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Collective intelligence and databases in eHealth: A survey [1]

Azahara Camacho [a,*], Mercedes G. Merayo [a] and Manuel Núñez [a]
[a] *Universidad Complutense de Madrid, Spain*
E-mail: {mariaazc,mgmerayo,manuelnu}@ucm.es

Abstract. Healthcare is one of the most important concerns of society, being extremely relevant the accuracy and quality of their services. Basically, eHealth can be considered as the area where electronic processes and communications are used to improve the quality of medical assistance. Despite the relative maturity of the field, recalls and problems related to medical devices, applications and services are still very frequent. Therefore, it is necessary to improve and expand current research to provide advances that can be transmitted to the society. As an initial step, it is essential to have a good understanding of the current state-of-the-art of eHealth. The main goal of this paper is to identify the most relevant and recent work on eHealth but, due to the immensity of the field and the scope of the journal, we will concentrate on the use of two specific technologies: databases and collective intelligence. In addition to review the main concepts related to eHealth and the most influent academic papers, we will describe projects which are essential for the correct performance of many healthcare services. As a result of our study, we reached some interesting conclusions that might be useful for future projects and we encourage to apply them in order to avoid some of the problems that we have found in existing projects.

Keywords: eHealth, databases, collective intelligence, security

1. Introduction

Disease outbreaks are a threat that medical professionals have to face. Even with the current systems and technologies, it is necessary to invest a lot of time to control the symptoms and find an effective solution. For instance, the latest epidemics of Ebola [61] and Zika [42] viruses have killed a huge number of people due to the lack of vaccines and information for their initial treatment. No one can dispute the fact that it is almost impossible to avoid these deaths, but a high number of lives could be saved if some measures would be adopted. One of the most important factors during these emergencies is the fast information exchange and the use of collaborative techniques in order to make decisions that can alleviate the consequences that will have to be confronted. The integration of healthcare, telecommunications and information technology (IT), also known as *eHealth*, has provided solutions to professionals to be applied in different areas related to health. Among other resources, the digitalization of the public healthcare systems has been widely adopted. The automatic processing of health records has allowed the use of collaborative techniques such as symptoms data sharing, pattern recognition of illnesses and detection of geographical areas affected by the latest diseases. Two of the most outstanding areas that can be applied to carry out these tasks are databases management and collective intelligence. On the one hand, databases allow us to collect and process a huge amount of information classified according to different criteria. On the other hand, the correct and *intelligent* management of data can provide extremely useful resources for the application of collective intelligence techniques. For example, fuzzy approaches

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[*] Corresponding author. E-mail: mariaazc@ucm.es.

have been used to classify data related to genes and to diagnosis [40,38].

Due to the relevant influence of eHealth in the advance of healthcare, in this paper we review the state-of-the-art in the field with the goal of analyzing its evolution and highlighting some of the most relevant projects related to IT. The aim of this paper is, therefore, to raise the researchers awareness about the relevance of improving healthcare systems with computational resources. In this way, it is foreseeable that in a near future, we could solve current problems, enhance the work environment of physicians and improve the lives of patients with better resources.

The rest of the paper is structured as follows. Section 2 explains the process of searching followed in this work. Section 3 presents the concept of eHealth. In order to clarify the field, in Section 4 we briefly analyze the differences between telemedicine and ehealth. Section 5 discusses the current research lines in eHealth while Section 6 explains the main technologies, focusing on databases and collective intelligence, that have been used for the development of these projects. Finally, Section 7 presents our conclusions.

2. Systematic Review Process

The central objective of this work is to analyze the state-of-the-art of eHealth concerning some specific IT areas. First, we established some patterns for the search process. In order to cover the maximum number of contributions, we perform our searches using a total of seven different academic databases and search engines.

- dblp Computer Science Bibliography [17]. Oriented to Computer Science papers, focusing on contributions to conferences and journals.
- Google Scholar [23]. Oriented to multidisciplinary papers from conferences, journals, books and academic work.
- IEEE Xplore [27]. Oriented to papers from Computer Science, Electronics and Engineering conferences and journals published by IEEE Computer Society.
- PubMed [43]. Oriented to life sciences and biomedical papers.
- Scopus[50]. Extensive abstract and citation database which is oriented to multidisciplinary papers from different resources.

