

Mobile electronic patient diaries with barcode based food identification for the treatment of food allergies

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Introduction

The management of food allergies consists in educating the patient to avoid ingesting the responsible allergen. Patients are required to keep food diaries to identify individual allergens in the daily food. Several studies have shown that significant amounts of the data in paper diaries is fudged or fabricated [1], [2]. Patients often report just minutes before the doctor's appointment about events from the preceding days or even weeks. These "parking lot diaries" are of course of poor data quality. The use of electronic, computer-based diaries promises a much higher accuracy of the collected data [3], [4]. Although ingredient lists must be printed on the food packages and the EU legislation improved the labelling of allergens [5], certain drawbacks exist. There is no central database with ingredient information available [6]. While purchasing their food, people are left alone with diverse ingredient descriptions that are difficult to read and understand. In the worst case affected persons increasingly disregard advisory labelling [7].

To overcome the mentioned obstacles, a major goal of the MENSSANA (Mobile Expert and Networking System for Systematical Analysis of Nutrition-based Allergies) project was the development of an integrated Allergy Information System for health professionals and patients, based on modern mobile computing and database tech-

nology. Figure 1 gives an overview of the actors and tools in the MENSSANA project.



Figure 1: MENSSANA Overview

The patient tool for interaction is the Personal Allergy Assistant (PAA[®]) that allows the concerned persons to keep their diary electronically and get easily information about food products using a barcode reading device. The data on the mobile device is synchronised with a particularly developed Electronic Patient Record for Allergies on a specific Server. The treating allergist has access to the patient data and can examine the electronic diary and, if required, update the patient allergy profile.



Figure 2: Screenshots of the PAA User interface: (I) main screen to select the main operation modes, (II) diary entries for a specific date, (III) warning dialog not to consume a specific food

Barcode based electronic patient diary (PAA®)

The PAA is a barcode-reading smartphone and allows creating diary entries simply by scanning the food package's EAN barcode. Automatic timestamps reduce potential data tampering and increase the data quality. Even the food intake of non-packed food (e.g. fruits and vegetables) as well as pharmaceuticals (e.g. antihistamines) and experienced symptoms are stored in the electronic diary. The assessable time relationship between the consumed product and the experienced symptoms is of high value for diagnostics as well as for therapy control. In addition, the PAA is able to give a warning before consumption, whether the food contains one of the patients threatening allergens. For that purpose the treating allergist manages the patients' individual allergy profile, based on his diagnostic results. The patient synchronises his PAA once per week remotely with the MESSANA Electronic Patient Record for Allergies (EPRA). The PAA stores the patient related information and data about all known food products and the patient's tolerance to them. This makes the device independent of a continuous online connection and thus reduces costs.

EAN barcodes

EAN (European Article Number) barcodes are printed on most of the available consumer products and are normally used at the supermarket checkout to allow a fast billing. The EAN barcode itself contains an eight or thirteen digit number. EAN barcodes are well standardised, cheap, and already widely used and accepted. RFID (Radio Frequency Identification) chips are nowadays mainly used in logistics but not in consumer retail as their costs compared to printed barcodes is fairly high. However, simple RFID chips also encode an index number similar to the EAN barcode. Thus, the PAA could be fairly easily enhanced

to be able to treat items with RFID chips using an RFID scanner, if RFID chips would be employed in future.

PAA user interface (UI)

One important asset of the PAA is its user friendliness. The UI (Figure 2) of the PAA can be roughly divided into two main parts: a Shopping (or Information) mode and a Diary mode. Besides these two parts, there is the Synchronisation mode, which is used only once or twice a week. In the diary mode, new entries can be easily added to the diary using either the barcode scanner or selection tools for unpacked food items, experienced disorders, taken pharmaceuticals or done activities. The fast access allows entering these entries with just one click. The shopping mode allows a quick search for information about a food product while being in a store. With this rapid lookup of food items, the PAA user gets an immediate response about his or her tolerance to the specific food product. Large buttons allow the access of functionality without using a specialised stylus. Also, the user can select the language of the PAA system between English, German, and French.

