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ORIGINAL ARTICLE

# Web-based eHealth applications with reference to food composition data

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**Background/Objectives:** Food composition data (FCD) can provide important information in relation to diet and health; therefore, data on food composition have broad applications in health care. The objective of this study was to provide an overview of added-value eHealth systems that use modern information and communication technologies to support health and are related to FCD and nutrition. This paper also examines whether reliable and comprehensive FCD are used in eHealth systems.
**Methods:** A total of 25 instances of eHealth systems from nine groups, defined with respect to the services that eHealth systems provide, were randomly selected. The selection of the population-based and expert-based eHealth systems took into account diversity, complexity and popularity.
**Results/Conclusions:** As most of the reviewed population-based eHealth systems used the United States Department of Agriculture nutrient database or basic FCD provided by the food products' producers, and only a few of them relied on local or national FCD, the author believes that, in general, the use of comprehensive FCD in the reviewed population-based eHealth systems has not reached a satisfactory level. Furthermore, many of these systems would increase their value by providing more detailed information on FCD and by addressing the nutritional aspects of health with greater emphasis. In contrast, most of the reviewed expert-based eHealth systems proved to be reliable and rich sources of nutrition information, respecting the need to address the subject from both national and international aspects.
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**Keywords:** food-composition data; eHealth; mHealth; medicine 2.0; nutrition; clinical nutrition

## Introduction

Food composition databases provide detailed information about the nutritional composition of foods. The values for energy, nutrients (including macronutrients, vitamins and minerals) and other important food components (such as fibre) for each of the foods listed are based on chemical analyses, which are carried out in analytical laboratories, or are estimated on the basis of other appropriate data. Information about the nutritional composition of foods is essential for a variety of purposes in many different fields of work (Williamson, 2006). It forms the basis for a quantitative study of nutrition, and is widely used in epidemiological research, clinical practice, health promotion, policy and food manufacturing.

Food composition data (FCD) may be available in different formats. Although printed food-composition tables are still produced in most countries, computerised databases have become increasingly important. They can hold large amounts of data and allow easy access to and manipulation of data. Electronic formats range from plain text and spreadsheet formats available on data carriers (for example, CD-ROMs) to databases with online access. In addition, there are many other products based on, or dependent on, FCD.

This paper provides an overview of added-value products based on FCD, with a focus on eHealth systems. eHealth systems refer to solutions at the edge of medicine/health care and information and communication technologies (ICTs), aimed at a wide spectrum of users, including consumers, health professionals and caterers. The paper also examines whether reliable and comprehensive FCD are used in eHealth systems.

## eHealth evolution: from medical informatics to (clinical) nutrition 3.0

The *medical informatics* underlying eHealth started in the 1950s with the rise of microchips and computers. In the

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1960s, the first complex software solutions for health and medicine were developed. Hospitals started using *Electronic Data Processing systems* in hospital administration and later on in patient care and medical decision making. The application of electronic data processing-based systems in primary health care started at the beginning of the 1970s. The use of telematics *(the integrated use of telecommunications and informatics)* in health and medical care in the 1980s profoundly changed the relationship between patients and health-care providers. In the 1990s, *telemedicine* expanded into *telehealth*, that is, the delivery of health-related services and information through telecommunications technologies (Mandil, 2005; Krupinski *et al*., 2006). Whereas telemedicine narrowly focussed on the curative aspect, telehealth has encompassed preventive, promotive and curative aspects. Today, telehealth stresses a myriad of technology solutions. Its delivery can be as simple as health professionals discussing a case over the telephone, or as sophisticated as using videoconferencing between providers at facilities in different countries, or even as complex as robotic technology. Since 2000, the term *eHealth* has been widely used and has become an accepted neologism despite the lack of an agreed definition.

In 2006, the Global Observatory for eHealth, established by the World Health Organization, defined eHealth as the use of ICTs for health (WHO Global Observatory for eHealth, 2006). The Global Observatory for eHealth has recognised eHealth as one of the most rapidly growing areas in health.

Besides the Global Observatory for eHealth's succinct definition of eHealth, there are many other recorded definitions, such as '*eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.*' (Eysenbach, 2001).