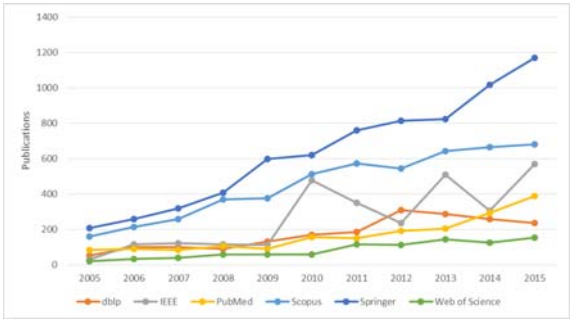

Fig. 1. Evolution of eHealth publications between 2005 and 2015.

- SpringerLink [53]. Oriented to multidisciplinary papers from journals, books, series, protocols and reference works published by Springer.
- Web of Science [60]. Similar to Scopus, but with a longer existence.

The next step in our methodology consisted on further studying the main characteristics and coverage of the considered databases and search engines. We analyzed the type of resources that are collected by each of them. The first analysis showed that the numbers that we obtained in Google Scholar were much bigger than the other ones. Due to its nature of academic search engine, Google Scholar is able to locate many unpublished papers and notes that could distort our total results. For this reason, we have decided to use it as a support tool, but not as a reference for our searches.

A good measure to decide how the field is evolving consists in classifying the contributions according to the year of publication. In Figure 1 we present the evolution of the number of publications per year since 2005 to 2015. We did not consider the current year, 2016, because we could only include partial results, corresponding to the first half of the year. The figures indicate that the contributions to the field have been steadily increasing during the last 10 years.

The first problem that we had to face was the different forms to write “eHealth”. The novelty of the concept provokes this lack of standardization of the term and this is the first *obstacle* to correctly review of the field. We can find three different expressions for representing the same concept: “eHealth”, “e-Health” and “electronic health”. Nevertheless, the last of these options is a more *light* concept that represents all the physical and electronic elements of the healthcare field. The two alternative options are quite similar but “e-Health” is more used than “eHealth” in general purpose databases while the result is the opposite (and with a proportion of 10 to 1) if we consider the largest

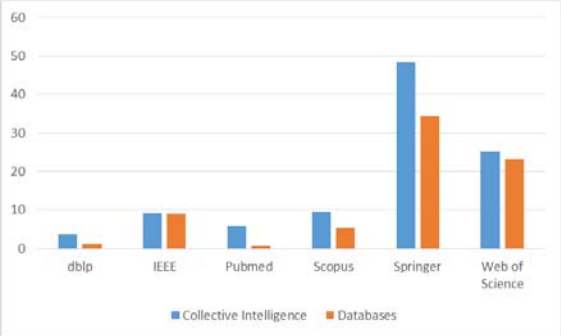

Fig. 3. Percentaje of IT papers related to eHealth in different databases.

database devoted to Medicine: PubMed. The results are given in Figure 2 (top). Therefore according to these facts, we decided to do our queries using both terms, "e-Health" and "eHealth", due to the higher possibility of finding more results if we combine these two options.

Then we continued our study with our selected IT keywords. Specifically, we concentrated on terms related to databases and collective intelligence. Some of the queries that we used for our work are given in Figure 2 (bottom). These results were really useful for our work because, as we can see in Figure 3, the database with a higher number of IT resources that have a connection with eHealth is Springer. For instance, in the case of the collaborative intelligence search, the query “eHealth” OR “e-Health” AND “decision” represents a 48.3% of the total publications of eHealth; if we add the keyword “collaboration” to the query, the total of results represents a 45% of the previous percentage, approximately 21.7% of the total. Accordingly, we decided that for our study SpringerLink was our preferential academic database, Google Scholar was a helpful search engine, and “eHealth” and “e-Health” were the main keywords for the latest published documents.

3. eHealth

In this section we discuss the different definitions that are covered under the eHealth epigraph, highlighting its purpose and the pros and cons of its application. This will help the reader to set in context the aim of this survey.

3.1. Definition

The progressive and fast growth of IT has had important consequences in different fields. Some of them have let researchers investigate and advance aspects which we have never imagined to deal with. In this line, the main aim of eHealth is to apply all the benefits of software, communications and hardware to Medicine.

