifying the intake or a wrong classification of the food product.

In this single step of calculation the three uncertainties can be magnified by the multiplication, however while the instrumental imprecision and the statistical variability are measured, uncertainties deriving from the lack of accuracy are not usually quantifiable.

Increasing standardisation enhancing protocols of study design and preparation, and recently introducing “computerized” tools in an extensive sense, including personal computer, tablet, smartphone, and similar ones [12] help to prevent unexpected and uncontrolled errors.

#### 4. CONCLUSIONS

Metrology principles are crucial for all the stages in dietary assessment. At pre-survey level for the reliability of inputs like food composition data and occurrence data. During the survey it may be the

reference theory for evaluating the accuracy of procedures for estimating values to deliver reliable data matrices to the statistical analysis.

Traceability of values is finally very helpful in the last stage of the data analysis, specifically the interpretation of the results. This is expected reducing the uncertainty and increase the compatibility of the systems and comparability of the information.

### ACKNOWLEDGMENTS

CREA – Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria [*Council for Agricultural Research and Economics*] has joined the METROFOOD-RI Joint Research Unit coordinated by the ENEA – Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile.

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