Non-packed food items

To allow the user to easily insert entries into the diary of non-packed food items, i.e. food items without barcodes, we defined a list of foods that are relevant for food allergy diagnosis. The food items are sorted into different groups, e.g. fruits, vegetables, meat, dairy products, and so on. For a quick access of the desired item, the user first selects the class of the food and afterwards the item itself. We also created a booklet with these food items and assigned barcode numbers to them. Thus, the user is able to scan the barcode of the food item and look it up or insert it into the diary the same way as with packed food when he or she uses the booklet. Currently, the booklet contains 321 different food items.

Protection of patient data

The synchronisation of the PAA with the central database system uses unprotected lines such as the GSM network and Internet. As patient relevant data is transferred, it is of very high importance that these data are well protected against illegal access. This protection has been realised by separating it into two complementing layers. First, on each connection, the PAA and the server system negotiate on a new encryption key and all data that is transferred is encrypted using this newly created key together with a state of the art encryption cipher (Blowfish). The approach to create a new encryption key for each connection ensures that, if one key would have been unfortunately eavesdropped, the key is useless for the attacker as it can not be used for another connection in order to illegally access data. The second measure to protect the sensitive data is to embed the whole PAA to server communication using a Virtual Private Network (VPN) Tunnel. The tunnel is encrypted using to predefined encryption keys and helps to fend off attacks in the forefront. This double layer protection makes it very unlikely that sensitive data can be misused.

Hardware selection

In order to perform the clinical study foreseen in the project a Windows Mobile PDA with cell phone capabilities has been selected. The GSM capability of the tool allows transferring the data to and from the server using the mobile phone network. Important for this PDA is the possibility to connect a barcode scanning device to it. For this, SDIO Scan Cards with CMOS linear imaging have been selected. This combination proofed to be the best-priced and favourable solution.

Allergy Information System

To warn the patient about potential allergic reactions before consumption, the Allergy Information System needs to interpret the products' ingredient lists. Unfortunately, the ingredient lists of food products are based on less structured free text, often in several languages, which uses synonyms and a variety of expressions for food ingredients and additives.

Morphological analysis of ingredient lists

The detection of the comprised allergens in ingredient lists requires the application of natural language processing. Several morphological analysis algorithms are applied in order to compare the contents with a list of known food ingredients. We decided to do this kind of semantic analysis in a semi-automatic way. The system will propose a potential solution that has to be validated by an operator before it will be used in the MENSSANA applications.

Definition of allergens

Prior to the development of the MENSSANA Electronic Patient Record for Allergies, there existed no entire listing of allergens related to food allergy. Using allergist expert knowledge, we defined a list of allergens that are relevant for food allergy. Currently, the resulting list comprises 665 entries that are included in the MENSSANA knowledge base. The attending physician uses these allergens to assign incompatible allergens to patients' profiles. As the allergens are linked to a list of possible ingredient names, the appropriate food products are marked dangerous for the corresponding patients. The mapping between the allergens and ingredient names will grow when more and more ingredient listings are evaluated and new entries to the ingredient names are appended. Figure 3 shows a screenshot of the MENSSANA Management application. In the lower part of the picture, one can discover that the system identified two allergens in the food relevant to the selected patient, namely *Hazelnut* and *Lemon*. In the MENSSANA knowledge base, the allergen *Hazelnut* is linked, besides many others, to the ingredient name *Haselnuss*, and this ingredient name has been identified to be present in the ingredient listing by the morphology algorithm (see above). *Lemon* has also been linked to an ingredient name that has been automatically detected by the morphology algorithm. This overview makes it easy for the attending physician to study in which food ingredient the affecting allergens are contained.

Outlook

Clinical study

Together with the Institut für Medizinische Statistik, Informatik und Epidemiologie (IMSIE) in Cologne, we have set up a study protocol and patient information for the MENSSANA clinical trial. The important question is, if a PDA based information service improves the quality of care and the quality of life (QoL) of people suffering from food-based allergies. The chosen approach shall be proved by a prospective study. To determine whether there is a significant change in QoL and health care costs over time a minimum of 100 patients will be enrolled. The study started in Spring 2008 by enrolling the first individuals.