The first reference to this new term dates back to 1999 [21] as part of a series named “what is eHealth?”. Previously, only industry and marketing used this term to talk about a new tendency in Medicine. As in others “e-terms”, the inclusion of an “e” in the denomination has a reason. In this case, there are more than one motivation to use it. Actually, a total of 10 different e’s have been identified: efficiency, enhancing quality, evidence based, empowerment, encouragement, education, enabling, extending, ethics and equity. All of them reflect what is eHealth, what are its goals and what are its receivers. However, this large number of adjectives does not conform a clear identification of the concept because there were some previous terms which reference, more or less, the same meaning.

One of the problems that we found at the beginning of our work was fixing a clear definition of eHealth. Due to the size of both fields, health and IT, it is almost impossible to cover all the implied elements, despite the fact of its clear objective. As a measure of this complexity, up to 51 possible definitions for eHealth have been collected [39]. Our conclusion is that the most appropriate one is the following [21]:

> “e-Health 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.”

We think that this description reflects all the properties and elements which define the field in the best way. Another definition which might be also suitable is the following [36]:

> “A new term needed to describe the combined use of electronic communication and information technology in the health sector. The use in the health sector of digital data transmitted, stored and retrieved electronically for clinical, educational and

Term	dblp	IEEE	PubMed	Scopus	SpringerLink	Web of Science
eHealth	570	610	22601	3941	3459	2385
e-Health	2068	3012	2033	5593	8519	5175
electronic health	1309	7711	172138	60169	344974	70937

Query	dblp	IEEE	PubMed	Scopus	Springer Link	Web of Science
"eHealth" OR "e-Health" AND "decision"	3,7%	9,2%	5,8%	9,5%	48,3%	25%
AND "collaboration" (percentage)	15,4%	36,1%	50,6%	30,7%	45%	40,4%
"eHealth" OR "e-Health" AND "database"	1,2%	9%	0,5%	5,3%	34,2%	23,1%
AND "management" (percentage)	10,1%	30,3%	61,7%	36,1%	14%	39,8%

Fig. 2. Different terms for eHealth (top) and used queries (bottom).

administrative purposes, both at the local site and at a distance."

However there are some aspects which are not covered by this last description like the attitude of the research and medical society involved in this field, which is one of the most characteristic element of this new term. Therefore we decided to choose the first one as the most suitable one. Most of the remaining 49 definitions are variations of these ones which are either incomplete or define something different.

3.2. Purpose of eHealth

The last work in the "what is eHealth?" series is a project formed by the results of 38 interviews conducted among different stakeholders in eHealth [3]. The main objective of the work was to explain the purposes of different scientists and to evaluate the methods regarding their outcomes. Similar to other studies [2,3], interviewed stakeholders are directly related either to eHealth or to Interactive Health Communications. The questions concerned the behavior or trend of eHealth evolution, the analysis of cost-effectiveness of eHealth programs, what measures would be applied to improve, etc. The answers of these questions can be classified in 4 different groups:

- Standardization. In this case there is a consensus between all the stakeholders that standardization processes and research methods are necessary. Actually, even though some academic papers show relevant advances in the field, they do not follow a common pattern and this is fundamental to develop a mature research topic.
- Methods and challenges. Some methods need to be enhanced in order to control their effectiveness. In other words, it is necessary to check that applications or activities with theoretical outcomes can be adapted to a real environment. Moreover, tests have to be done in populations whose conditions fit the requirements. Only with such a systematic approach it is possible that results can be analyzed to control future economic investments and social acceptance.
- Quality for the future. Due to the fact that Internet was created as a complement and a tool to find information, sometimes its benefits were not exploited. However, this has been currently corrected and, as a result, we gain a huge number of advantages. One of them is the accessibility for people who live in little towns or whose connections with other populations are quite deficient. But despite this, there are not enough investments to develop all the planned projects because it is not considered the key of healthcare problems. It is considered just a tool to facilitate the communication between patients and physicians.
- Improve disadvantage populations. This field is one of the best options to expand the application of eHealth. However, its expansion strongly depends on the use of computers and this type of populations do not have the resources to acquire them.

3.3. Drawbacks and barriers

The year 2002 can be considered the start of the current eHealth trend because the Association of Ameri-

can Medical Colleges, in collaboration with the Clinical Research Roundtable of the Institute of Medicine, sponsored a conference to discuss Health Information Technology (HIT) and the future of clinical research. Research lines and objectives were defined, including the use of PDAs to collect patient data, sensors to control critical issues and the management of the geographical situation of the patient to manage health risks. All these measures have the aim of helping people with unfavorable conditions such as living places with difficult access, patients with obesity and elderly people [48,58].