### *Medicine 2.0*

One of most commonly discussed terms related to eHealth and Web 2.0 (Web 2.0 generally comprises web applications that facilitate interactive information sharing and collaboration on the World Wide Web and allows users to interact with each other as contributors to the website's content) is Medicine 2.0 (or Health 2.0). The concise definition of Medicine 2.0 was suggested by Hughes *et al*. (2008): '*Medicine 2.0 is the use of a specific set of Web tools (blogs, Podcasts, tagging, search, wikis, etc.) by actors in health care, including doctors, patients, and scientists, using principles of open source and generation of content by users, and the power of networks in order to personalize health care, collaborate, and promote health education.*'

Although neither stakeholders nor the principal tools used distinguish Medicine 2.0 from eHealth, the principles of open source, the generation of content by users, the power of networks, personalised health care and the focus on collaboration across all stakeholders are not representative of the key objectives of Medicine 2.0.

The emergence and adoption of Web 3.0 led to semantic web applications that have a major impact on medicine and bioinformatics. Web 3.0 enables the processing of huge amounts of data from disparate systems and the building of semantic relations between the data for knowledge discovery. Modern eHealth systems (also called Medicine 3.0 systems), developed by using the latest ICTs, are very personalised and may treat patients' health problems according to their personal profiles (for example, genetic profile). Moreover, such systems are based on the input, and thus knowledge, of experts, whereas Web 2.0 systems are based on the input of collective intelligence.

Although the history of nutritional science dates back hundreds of years (Carpenter, 2003), the importance of adequate nutritional support, which is as fundamental to a patient's treatment as drugs and other therapeutic methods, has not been widely appreciated (Sobotka, 2004). eHealth systems supporting effective nutrition education and providing the latest nutrition information, which are crucial for the promotion of (clinical) nutrition into broad (clinical) practice, are essential and deserve their own term, such as Nutrition 3.0 or Clinical Nutrition 3.0.

There is strong evidence supporting the effectiveness of eHealth solutions in health care. Many research studies have been carried out demonstrating health-behaviour change (Cobb *et al*., 2005; Marcus *et al*., 2007; Cullen and Thomson, 2008; Hunter *et al*., 2008), as well as improved chronic illness care and disease management (Lorig *et al*., 2006; Bourgeios *et al*., 2008), because of eHealth support.

## eHealth systems based on FCD

Many eHealth systems have been developed to deal with information management and the procedural challenges of health care. In this paper, a selection of eHealth systems that provide different services based on FCD is presented. These services include citizen-oriented and specialist-oriented services, telehealth services and mobile eHealth services. According to the statistical data provided by Quantcast (available from http://www.quantcast.com/), the selected systems reach several million people each month. A deeper insight into health-promotion websites, in-house hospital information systems and cross-border clinic-to-clinic services is provided by knowledge bases, such as the Good eHealth Knowledge Base (available from http://kb.good-ehealth.org/).

### *Citizen-oriented services*

eHealth systems providing citizen-oriented services may be classified as *Information provision systems* or *Systems supporting virtual communities* (Table 1). So-called social networking has

