Importance and Quality of Eating Related Photos in Diabetics

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Abstract. Data are the crucial component of most computer based clinical decision support systems. This review focuses on data for a system which should improve everyday life of diabetics. The aim is to identify issues arising during the process of acquisition of photos of dishes obtained by diabetic patients. Solutions are proposed that will improve the quality of subsequent processing and final conclusions. This research will lead to a proposal of some guidelines that patients should follow when taking the pictures of dishes. For this purpose, a sample of 906 photos from 6 patients including meals and text records of activities was examined carefully in order to extract useful information about how do diabetics chose to record the details, how much and how long do they follow the suggestions. Based on the analysis, representative examples are presented with corresponding suggestions for each case.

Keywords: Data analysis · Data quality · Food · Diabetes · Photos · Meals

1 Introduction

The International Diabetes Federation (IDF) is an umbrella organization of over 230 national diabetes associations in 170 countries and territories. It represents the interests of the growing number of people with diabetes and those at risk. The Federation has been leading the global diabetes community since 1950. According to IDF, 415 million people have diabetes in the world and more than 59.8 million of them are from the EUR Region; by 2040 this will rise to 71.19 million[1]. There were 799,300 cases of diabetes in Czech Republic in 2015. Based on the research, the prevalence of diabetes in adults (20–79 years) is 9.9 %, while the total number of cases of diabetic adult patients (from the same age) are 799.3 (1000s) (see Fig. 1).

Diabetes mellitus (or simply diabetes) is a chronic disease that occurs when the pancreas is no longer able to make insulin (*type 1 diabetes mellitus*), or when the body cannot make good use of the insulin it produces (*type 2 diabetes mellitus*). Both cases lead to an increased blood glucose levels (called hyperglycemia), which if causes diabetic complications such as heart failure, heart attack, lesions

[1] http://www.idf.org/who-we-are.

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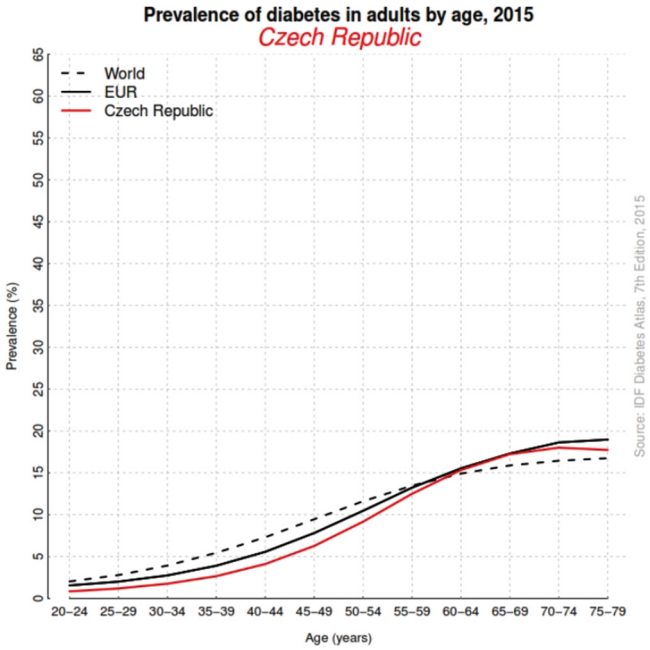

Fig. 1. The figure describes which age groups in the population have the highest proportions of diabetes. The *dotted* line is the distribution of diabetes prevalence by age for the world; the *black* line is the distribution for the region; and the country distribution is plotted in the *red* line. Many middle- and low-income countries have more people under the age of 60 with diabetes compared to the world average. Meanwhile, for high-income countries, a growing population over the age of 60 makes up the largest proportion of diabetes prevalence. (Color figure online) (Source: IDF Diabetes Atlas, 7th Edition, 2015)

of the retina, nerve damage etc. The complexity of diabetes and its effects highly motivates the research on diabetes, where an understanding of the effect of food on glucose levels plays an important role.