One of the most recurrent drawbacks in eHealth is healthcare politics of each country. There are countries having enough resources for research and investment but with a chaotic public health system. The most paradigmatic example is the United States case [25] which explains the lack of sense of funding research in order to improve the quality of life of people, if they cannot afford it. Despite this, researchers identified the following desired lines of work:

- Develop and exploit the Electronic Medical Records (EMR) / Personal Health Records (PHR). These are databases where medical information is stored in order to prevent errors, taking advantage of available resources and studying future possible pandemics [14].
- Create a national health network. Doctors and physicians could share medical histories of patients. Thus, it would be easier to attend patients in a different place from their original medical center.

However, it is necessary to take into account that these ideas could be developed only if all barriers are destroyed. Those impediments are [59]:

- Legal. It is necessary to respect confidentiality, integrity and availability of patients data.
- Economic. In the case of the United States, their economic policies are not prepared for this kind of situations and a big reform would be necessary.
- Privacy. This is related to legal problems and, specially, to data which are part of EMR and PHR.
- Technological. There do not exist standards and methods for establishing research patterns for each project. In addition, resources to ameliorate this problem are usually not available.

In 2009, eHealth was considered one of the keys to prevent and solve the healthcare crisis of the United States. Although new Research & Development projects are fundamental to advance the state-of-the-art, eHealth is more than that. In particular, progresses in eHealth need qualified people, appropriate devices and facilities to work in the best conditions. However, these requirements need a great investment of money and this is the main problem for almost every country which decides to afford this new challenge. A year later after this checkpoint, the undisputed need to establish a methodology for eHealth projects was remarked again in a survey [11]. This study enumerates the most important contributions to the field until 2010 and presents relevant conclusions. One of them is that the deficiencies of eHealth are *quantity*, *quality* and *consistency*. Another conclusion of the survey concerns the invested amount of money. No one could dispute the fact that every year this amount increases, but without any scientific document that explains the outputs, the achievements and the reasons why they were novel. Finally, the authors emphasize that the existence of a methodology or a common research pattern to be applied in previous projects would strongly improve current and future results, in particular, they would be more innovative.

4. eHealth vs Telemedicine

One of the concepts related to eHealth is *telemedicine*. In some sense, this could be considered the former concept of the current meaning of eHealth. It represented the whole world of healthcare related to electronics and computers during the 20th century. However, this term has fallen into disuse. In particular, there are different reasons that have provoked its misuse and the emergence of the new term [35]. Currently, the term telemedicine tends to be used for professionals and ancient healthcare hardware, whereas eHealth tends to be used for all the new elements of communication, web-services and software which are applied in Medicine.

There exists a classification of 6 different categories for highlighting the main purposes of telemedicine [33]. These categories are:

- Handling adverse conditions. They deal with keeping elderly people from harmful circumstances, offering diverse services such as:
  - Manual emergency call for elderly with dementia [32].
  - Automated detection of deviant behaviour [9].

  - Automated detection of falls focused on a pilot case of monitoring assisted living [6].
  - Automated detection of cardiac emergencies as a platform for supporting medical services of heart failures [57].
  - Handling potentially dangerous situations [16].

- Assessing state of health. Part of the telemedicine services are offered as complements to the current healthcare services which provide information of patients directly to doctors. These complements might be used for tasks such as:

  - Recognition of unknown diseases and medical conditions. For example, elderly people having an infection of the urinary track are diagnosed by making statics of the frequency of their bathroom visits [6].
  - Monitoring of known diseases [30].
  - Monitoring therapeutic interventions. In this group we include the control of patients which have suffered a heart disease and their post-surgeon evolution is monitored [8,24].

- Consultation and education. Its main objective is to provide enough resources to elderly people for their own autonomy. As a result of this behavior, there should be an improvement in the quality of life of patients and caregivers because they might have a better control of their health [7].
- Motivation and feedback. One of the problems in health services is the level of attrition. In order to prevent this, it is necessary to motivate patients and show them all the benefits that they are able to get in the future after the treatment [10].
- Service ordering. This category is mainly related to "Consultation and education" [22] because it deals with enhancing the independence of elderly. One of their needs is the opportunity to ask services (delivering meals, home chores, etc) without external help.
- Social inclusion. The Constitution of the World Health Organization defines health as "a state of complete physical, mental and social well-being". Therefore, it is crucial that the society accepts that patients are normal people. Their illnesses cannot be an impediment for developing their daily routine [13].

