Computers in Biology and Medicine 42 (2012) 964–974

Contents lists available at SciVerse ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/cbm

Automation of Food Questionnaires in Medical Studies: A state-of-the-art review and future prospects

Zoe Falomir [a,*], María Arregui [a,b], Francisco Madueño [a], Dolores Corella [c,d], Óscar Coltell [a,d]

[a] Department of Languages and Computer Systems, Universitat Jaume I, Castelló, Spain
[b] Department of Epidemiology, German Institute of Human Nutrition (DIfE), Potsdam-Rehbruecke, Germany
[c] Department of Preventive Medicine and Public Health, Faculty of Medicine, Universitat de València, Spain
[d] CIBER Physiopatology of Obesity and Nutrition, Spain

ARTICLE INFO

Article history:
Received 24 February 2012
Accepted 17 July 2012

Keywords:
Food frequency questionnaire (FFQ)
24 h dietary recall (24HDR)
Food composition database
Engineering technologies
World wide web (WWW)

ABSTRACT

Applications for automating the most commonly used dietary surveys in nutritional research, Food Frequency Questionnaires (FFQs) and 24 h Dietary Recalls (24HDRs), are reviewed in this paper. A comprehensive search of electronic databases was carried out and findings were classified by a group of experts in nutrition and computer science into: (i) Computerized Questionnaires and Web-based Questionnaires; (ii) FFQs and 24HDRs and combinations of both; and (iii) interviewer-administered or self-administered questionnaires. A discussion on the classification made and the works reported is included. Finally, works that apply innovative technologies are outlined and the future trends for automating questionnaires in nutrition are identified.

Contents

1. Introduction

Dietary factors are linked to the leading noncommunicable causes of death [1]: cardiovascular diseases, some cancers, type 2 diabetes, etc. The study of the interaction between diet and the genome is crucial to prevent and treat these diseases. The

* Corresponding author. Tel.: +34 964728340; fax: +34 964 728435.
E-mail addresses: zfalomir@gmail.com, zfalomir@uji.es (Z. Falomir), maria.arregui@dife.de (M. Arregui), madueno@uji.es (F. Madueño), dolores.corella@uv.es (D. Corella), ocoltell@uji.es (Ó. Coltell).

0010-4825/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.compbiomed.2012.07.008

assessment of a person's diet is a painstaking task which consists of analysing their daily intake over one or more years. However, in epidemiological studies of diet-disease association, this assessment is not feasible and, in practice, only a portion of the intake information is evaluated and then the habitual participants' intake is extrapolated. In order to obtain enough statistical power to avoid measurement errors and changes in diet, it is necessary to obtain repeated measures of dietary information from a large number of participants over time. For extracting information on participants' diet, nutritionists use Food Frequency Questionnaires (FFQ), 24 h dietary recalls (24HDRs), dietary records or dietary histories. These surveys collect data on consumed foods or dishes, which can be transformed into energy and nutrient intake using food composition tables (FCTs).

FFQs and 24HDRs are the most widely used tools to extract information on diet in the field of epidemiological studies. Both techniques assume that participants have some regularity in their diet and are able to quantify it.

FFQs ask participants to report their usual frequency of consumption of each food from a list and for a specific period of time [2]. They assess habitual consumption of foods or nutrients. FFQs present general questions such as '*Do you eat olive oil*?' and if participants respond '*yes*', the FFQs ask the frequency of consumption (i.e. '*How often do you eat olive oil*? *Units per day/week/month/year*, *etc.*'). The FFQs that include portion-sizes of foods are also referred to as *semiquantitative* FFQs. The use of FFQs is widespread because of their advantages such as easy administration and translation into nutrients, and also because they can cover seasonal intake variations and foods of occasional consumption. However, the automation of nutrient calculation is intensive and requires considerable computing and nutritional expertise [3]. Many FFQs were developed for different purposes, from capturing usual intake among large population-based samples [4] to tailoring the questionnaire to measure intake of a particular nutrient/food/food group in small specialized samples such as: iron [5], omega-3 fatty acids [6], calcium [7], phytosterols [8], etc.