Clinical Decision Support Systems (CDSS) can help doctors and patients with the treatment of diabetes. One of CDSS, FEL-Expert system, is a universal diagnostic expert system that is able to provide expert advice, decision or solution recommendation in a particular situation. Figure 2 shows the basic architecture of such an expert system [4]. The first and one of the most crucial steps in the development of such system is data acquisition, information extraction and drawing conclusion. In the light of the acquisition of data by patients, the quality (not only the quantity) of the data can help the experts to increase reliability of the conclusions and simultaneously reduces an unnecessary and bothering effort related to the data acquisition For those reasons, a set of examples was collected, specific quality issues are detected and their solutions are proposed in this paper.

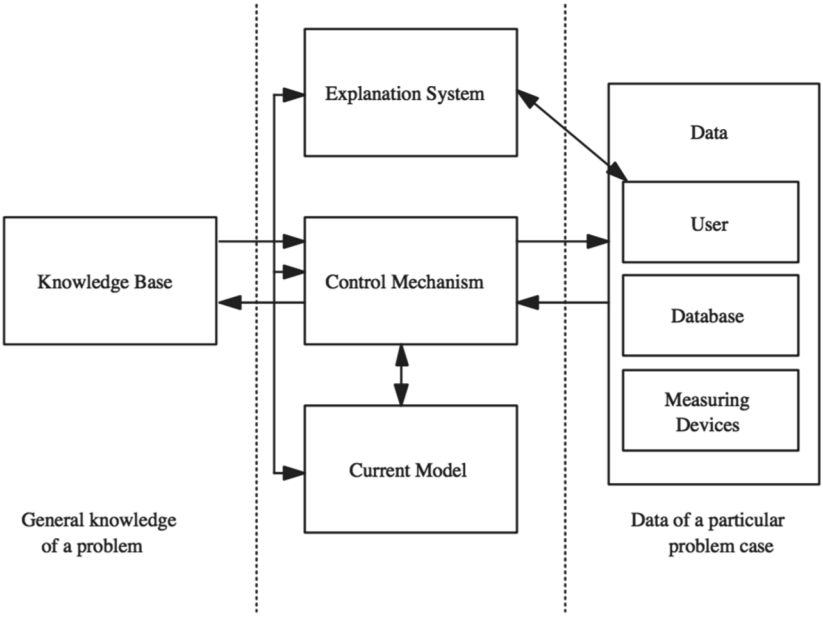

Fig. 2. Block schema of a diagnostic expert system (Source: Uncertainty processing in FEL-Expert, Lecture notes, [4])

2 Diabetes Mellitus, Carbs and Activity

The monitoring of diabetes includes monitoring of weight loss, exercise and healthy eating (meals that optimally combine all three food categories ratio). The food ingredients are proteins (e.g. meat, fish, cheese, egg, milk), carbohydrates and fat [3]. It is a myth that diabetics should not eat carbohydrates. It used to be advise by physicians before insulin became available, because it was known that carbohydrates increase the blood glucose levels. Today, however, diabetics can enjoy a healthy and balanced diet, which should include carbohydrates [2]. After many years of several investigations and efforts, it becomes clearer than ever how important is to incorporate proper nutrition and exercise in everyday life.

3 Pilot Study

In order to be able to create a knowledge base for a CDSS, we asked patients with *type 1 diabetes mellitus* to record daily consumed meals and snacks, write down the time and take pictures of meals. An information from pictures can provide the calculation of the size of the portions. Further, insulin levels and the values of blood glucose are recorded by sensors within one month. Moreover, it was suggested to patients to record the time that they use bolus insulin. Up

Table 1. Summary of the patients

Sex	Age (yrs)	Weight (kg)	Height (m)	BMI	Total insulin dose (avg)	HBA1c (mmol/mol)
F	27	74	1.55	30.8	41.1	80
M	54	88	1.84	25.99	47.2	39
F	45	70	1.73	23.39	43.2	96
M	47	92	1.89	25.76	43.6	64
M	45	86	1.85	25	40	59
M	35	102	1.92	27.6	53	59

to now, eating habits of six patients (two women and four men) with type 1 diabetes mellitus were captures. The age ranged between 27 and 54 years.