5. Research lines and relevant past projects in eHealth

Following the "what is eHealth?" series, a study of the most promising areas in the field was developed [41]. Some of these areas correspond to computer issues related to medicine (tools, networks, applications, etc), patient records, healthcare business management, information for patients and clinician-patient communication tools. In order to fulfil these aims, some new technologies which are able to impact on them are considered: satellite communications, wireless networks, smartphones, digital TV, virtual reality, nanotechnology and bioinformatics.

In order to involve all these possible areas, in 2005 some patterns were created to advance research in eHealth [28]. Given the fact that this is a wide field, research work expressed as scientific papers did not follow a clear tendency. It is important to remark that in the early years, papers did not provide any insightful result to the research community. Actually, most of the work only considered the relevance of the issue, but without any advance in the area. Finally, this trend started to change and some of the papers included results obtained by professionals and stakeholders of Medicine. This was a consultation which consisted on the recreation of some scenarios where eHealth might develop a key role. In addition, it also showed the results of the revision of relevant policy for medical field. As a result, it was possible to develop a proposal as a pattern for best practices:

- Apply computing training for health professionals.
- Analyze other e-sectors to implement best practices and barriers to apply in eHealth.
- Study web-based services for citizens in other fields, to catch their opinions and experiences, in order to enhance the usage of eHealth applications.
- Research previous work on telemedicine and its barriers.
- Estimate costs and benefits of eHealth solutions being developed in current health systems.

This list reflects some aspects which are crucial to respect the data control of patients such as responsibility, reliability, regulation, accessibility, confidentiality, security and property. Nevertheless, one of the main deficiencies of this last work [28] was that the authors only studied people related to the medical sector. They did not consider IT workers, computer engineers or de-

signers to define the list of research lines and technologies to use. It could have been interesting to take them into account for analysing the advantages, disadvantages, requirements and limits of new technologies because they might had another point of view which considered the latest advances and problems detected in the IT world. According to this lack of information, it is clear the necessity of taking into account the importance of defining a group of patterns in order to prevent failures identified in the past [19]. In fact, eHealth needs people who work together towards a common goal: starting a strategic and investment plan for its evolution [51]. The authors identified a group of principles which has to be applied to reach this goal:

- Simplify complex contexts.
- Apply a pragmatic view.
- Evaluate costs.
- Control the components (health informatics, e-learning, e-commerce, etc) being applied.
- Obtain correct eHealth solutions to previously established conditions.
- Plan applications in the long term.
- Propose objectives in the medium term.

Although it is essential to have a real point of view of reality when a research field is so recent, in the case of eHealth, it is indispensable to control aspects such as poverty, culture, politics or barriers of the society where the proposals will be implemented. This is so because these results will be the first step of a work strategy. In fact, depending on the specific population, it might be necessary to adapt the conditions of the proposals to get real and valid outcomes.

eHealth includes a wide range of topics, from the commercial part of healthcare to the aim of improving health solutions. If we limit the scope just to those that are directly related to the state of the patient, we are probably delimitating the area where more research work is needed. One of the most important groups turns around heart issues. The main categories of cardiovascular medicine are divided into different lines inside the eHealth world [15]. However, it is widely known that one of the fears of the society is the overcomputerization of the health service, which provokes an initial rejection to its research. Despite this complications, there are successful projects as epSOS showing the reasons of its utility. epSOS is a European project which pretended to create a network including more than 20 European countries in order to make healthcare faster and better for European patients. The goal was that if a European citizen travels around Europe and has a problem which requires a physician, his Electronic Health Record (EHR) and prescriptions will be available for the doctor who treats him. However, this wide availability of EHRs might represent vulnerabilities. Therefore, the question “it is eHealth secure and private?” is asked very often. There are many tools and methods in computer security to prevent malicious attacks [47]. It is crucial to control the state of the data and the devices which we are managing, because the more connected they are, the more vulnerable we are. Moreover, people tend to not be enough aware of the danger of public connections and public services which might reveal private data. For these reasons, privacy and security are likely goals that should be achieved in future eHealth projects. However, this needs a great deal of effort in form of people awareness, permissions and standards for device connections and encrypted information in EHRs. If these efforts are applied, then it is plausible that improvements in the healthcare service of many developing countries might be performed like the successful stories of some African countries [5]. With virtual services and better networks of patients data, critical illnesses could be prioritize in order to prevent future patients affected by a specific disease. With communication platforms, physicians and patients will be in touch and any unexpected event in the daily routine of the illness will be notified to the medical center at the moment.