**Table 1** eHealth systems using food composition data

| | |
|---|---|
| *Citizen-oriented services* | |
| *Information provision eHealth systems* | |
| Wolfram\|Alpha[a] | An *inference engine*, which is a software tool that tries to derive answers from a knowledge base. The main source of FCD is the USDA National Nutrient Database for Standard References, Release 21. Microsoft confirmed a partnership with Wolfram\|Alpha that incorporates health and nutrition-related data into the **Bing**[b] search results |
| eMedTV[c] | Offers health channels, each serving as a portal to an extensive library of peer-reviewed medical information, both in written and multimedia format |
| SurveyorHealth[d] | An advanced drug safety utility that immediately creates a personalised risk assessment for a given user. It shows not only drug–drug interactions but also the much more common and often dangerous adverse side effects of a drug. Another similar tool is provided by the **LaegeMiddel**[e] system, which was awarded the World Summit Award[f] in 2008. Although the LaegeMiddel system provides information on some drug-micronutrient interaction, the Surveyor Health system does not provide any information on drug–food interactions |
| *eHealth systems supporting virtual communities* | |
| eHealthForum[g] | A *virtual community* for medical questions and answers. It works with trusted content providers to bring health information to people everywhere. The system connects registered members with others by symptom, side effect, syndrome, surgery and disease |
| PatientsLikeMe[h] | A *community-based personalised medicine platform* for people with life-changing conditions. Its Genetics Search Engine is an important step toward incorporating genetics for the PatientsLikeMe communities. Nutrition information is provided to a lesser extent, with emphasis on nutritional supplements |
| *Specialist-oriented services* | |
| *Information provision eHealth systems* | |
| Medscape[i] | A resource for specialists and consumers alike. It features peer-reviewed original medical journal articles, Continuing Medical Education, a customised version of the MEDLINE database, daily medical news, major conference coverage, and drug information, including a drug database (Medscape Drug Reference) and drug-interaction checker. |
| *Journal of Medical Internet Research (JMIR)*[j] | The leading eHealth *open-access, peer-reviewed*[k], *online journal*, which has been publishing research and opinions on how the Internet is changing medical practice, transforming biomedical research and empowering health-care consumers. The JMIR's sister publication is the **Cases Journal**[l]. Although the *JMIR* is a more selective journal, the Cases Journal publishes any case report from any area of medicine that is understandable, ethical, authentic, and includes all the information essential for its interpretation. The published articles are listed in PubMed and are covered by PubMed Central and Scopus |
| e-Book[m] | An *engine* for searching the Internet |
| CiteULike[n] | A *social bookmarking tool*, designed specifically for the needs of scientists and scholars, to promote and develop the sharing of scientific references among researchers. The CiteULike's breed **Connotea**[o] is an online *reference management service* for researchers, clinicians and scientists |
| *eLearning and professional collaboration eHealth systems* | |
| Medting[p] | Aimed at the *exchange of clinical cases, images and videos*. It may be exclusively used by clinicians for clinical peer-review, telemedicine, research, teaching, second opinion and decision support purposes. Medting complies with the HONcode[q] standard for trustworthy health information |
| *eHealth grids* | |
| Computational grids | **Healthgrids**[r] are grid infrastructures comprising applications, services or middleware components that deal with the specific problems arising from the processing of biomedical data. Resources in Healthgrids are databases, computing power, medical expertise and even medical devices. Another example is **NuGO-GRID**[s] that provides database and computing resources for bioinformatics |
| Knowledge grids | **The EuroFIR**[t] (European Food Information Resource) information platform is an example of a knowledge grid, which focuses on providing support for data categorisation, information discovery, ontologies, and knowledge sharing and reuse. It provides the first comprehensive pan-European food information resource, using state-of-the-art database linking, to allow effective management, updating, extending and comparability |
| *Telehealth services* | |
| *eHealth systems for personal medical records* | |
| Google Health[u] | A *personal health-information centralisation service* by Google that recently underwent a two-month pilot test with 1600 patients of The Cleveland Clinic. Its search engine provides information not only on USDA National Nutrient Database but also on other FCDBs |
| Microsoft HealthVault[v] | A competitive example of an integrated patient-centred platform for delivering all aspects of digital health care that support PMRs. As the HealthVault also works together with doctors, hospitals, pharmacies, and manufacturers of health devices, it may be classified as a Health 3.0 system. According to the information from the List of all HealthVault vocabularies, this system uses the USDA National Nutrient Database, Version 20 |
| SugarStats[w] | Provides online diabetes management, community support and collaborative sharing to motivate and improve health |
| *Health 3.0 (or Nutrition 3.0, or Clinical Nutrition 3.0)* | |
| MediXine[x] | A system that provides *multimodal communication services* for health care and wellness. These include population-based health forecasting and reminder systems, expert-based scheduling and feedback systems, and patient-based disease management and care systems |

**Table 1** *Continued*

| | |
|---|---|
| *Mobile device-based applications (mHealth)* | |
| USDA Palm OS | An example of a FCDB that provides people with a mechanism for looking up the nutritional information about foods by using a personal digital assistant (USDA (United States Department of Agriculture), 2008) |
| myFoodPhone[y] | Another example of a mobile application, which enables people to take pictures of foods they are consuming with their camera-equipped mobile phone and post them to an online food journal to receive feedback from a nutritionist |
| *Barcode recognition ehealth systems* | |
| GoodGuide for iPhone[z] | With this iPhone application, the user scans the barcode of a product and immediately receives detailed ratings for health, environment and social responsibility for more than 50 000 products and companies. The nutrition information is obtained from food producers |
| Hybridmedia (Järvinen, 2005) | A similar, yet more advanced tool to deliver personalised product-specific information about food that has been developed and patented in the TIVIK project. It provides food information from the FCDB Fineli, established by the National Public Health Institute in Finland |