The first elements that are necessary for further analysis and calculations are the gender, age, height and weight (Table 1). Then, the Body Mass Index (BMI) was evaluated for each patient:

$$BMI = \frac{weight(kg)}{height^2(m)} \tag{1}$$

The total average insulin dose (during one month) and the levels of glycated hemoglobin (HBA1c) are also included in the Table 1. By measuring glycated haemoglobin (HbA1c), clinicians are able to get an overall picture about average blood sugar levels. This is important as the higher the HbA1c, the greater the risk of developing diabetes-related complications. The target value for HbA1c of diabetics is 48 mmol/mol (6.5 %) [2]. BMI assigns the persons as underweight (15–18.5), normal weight (healthy, 18.5–25), overweight (25–30) or obese (30–40) [5]. In our sample, one patient is characterized as obese (the first patient), four as overweight, and only one patient was keeping a normal weight. Additionally, all patients have elevated HBA1c levels except one. This first picture makes clear that patients should be motivated to control diabetes in a better and more effective way.

As already mentioned, the process of creating a strong and comprehensive knowledge base will be focused in the project. This obviously needs much more data to be acquired. However first, the quality of data acquisition must be improved to make it possible to get a more useful information from the recordings and pictures. Particularly, a metric systems (e.g.calculation of quantities with linear scales) is missing as well as and the lack of records about activities (gymnastics, walking, etc.) It is noteworthy that while same instructions were given to all patients, almost 6 different versions of the data appeared due different personalities of the patients (e.g. how each one wants to improve his daily life). Moreover, the patients probably differ in the free time that each patient devotes to data acquisition. It was observed that women recorded more pictures than males, which can be observed in the Table 2).

In the following, we will present an analytical explanation of the basic problems which arose in the recording of meals and activities, taking photos and using the metric systems. In any case, we will try to suggest alternatives that

Table 2. Total estimation of number of photos per patient

Sex	Number of photos
F	267
M	163
F	270
M	163
M	70
M	117

should make the process easier for patients and more efficient for the experts who will get a most "powerful weapon" and a more solid foundation for creation of a functional expert system.

3.1 Recording Meals - Text Records

Initially, patients were asked to record meals and snacks that they consumed during one month. Table 3 shows how many records have been gained from each patient. Although instructions were the same for all patients, we noticed that they did not succeed to write down daily meals which probably attributed to lack of time or some other difficulties of recording (e.g. eating out in a restaurant). The complete lack of information for the last patient complicates the analysis of data because the recordings provide additional information that is not "visible" in images. In the case that there is no time to record the necessary details of meals, as may occur when the patient goes into a restaurant or eats during the work, a better proposal would be probably to make voice records using cell phone which is faster and more simple both for the patients and the experts.

Table 3. Number of recordings/total days of records from each patient

Patient	Photos/total days of records
1	30/33
2	30/36
3	32/43
4	19/19
5	30/33
6	0/13

Furthermore, we will try to represent the quality of records content and propose solutions for improvement. We will start with presentation the wrong examples to be avoided. The first information that should be provided is the type

of these food or drinks (e.g. type of bread). Most of the times, this information is not evident even in photos but is very important for the analysis of data because there are a few different kinds of beer or bread with different carbohydrate content.