In conclusion, there is a huge number of purposes and possibilities to apply on research eHealth projects. During the rest of the paper we focus our study on works where the application of databases and collective intelligence techniques are the main tool for their fulfilment.

6. Collective Intelligence and Database Management in eHealth

Since researchers are the main driving force behind some of the most novel techniques that have been developed in eHealth, they are the most updated professionals to inform about the extensions and improvements that should be undertaken. As we previously argued, databases management and collective intelligence can play a fundamental role in the further development of eHealth.

The main goal of databases management is to facilitate the manipulation of stored data [46]. In the case of eHealth, it is essential to keep under control as much information as possible because this allows medical

professionals to improve the quality of their work. The access to the record of a patient and the treatments that he had received can be extremely helpful to diagnose and determine the best therapy. However, keeping the security and safety of the patient data is a must and it is necessary to protect sensitive information by means of better communication protocols [45] and cryptographic security models [44].

Collective intelligence is a concept that, in 1785, was already used in order to highlight the relevance of the same vote of different people against the vote of only one person [31]. The key of this family of techniques is the great deal of knowledge that can be generated from the collaboration and consensus of many actors. This idea is usually compared with the results that are obtained from the collective work of ant or bee colonies [54]. In the case of eHealth, collective intelligence is derived from information that is collected in databases, software and hardware that are used by physicians and patients for their treatments, and experts that are constantly improving the connections between all these elements with the aim of enhancing the decisions that are made.

The relevance of a new technique, developed as the product of research, in the society can be measured by the number of successful projects using it. In the case of the two techniques that we are studying, there exist plausible evidences of their impact. Next we review some successful applications of databases management and collective intelligence in eHealth.

6.1. Use and application of databases in eHealth

In our daily routine we generate huge amounts of data. An important percentage of this information is obtained from medical resources such as implantable medical devices, medical records of patients or results from the laboratories of the medical centers. The application of databases management techniques is essential to make the most of this data and improve the lives of numerous patients with the analysis of their cases. There is a myriad of databases devoted to the collection and organization of medical information and it is impossible to review all of them. Therefore, in this work we focus on the most relevant projects carried out in Europe and the United States of America.

- Electronic Medical Records (EMR) - USA. The digital versions of the paper charts that are collected in medical clinics are stored here. Notes and information about a specific patient are registered in this database, increasing its relevance because it offers the opportunity of tracking data over time and identify possible improvements for the patient's health index [12] . A clear example of its utility is the eMERGE network [34], a complete web of biobanks with data from EMR that can be used to facilitate the diagnosis of possible genomic diseases.
- Personal Health Records (PHR) - USA. It stores the patient information related to diagnoses, medications, immunizations, family medical histories and providers, with the aim of being created, modified and managed by the patients. This is an innovative project in which professionals try to deeply involve patients in their own care. This project was motivated by the Hurricane Katrina, in 2005, which exposed the numerous vulnerabilities of the American Healthcare System. One of the proposals of PHR is its integration with EMR, providing greater benefits for patients [56].
- epSOS / Electronic Health Record (EHR) - European Union. The EHR is an essential tool for the shared care of patients. Due to the numerous actors that are able to access these records, keeping the security of data and the privacy of the patients is a challenge for the implementation of this project. epSOS was a 72 months program whose main aim was to design, build and evaluate an infrastructure to provide interoperability between EHR systems in Europe [26]. The project finished in 2014 and the most relevant results were the usability and availability of the project taking into account the needed time response and the system used for its integration [20].

6.2. Use and application of collective intelligence in eHealth

One of the capacities that are derived from the intelligence of an individual is logic, which is the use and study of valid reasonings. In the case of collective intelligence, *fuzzy logic* [29] is widely used because most reasonings cannot be concluded with a simple true/false answer. We will see in the review of the most relevant contributions of collective intelligence to eHealth that fuzzy logic is usually involved.