Abbreviations: FCD, food composition data; FCDB, food composition database; ICT, information and communication technologies; PMR, personal medical record; USDA, United States Department of Agriculture.
[a]Available from http:// www.wolframalpha.com/
[b]Available from http:// www.bing.com/
[c]Available from http:// www.emedtv.com/
[d]Available from http://www.pharmasurveyor.com/
[e]Available from http://www.medicinkombination.dk/
[f]The World Summit Award is a global initiative to select and promote the world's best e-Content.
[g]Available from http://ehealthforum.com/
[h]Available from http://www.patientslikeme
[i]Available from http://www.medicinkombination.dk/
[j]Available from http://www.jmir.org/
[k]As ICTs have developed, science can directly use new tools and apply similar concepts by analogy (gunther-eysenbach.blogspot.com/2008/06/open-peer-review-20-vs-traditional.html; www.scientificamerican.com/article.cfm?id = science-2-point-0).
[l]Available from http://casesjournal.com/
[m]Available from http://www.toodoc.com/
[n]Available from http://www.citeulike.org/
[o]Available from http://www.connotea.org/
[p]Available from http://medting.com/
[q]HONcode (available from http://www.hon.ch/) is the oldest and the most used ethical and trustworthy code for medical and health-related information available on the Internet. The HONcode is designed for two target audiences: the general public and the Web publisher, actively involving the site owner in the process of certification. The HONcode is granted by the HON Foundation, which is a non-governmental organisation, internationally known for its pioneering work in the field of health information ethics.
[r]Available from http://community.healthgrid.org/
[s]Available from http://www.nugo.org/
[t]Available from http://www.eurofir.net/
[u]Available from http://www.google.com/health/
[v]Available from http://www.healthvault.com/
[w]Available from http://www.sugarstats.com/
[x]Available from http://www.medixine.com/
[y]Available from http://www.myfoodphone.com/
[z]Available from http://www.goodguide.com/

become central to many eHealth systems and involves the explicit modelling of the connections between people, forming a complex network of relations, which in turn enables and facilitates collaboration and collaborative filtering processes (Eysenbach, 2008).

Devices called *embedded systems* may incorporate an information-provision eHealth system. An example of such devices is nutrition scales, which are digital kitchen scales that help individuals understand the essential nutritional values of the foods they eat. Household appliances such as refrigerators, microwave ovens or cooker hoods may be equipped with an LCD screen, DVD and WLAN device, which connect the kitchen with the outside world (using the Internet). In shops and restaurants, information terminals (such as tablet PCs), smart scales and personal shopping assistants mounted on shopping trollies may be used to help the consumer make informed choices directly at the point of decision.

*Specialist-oriented services*

eHealth systems providing specialist-oriented services may be grouped into *Information provision systems, eLearning and professional collaboration systems, and Grids* (Table 1).

*Telehealth services*
In the field of telehealth, eHealth systems may be grouped into *Personal medical records* (also called electronic health records, patient health records or personal health records, are not the same as medical records; whereas medical records contain information about the person's health that is compiled and maintained by each of his or her health-care providers, a personal medical record is information about his health compiled and maintained by the patient) and *Health 3.0* (or Nutrition 3.0, or Clinical Nutrition 3.0) (Table 1).

In the context of Web 3.0, *inference engines* combine the latest innovations from the field of artificial intelligence with domain-specific ontologies to enable deductive reasoning at the machine level. An example of such an engine is the MenuGene system, which is designed for dietary-menu planning. The engine is based on a genetic algorithm that was developed to provide the means for computer-based personalised dietary-menu planning (Gaal *et al.*, 2005; Koroušić Seljak, 2009).

*Mobile eHealth services*
Mobile eHealth, or more briefly *mHealth*, broadly encompasses the use of mobile telecommunications and multimedia technologies integrated within increasingly mobile and wireless health-care delivery systems. With the rapid advances in ICTs, including nanotechnology, biomonitoring, mobile networks, pervasive computing, wearable systems and drug-delivery approaches, the boundaries of mHealth are shifting. There is the expectation that with the appropriate technology choice we could transform the health-care sector in such a way as to generally link its systems with mobile devices.

Mobile devices (cell phones and other handheld devices) are becoming increasingly important Internet-access devices. In addition, wireless technologies used for transmitting mobile voice and data services accelerate the development of a wide spectrum of mHealth systems.

*Mobile device-based health-care applications*. Currently, there are many mobile device-based applications available for recording and reinforcing nutrition (Table 1). In addition, mobile phones have become integral tools for delivering audio, text and video messages, including games that reinforce healthy behaviour.

*Barcode recognition systems*. With the development of barcode recognition systems (such as the Barcode Recognition Toolkit BaToo (Adelmann, 2008)) that can be used on camera-equipped mobile devices, mHealth applications providing FCD-related information are available (Table 1).