Barcode reading via barcode photo recognition

The PAA solution with external barcode reader has the disadvantage that due to the required dedicated hardware, the number of users is limited. However, many people own mobile phones with a built-in camera. The concerned persons should use the integrated camera of the mobile phone to take a picture of the barcode printed

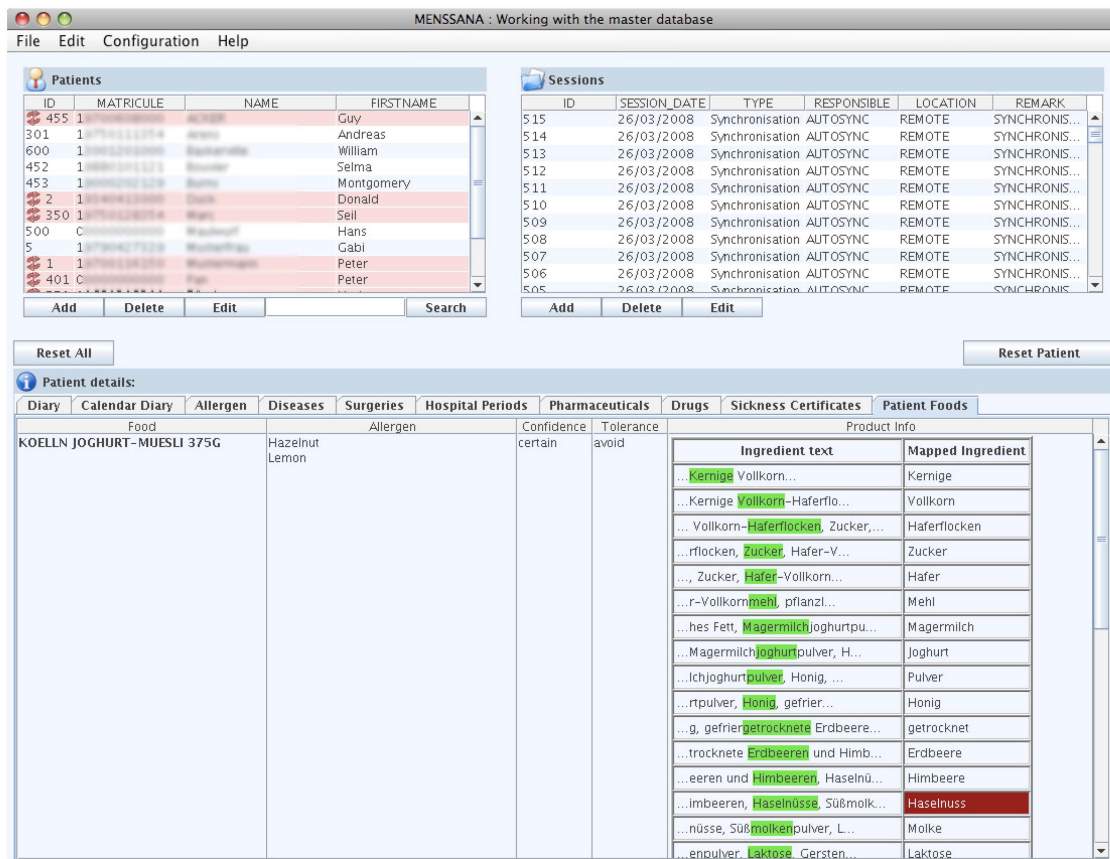


Figure 3: MENSSANA Management GUI

on product packages. For testing purposes, a new version of the PAA software has been developed, which runs on conventional mobile phones. It has been tested, how the internal camera can be used to recognise the barcodes of food products. We expect the coming generations of mobile phones to be powerful enough to perform the necessary tasks and have enough storage capabilities. This would make the PAA approach available to a wider audience.

Notes

Conflict of interest

Non declared.

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