# Challenges and limits in personalized dietary logging and analysis

**I. Vassanyi[1], I. Kosa[2], B.Pinter[1]**
[1]*Medical Informatics R&D Center, University of Pannonia, Hungary*
[2]*Cardiac Rehabilitation Institute of Military Hospital, Balatonfured, Hungary*
[1]*E-mail: vassanyi@almos.vein.hu*

**Introduction.** Healthy lifestyle, especially proper nutrition, can be a decisive factor for disease prevention and also for the efficient and cost-effective therapy of chronic illnesses. In this paper, we present our results in personalized dietary logging using modern information technology.

**An overview of dietary logging.** The challenge in dietary logging is the estimation of nutrients that enter the body by absorption as a result of food or drink consumption. The basis of most computerized services available for dietary logging is a Food Composition Database (FCDB) with the nutrient content for a wide range of common foods. Nutrients are the basic carbohydrates, proteins, minerals, vitamins etc. and foods are either ingredients of dishes (like white flour or olive oil) or they are consumed alone like apple or red wine. Some FCDB's, like the USDA SR FCDB are free for download [1]. In order to compute the nutrient content of the user's meals, the dietary database must also contain a highly culture-specific set of recipes as well. There are several web-based or mobile applications that provide an interface for the logging of the user's meal and various services related to the analysis of the log like daily/weekly overview charts, support for losing or gaining weight etc. The Calorie Counter android application boasts with the biggest recipe database of more than half a million [2], a large part of which was contributed by the users. Similar applications, with a smaller database, are the My Diet Diary and Tracker 2 Go [3,4]. Though such services provide detailed nutritional analysis, a seldom analysed point is the absorbed nutrient estimation accuracy attainable by such FCDB-based user logs. There are several sources of possible errors:

1. *Shortcomings of the dietary database or the user interface*: the food or dish that the user tries to log is either not contained in the database or it is contained by another name.
2. *Food and dish variants*: the dish is supported but its recipe differs significantly from the one contained in the database, or its nutrient content is different from the values stored in the FCDB due to spatial or seasonal variations.
3. *Amounts over - or underestimated by the user*. A minimum requirement for a dietary database is to support natural, common measurement units for foods like 'a plateful of bouillon' or 'a small apple' etc.
4. *Cooking transformations and personal variability of absorption.* Cooking can modify the nutrient contents of ingredients (foods) and not all nutrients consumed are absorbed by the body.

The positive effect of personalized counselling was shown in several studies [5], but the above errors cannot be neglected. In this paper, we are concerned with the errors 1 - 3 in the MenuGene dietary expert system developed at the University of Pannonia [6].

**The MenuGene expert system.** The Menugene system supports dietary logging on web and mobile interfaces, dietary log analysis, and also personalized menu generation using a dietary database specialized for the Hungarian culture. Its data base currently stores 9500 food items along with their nutrient contents and 1373 dishes composed from the foods, but on the primary user interfaces we show only the most important 299 dishes and 360 foods, organized in 195 sets, to simplify the search and thus preserve user motivation.