Table 4. Different types of food and carbs

Type of bread	Total carbs (g)
white bread (2 slices serving)	25.30
Rye bread (2 slices serving)	24.51
Mixed grain bread (2 slices serving)	24.13
Dinner roll (1 roll serving)	14.11
Type of rice	Total carbs (g)
White (1 cup of cooked)	44.08
Brown (1 cup of cooked)	44.42
Beer (1 can or bottle)	Total carbs (g)
Regular	12.64
Brown ale	18.00
Light	5.81

Table 4 shows some examples in the content of carbohydrates and demonstrates how important is to know the particular type of the food[2]. For example, if we only see the picture of a glass of beer we can not suppose or understand the type of it. As a result, we should recommend patients to write down the type or take a picture of the bottle of the beer and the ingredients. Another useful information is to record the weight of the food when it is necessary and we can make estimations from the pictures. There are two solutions in order to give the portion size. First, the patient should take a picture of the whole package(in order the grams to be obvious) and refer how much he/she consumed. The other way is to write down the weight (or its estimate). For example, when we see bowl of yogurt it is really difficult to estimate its weight so the patient should add this information in the text records. In Fig. 3 the patient took a picture of the package of the yogurt so we can easily estimate the food portion and the only additional information we need to know is how much of it he/she consumed. In Fig. 4 patient took a picture of a bowl of yogurt and he recorded the whole meal (not the portion size or grams of yogurt in the bowl).

In Fig. 5 the patient recorded details in a better way but not as satisfactory as we need. She recorded the exact grams of meat, we can make an estimation of the amount of potatoes, but it would be useful to know also the type and the amount of vegetables. In summary, we could suggest some simple solutions

[2] https://www.fatsecret.com/calories-nutrition.

Fig. 3. Example of yoghurt photo

Fig. 4. Another example of yoghurt photo

that will make a difference in the quality of data and make them more reliable. Patients must pay attention to the differences between the different types of the same food (as shown in Table 4), record the quantity (grams, portion size etc.) especially when it is not obvious from the photos (e.g. mashed potatoes; the patient should give details about the recipe and how many potatoes he/she used). In case of lack of time or ability to write down details, voice record should be used. Another important factor is the way of cooking as it has been shown

Fig. 5. Photos from patients(c)

to play an important role on to the calories you get from the consumption of food [1]. Therefore, we advise patients to record the quantity, the type of food and the way of cooking so that together with the photographic material it will make a more complete picture of their eating habits.

3.2 Metric Systems

Obviously, another factor than can play a vital role to the best estimation of portion sizes is addition of a ruler. What can patients use as a ruler and in which way? Apart from the rulers with scales, an alternative suggested to patients are spoons, forks or knives and in some cases pens or pencils. We will initially examine the sample of patients on the use of rulers of all kind in order to discuss the results and notice the advantages and disadvantages of using them. What is more, after the examination we will present some better ways to improve pictures by using rulers.

Table 5. Use of rulers/total days of records from each patient

Patient	Rulers/total days of records
1	59/267
2	14/163
3	129/270
4	13/70
5	60/163
6	16/117

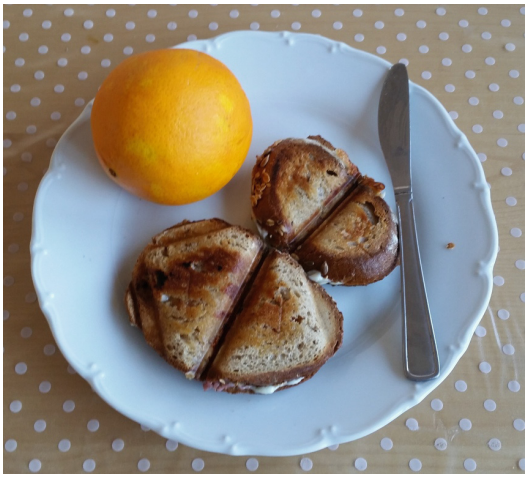

Fig. 6. Photos from patients(d)