There are different areas where these techniques of collective intelligence have been applied. One of them is the search of improvements and solutions for illnesses. An important contribution consists in developing systems to assess the degree of disability of pa-

tients [49]. Previous work only took into account few data of the patient and general information, but specific data related to locomotion was oversaw. With this new approach, physicians are able to use a system that implements an algorithm based on fuzzy clustering. The system provides a complete representation of the information that is derived from the kinetic studies that are performed with the patient. Another work in which collective intelligence was applied focusing on one of the most illnesses problems of the current society is obesity. Starting from the Human-Robot Interaction research, it is possible to develop a system that employs machine learning algorithms in order to feature a humanoid robot Health Coach that helps to reduce childhood obesity [1]. Other example of this kind of application is chronic disease with elderly patients [18]. As in the case of locomotion problems, the medical community does not have enough resources to decide the best treatment for chronic diseases. Most of them are detected in elderly patients and their health index tends to be quite low. In order to deal with this issue, a tool that uses fuzzy logic and recurrent neural networks has been developed. The main purpose of the tool is to combine all the requirements of the patients and the conditions of the new chronic diseases that they are developing. Although these proposals are planned in order to avoid or reduce health problems of the society, it is not necessary to have a low health index to be one of the studied members of these projects. The analysis of the variations that we suffer in our daily routine is an important information source for detecting trends that can be applied in self-caring for individuals at home. In this line, an Intelligent-Mamdani Inference Scheme has been proposed to define approximate health conditions of the individuals via their blood pressure and the body mass index in out-of-hospital, concluding that the scheme is feasible to infer personal health status [62].

The improvements of the lives of patients are not only a matter of treatments, it is also a matter of efficiency. As we said in previous section, eHealth covers numerous areas and one of them is the healthcare service. The problem of optimal decisions for waiting time contracts in this service has been studied with the use of fuzzy techniques [52]. In this case, the goal is to maximize the utility of the Public Health Administration with the use of a fuzzy waiting time model according to the requirements of the patients. The higher the patient's health index is, the higher the waiting time will be. However, the money invested in the treatment will be lower than in the case of a patient whose health index is low. Similar to this case is the problem with the suppliers of medical devices. Given the fact that there are numerous facts that motivate the decision of choosing a specific one among a big group of competitors, there was a lack of systems to analyze and compare the aspects of the available medical devices. A fuzzy multi-criteria decision-making approach was proposed in order to evaluate all the requirements and create a ranking that can be used to compare the different options, helping to select the most suitable one [55].

Finally, although there are numerous examples of applications, there is one more are where collective intelligence plays an important role. This is the quantification of the quality of the service. Despite the application of innovative techniques to improve the services of the healthcare system, there is not enough evidence of these improvements. This thought was presented by the Turkish Ministry of Health which implanted some regulations in order to quantify it [4]. The resource used for this study was a multiple criteria decision making tool that was based on numerous parameters of the qualification of the service obtained from the literature. As a result, the quality parameters were determined and obtained by using an analytic hierarchy process according to providers and patients. Sometimes there are problems with the use of the data that should be taken into account to make the decision due to the fact that it contains sensitive information. For these cases, some professionals have proposed an estimator based on a frequently used statistical method in survival analysis, derived from the application of fuzzy logic with this censored information. An example is the study of the survival times of AIDS patients under ten years old in Hamadan-Iran [37]. It was shown that the results obtained from the application of these new techniques were more reasonable than the obtained from standard methods.

7. Conclusions

In this paper we have reviewed the main concepts and projects related to eHealth and the contributions of databases and collective intelligence to the field. Base on the reported work, there are different conclusions that we should take into account. It is clear that eHealth is a prosperous research field. However, in order to have a worldwide spread of the obtained results we need to improve, and reduce, its requirements. This will allow people to get used to new methods and

find their usability, applicability and stability in their daily routine. Concerning eHealth researchers, it is extremely useful that scientists concentrate on finding the solution of a local problem in their own regions. However, it is essential, after this local effort, that the experiences and results are shared at a higher scale, so that they can be adapted to other environments. There are drawbacks and constraints which are external to research, such as politics, resources and cultural behavior. Taking into account these problems, it is necessary to look for good solutions to improve healthcare using, adapting and extending the numerous available techniques in other areas of work, in particular, in Computer Science. In this paper we have reviewed two of these areas: database management and collective intelligence. Many evidences of their applicability have been shown and we fervently encourage to continue this direction.

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