With the advent of *matrix codes* such as Ezcode, QR Code, HCCB and others, which were created and designed specifically for mobile devices, new mobile applications can be foreseen. A feature of these codes is that even a low-resolution camera is enough to encode an arbitrarily larger URL or command because of the database lookup. The act of linking from physical world objects is known as a *hardlink* or *physical world hyperlinks*.

*Voice response systems*. Barcode recognition systems are similar to voice response systems, which have been used for reminders, surveys, nutritional screening and assessment, and disease management, and also in the field of mHealth. In voice response systems, the input interaction is a recorded voice instead of a picture. Siek *et al.* (2009) conducted a study to compare the use of barcode scanning and voice recording. They found that the participants preferred voice recording.

*Wearable mHealth*. An important component of wearable mHealth systems is the integration of medical microsensors or mobile devices for non-invasive measurements of physiological parameters. These may be worn on the body or incorporated into the clothes (or other textiles). There are also stand-alone, wearable devices, such as ultramobile PCs and smart phones, which may deliver full PC performance. They are usually carried in a pocket or a holster. Smart phones have made it possible for a wide range of wearable concepts, systems and applications to become feasible.

Wearable mHealth systems may be used in home health care, for example, to treat diabetes through effective monitoring (Hovorka *et al.*, 2004). An example of such a treatment system that continuously measures and controls the glucose concentration in subjects with type-1 diabetes is the ADICOL (available from http://www.adicol.org/) system. The modular concept of the ADICOL's extracorporeal artificial pancreas consists of a minimally invasive subcutaneous glucose system, an ultra PC and an insulin pump delivering, subcutaneously, insulin lispro.

A comprehensive overview of some of the up-to-date mobile-health applications and research is presented in the book entitled *Mobile Health Solutions for Biomedical Applications* (Olla and Tan, 2009).

## Reliability of information in ICTs

Undoubtedly, the importance of ICTs to the future of health care is now widely accepted. However, there are obstacles that have been identified through a number of surveys (Eysenbach *et al.*, 2002; Koch, 2006), which need to be considered during the development and use of eHealth services and systems:

- Health-care content available on the Internet may be inappropriate or too complex, as it may be unscreened or not delivered by health professionals.
- An eHealth system may not suit the design criteria. Many commercial and even research systems may present serious functional deficiencies, such as poor

interoperability and non-compliance with information standards and normalisation of codes.

- An eHealth system may not adhere to ethical guidelines (for example, transparency and disclosure of authorship).
- The personal privacy of users may not be ensured.

A review by Eysenbach *et al*. (2002) looked at studies examining the quality of eHealth systems. Of the 85 studies that met the author's inclusion criteria, two reported on diet- and nutrition-related eHealth systems. The two studies looked at 212 websites containing information about nutrition, food and diet, and both studies concluded that diet- and nutrition-related eHealth systems were highly inaccurate (45.5 and 88.9%, respectively) (accuracy was defined as the degree of concordance of the information provided with the best evidence or with generally accepted medical practice; the information was declared as inaccurate if it did not comply with nutritional guidelines). The quality criteria used included accuracy, completeness, readability, design, disclosures and the references provided. These criteria also reflected the FCD reliability.

As one of the biggest concerns is privacy (Ehealth week, 2010), the mechanism of digital credential has been designed to protect the practitioner's and the patient's privacy and confidentiality when they use the Internet to send and receive medical information. A combination of compliance, conformance and accreditation that underpins the certification offers a high level of assurance with respect to quality and interoperability.

## Use of FCD in eHealth services

According to the information provided by the system's publishers, most of the reviewed eHealth services used the United States Department of Agriculture nutrient database or basic FCD provided by food producers and only a few of them relied on local or national FCD. In addition, many of these systems did not provide sufficient information on the source of the FCD used and they often also lacked information on dietary reference values. Most of the population-based eHealth systems did not support dynamic adaptation to recent advances in the field of nutrition. For instance, drug-safety utilities could show, besides drug–drug interactions, drug–food interactions. In most systems, FCD interpretations were based on calculations derived from Daily Reference Values, Reference Daily Intakes, published research and the recommendations of the United States Food and Drug Administration, but they could not be tailored to national recommendations.

In contrast, most of the reviewed expert-based (that is, specialist oriented) eHealth systems proved reliable and were good sources of nutrition information, respecting the need to address the subject from both national and international aspects.

## Conclusion

Although there is a wide spectrum of eHealth systems based on FCD, the author believes that, in general, the use of comprehensive FCD in population-based (that is, citizen-oriented and mobile) eHealth systems has yet to reach a satisfactory level.

## Conflict of interest

The authors declare no conflict of interest.

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