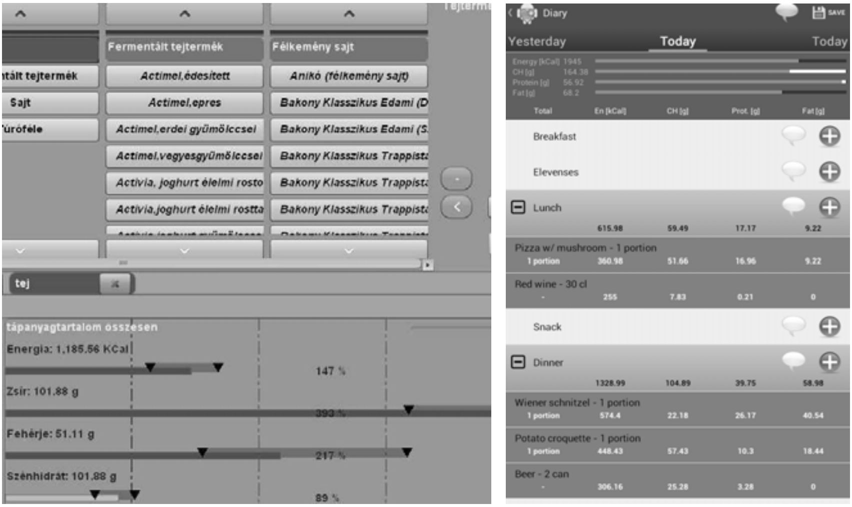


**Fig. 1.** Menugene user interfaces: DietLog (left), Lavinia (right)

**Logging precision: first study.** In the first study, we asked 26 volunteers (university students) to record their meals for 3 days using our web based user interface called Dietlog as well as in a pocket diary printed on paper. Dietlog supports a hierarchical set-based search as well as the usual keyword based search (see Fig. 1). We also allow to log generalized sets (like 'pasta') when the user does not find an exact match. The volunteers received unique passwords for the Dietlog, so they could manipulate only their own log. They were asked to record in the pocket diary exactly what they consumed and everything they consumed. Then the next time they had internet access, they entered new items of the pocket diary into the Dietlog. An entry in the Dietlog contains three parts: the selected food/set/recipe name, a unit and a quantity. The paper diary contains free text.

The Dietlog application recorded the user interaction events (mouse clicks on buttons, texts entered etc) with a timestamp. At the end of the survey, we reclaimed the pocket diaries and analyzed each diary entry manually in comparison with the corresponding Dietlog entry (called the web-log) and user event sequence associated with the entry (called the event-log). The goal of the study was to assess the completeness of dishes and foods, as well as the measurement units supported by the database.

The completed logs in Dietlog contained 523 foods, 180 recipes, and 28 generalized set items, the average time for recording a meal was 51.9 s. The set-based search was used in 51% of the cases. The results for database completeness are summarized in Table 1.

**Table 1.** Dietlog entries vs. paper based diary entries

| Food or dish item | Measurement unit | No. of cases |
|---|---|---|
| Perfect | Perfect | 487 |
| Not perfect | Not perfect | 44 |
| Not perfect | Perfect | 107 |
| Perfect | Not perfect | 84 |
| Missing | Missing | 54 |

The incompleteness of the database resulted in inaccurate items and/or measurement units. We calculated the error with respect to nutrient contents that follows from this incompleteness and found that the web based diaries contained an average daily error of 15.2% (n = 65, inter-quartile range =25.8%) for energy content and 16.9% (n = 65, i.q. range = 26.3%) for carbohydrates.

**Logging precision: second study.** In the second study, we used our android based application called Lavinia (see Fig. 1) to log hospital menus in a rehabilitation hospital. This setting was quite different from the previous study since we had information on the dietary contents of every meal computed manually by the dietitians of the hospital, which made it possible to measure the logging error caused by the recipe variants of the same dish (type 2 error).

The test period was 22 days long, for 5 different menus, so in total we entered 110 days, with 3 meals per day, into Lavinia. Then we computed the nutrient contents with our system and compared the results with the hospital values. During the assessment of the results, we distinguished items (foods and dishes) that could be found in Lavinia with the same name, items that had a different name in Lavinia, and items that were missing. Some items occurred quite frequently (which was a new 'hospital' feature compared to our first study), so per-item nutrient content errors were also weighed with their relative frequency.

The total of 1179 logged items contained 156 different dishes (with a recipe) and 38 foods. Considering foods and dishes together, 68% of them were supported with the same name, 7.7% with a different name, and 24.2% were missing. The missing items, however, were mostly special ones occurring rarely, so the weighed ratios were 86.8% (same name), 4.1% (different name) and only 9.2% (missing), a more encouraging result. Considering only dishes, 66.0% (weighed: 79.2%) were supported with the same name, 7.7% (weighed: 4.8%) with a different name and 26.3% (weighed: 16.0%) were missing, the latter mainly due to special dishes designed for diabetic patients. For the foods only, 76.3% (weighed: 93.1%) of them were supported with the same name, 7.9% (weighed: 3.4%) with a different name and only 15.8% (weighed: 3.4%) were missing. The ratio of missing or hard-to-find items is characteristic to the error of nutrient estimations, so we can roughly say that the chance of not finding an item is around 15%.

**Conclusions and future work.** A general conclusion is that although single items in a dietary log may be quite inaccurate with respect to energy and other nutrient content, the summed resultant of these positive/negative errors is quite low for a longer period. The studies presented show that a relatively simple database with a well designed user interface can deliver nutrient estimation errors around 15%. Current work on the MenuGene system is focused on integrating more medical intelligence for the support of diabetes.

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The paper gives an overview of the challenges of dietary logging applications based on food composition and recipe databases. The MenuGene dietary expert system is briefly introduced with its web-based and mobile user interfaces Dietlog and Lavinia. The focus is the reliability and accuracy of nutrient content estimations based on user logs. The paper presents the results of two small-scale studies that measured the real accuracy of logging, one with healthy users in everyday life, and another in a clinical setting. The results showed that an overall content estimate accuracy of ca. 15% was attainable.