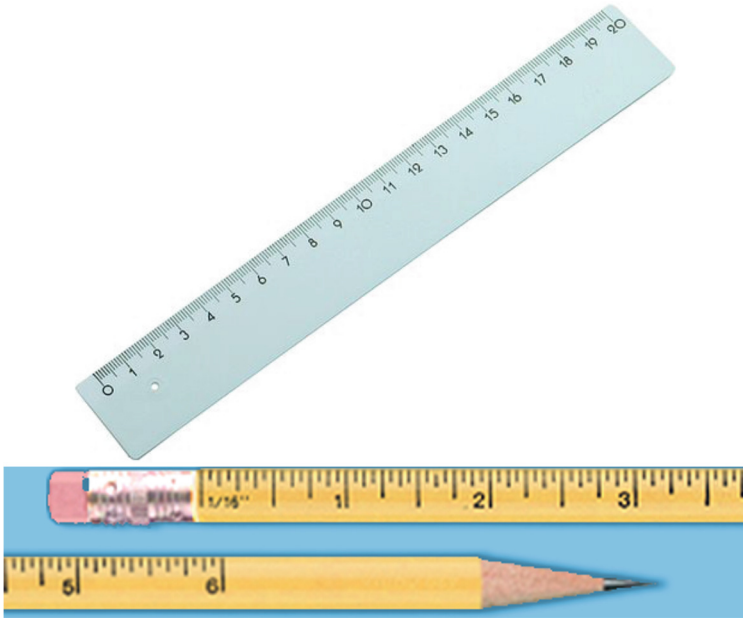

Fig. 7. Suggestions for better estimations

Table 5 shows that the use of rulers or their alternatives (spoon, knife, fork) according to the total registered meals is quite small. We will examine some extended photos and we will introduce some better ways to use them. In most cases, the issue is not just the use of a ruler but also to find the right and

Fig. 8. Photos from patients(e)

Fig. 9. Photos from patients(f)

most convenient way to do that. As a result, we can present some disappointing examples and how to improve them. We can suggest the use of scale as another alternative way of reference ruler. In Fig. 6 the patient decided to use a knife as a ruler, but first of all it is not obvious what the patient wanted to measure. The first suggestion can be to measure separately the ingredients and in different photos to help scientists to make conclusions. Obviously, it is not convenient to use knives (or spoons and forks), because there are many kinds and different scales. It is better prefer a common ruler. However, it is remarkable that no

Fig. 10. Photos from patients(g)

patient used this ruler. Another alternative method would be the use of common pencils with scales (Figure 7).

3.3 Quality of Photos

Another important factor is the angle of making photos. It is very useful if we can estimate size of the food (e.g. width, height and thickness of a piece of bread). It is very useful to shoot also the packages of products at a distance from which one can read the ingredients or find the details about the product. A good example of a difference can be found on Figs. 8 and 9. Instead of taking pictures of just the slices of salami, it is better to photograph the packaging of salami and report how many pieces are consumed.

Fig. 11. Photos from patients(h)

Figure 10 shows the difference between the ways of taking pictures. In the first picture we cannot estimate the size of the slice of bread and the patient did not record any details about that, but in the second picture, even if the patient does not write down details about the portion size we can make an estimation about it. So, it is clear that it is important for patients and clinicians to know the proper way of taking pictures to avoid a wasted effort.

Another improvement would be the recording of food before and after consumption (see Fig. 11). Thus, patients do not have to write many details as a picture equals to a thousand of words in many cases.

4 Discussion and Conclusions

The first estimates after the connection of the meal with the glucose levels shown the great need to consult patients about the correct way to combine food and to integrate gymnastics and activities in their everyday lives. These instructions would help patients to manage the disease and will inspire the prevention of it against the sedentary lifestyle that promote from the western society. This project is at the beginning stage but the question of quality, reliability and usefulness of the data is crucial for its future success. This question is also solved by many research groups in recent years. In this review, we suggested solutions useful for the patients but at the same time support experts to reach better conclusions and create a really useful knowledge base for future applications. It is very important for patients to find and realize the real importance of recording the data properly in order to help themselves but also to other patients all over the world.

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