24HDRs ask the respondent to recall all the foods and beverages consumed in the preceding 24 h or day [2]. They usually use open-answer questions, such as '*List all the beverages you drank and all the foods you ate yesterday between midnight and midnight*' (unstructured recall) or '*List all the beverages you drank and all the foods you ate yesterday for breakfast/lunch/dinner/snacks*' or '*What did you eat when you woke up*?' (meal based recall). 24HDRs are used to collect high-quality dietary data because: (i) they are based on short-term memory, (ii) they do not consist of a closed list of foods and (iii) they provide quantitative information rather than consumption ranges. Therefore they do not require adaptation to specific populations such as FFQs. A single 24HDR is not considered representative of an individual's usual diet, so multiple 24HDRs are preferred for many nutritional studies. They also require highly trained interviewers, thus 24HDRs are not considered economical or practical in research settings with large samples and FFQs are frequently used. If 24HDRs could be self-administered using computer technologies to substitute the interviewer, they could be more feasible for large-scale studies [9].

Dietary records are more precise than 24HDRs because food intake is registered at the time of the eating. However, dietary records present high respondent burden, high investigator cost, and an extensive training and motivation of participants [2]. Therefore dietary records are usually substituted by 24HDRs in nutrition studies. The same disadvantages are present in diet histories in large population nutritional studies because they collect information not only about the food frequency of intake but also about the typical makeup of meals [2]. They also include more than one intake survey, such as the combination of a 24HDR, a FFQ and 3-day diet records [10]. Moreover they sometimes involve difficult cognitive tasks for the respondents, are not quantifiably precise and can have a high investigator burden [2].

There is no ideal method of reference or gold standard for estimating the validity of a food survey. In practice, relative validations of a questionnaire (i.e. FFQ) are performed with respect to another questionnaire (i.e. 24HDRs) taking into account that the sources of error between the reference questionnaire and that evaluated must be as independent as possible. By comparing both surveys, correlation coefficients are obtained which indicate the validity of the instrument and the calibration coefficients to be applied for correcting further executions. This is the reason why studies usually combine FFQ and 24HDRs for obtaining results and validate them [11,12].

Traditionally, FFQs and 24HDRs were administered in paper (i.e. Harvard paper FFQs[1]). However, as information and communication technologies have gained importance in recent years, great efforts have been made to automate the questionnaires involved in epidemiological and other nutritional studies in order to save costs.

First, computer programs were developed for helping researchers to administer questionnaires to participants and to accelerate the extraction and processing of the important data from FFQs [13–15,3,6,16] and from 24HDRs [17–19]. Then, other software applications automated self-administered FFQs [20,21,5,22,6,7], 24HDRs [23–25], and combinations of both [26] were developed. And all these tools needed a specific computer system in order to function correctly.

When the World Wide Web became widespread, dietary Web-based questionnaires substituted computerized questionnaires for improving accessibility and for obtaining a multi-platform functionality, such as on-line FFQs [8,27–39], on-line 24HDRs [9,40–43] and combinations of both [11,44,45].

In literature there are numerous works concerning the development, validation, repeatability of FFQs and 24HDRs in epidemiological studies. However, there are fewer approaches describing engineering developments for the automation, evolution and acceleration of results extraction in epidemiological studies. Our contribution here is: (i) to provide a broad state-of-the-art review from a technological point of view of studies that used an automated FFQ or 24HDR, (ii) to compare them and discuss their characteristics, (iii) to present recent developments that use innovative technologies, and (iv) to outline future prospects.

A few similar reviews are found in the literature [46,47,1,48]. A very brief review on technologies applied to FFQ was presented by García-Segovia et al. [46]. A classification of Web tools and other computer applications used in nutrigenomic research was undertaken by Stumbo et al. [47]. They presented the most commonly used tools in US and Europe providing a description from the point of view of a researcher in nutrition. Long et al. [1] presented a review of the evidence on the effectiveness of technology-based methods for dietary assessment by reporting six technology-based methods. Ngo et al. [48] reviewed automated nutrition questionnaires and outlined some innovative methods for automating questionnaires, such as smart cards, personal digital assistants (PDAs) and mobile phones. In this paper, a wider period of time is taken into consideration, a broader description is presented regarding computerized and Web-based FFQs and 24HDRs, a comparative discussion is provided on the automation and administration of questionnaires and also innovative technologies are reported. An engineering perspective of all the works is given, when available, and useful recommendations for automating questionnaires in nutrition are outlined.

[1] Harvard paper FFQs: https://regepi.bwh.harvard.edu/health/nutrition.html.