

New Tool for Acquiring Tacit Knowledge in Healthcare

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ABSTRACT

Over the last ten years, knowledge management (KM) has penetrated increasingly in organisational and management processes in healthcare as a concept and a set of good practices in order to systematically identify, capture and share knowledge into an organization. However, there is a lack of a practical system that records tacit knowledge and turns it into explicit. Healthcare professionals are arguably the most reliable asset that clinical organizations currently owing to their experience and knowledge of corresponding medical specialities. The main goal of this project is to create a tacit knowledge platform that acquires, stores and transmits medical experience at the clinician's group at the Hospital Sant Joan de Déu de Manresa. Through specific web and app designs, we describe a new system that guarantees the acquisition of tacit knowledge, through recordings and analysis of medical sessions, and its transformation into explicit knowledge. This interface is presented as an educational tool and to enhance the information exchange of state-of-the-art medical topics, different pathology treatments, diagnostic, and surgical practice of more common interventions. A key feature of the developed interface is the search engine in the developed tools to browse all performed sessions and literature reviews, which was a priority for healthcare professionals. A preliminary evaluation of the developed tools by healthcare professionals provided very promising results, demonstrating the benefit of KM in clinical environments.

Key words: management of knowledge; tacit knowledge; medical sessions; video processing; web and mobile app development; search engines.

1. INTRODUCTION

Knowledge management (KM) consists of strategies and processes for the identification, acquisition, structuring, interchange, and application of information in order to generate sustainable sources of knowledge [1]. The aim of KM is then to provide a framework using appropriate techniques, technologies, strategies and processes to convert the data and information into valuable knowledge assets [2].

According to Nicolini et al. [3], one of the main points of debate around healthcare knowledge involves its acquisition and management processes, which has three main topics: 1) the nature and characteristics of the acquired knowledge in this sector; 2) the consequences of its management; and 3) the facilitators to achieve this knowledge. Although KM has tried to partially minimize knowledge dispersion and promote KM self-documentation such as elaboration of protocols, documents, procedures or clinical guidelines, the main problem remains finding appropriate methodologies for tacit knowledge acquisition. Nonaka and Takeuchi [4] distinguish between two types of knowledge: the **explicit** one, which can be structured, recorded and shared; and the **tacit** one, which is mainly based on professional learning experiences and thus, quite difficult to be structured, registered and shared. This project intends to propose a solution to the tacit knowledge acquisition and thus improve healthcare data management and knowledge transfer.

A possible environment well suited for exchanging clinical knowledge including scientific evidences is the clinical sessions that most of groups of healthcare professionals have regularly (e.g. weekly, biweekly). These clinical sessions are in a context where acquired knowledge, professional skills, clinical evidence and its derived results are communicated and debated. In consequence, these sessions are an ideal environment where different professional experiences are shared, guaranteeing the requisites of active learning, and being useful not only for personal within the same group, but also for external healthcare professionals. Due to the constant progress in medicine and technology, the different types of knowledge are constantly evolving and moreover, they are highly dependent on professional experiences and background.

In most clinical sessions organized in healthcare working groups, such as in the ones at Hospital Sant Joan de Deú de Manresa (HSJDM), there is a lot of knowledge that is lost. In particular at HSJDM non-standardized Powerpoint slides were the only registered piece of information out of a clinical session but not even stored in a common and easily accessible server. High-quality information was transmitted and discussed but not explicitly recorded. Therefore, there is a clear need for some methodologies to convert the lost tacit knowledge into explicit one.

One important challenge in KM is to find an appropriate environment and tools where all learning requirements defined by healthcare professionals are fulfilled, and in a continuous and evolving way. Therefore, it was necessary to use a flexible enough technology capable of registering, analysing and showing in a user-friendly visualization interface knowledge derived from the clinical sessions. All these processing steps must consider the input and feedback of the speakers and must be used as an education and consulting tool not only for professionals, but also for physicians, nurses and students. For these reasons, we developed a computer-based strategy to transform tacit knowledge into explicit one that has the following phases (see Figure 1): 1) Use of MED1C (1d3a¹, Barcelona, Spain) and SkillCatch commercial softwares for the acquisition and post-processing of video recordings from clinical sessions; 2) Design and implementation of an interface for the user, both via web and for mobile devices (app); and 3) Generation of a database of tacit knowledge on the most frequent clinical interventions to visualize and crystallize this knowledge. These steps were standardized and adapted to work in a clinical environment, in particular at HSJDM (e.g. to be compatible with the hospital (intranet) website).

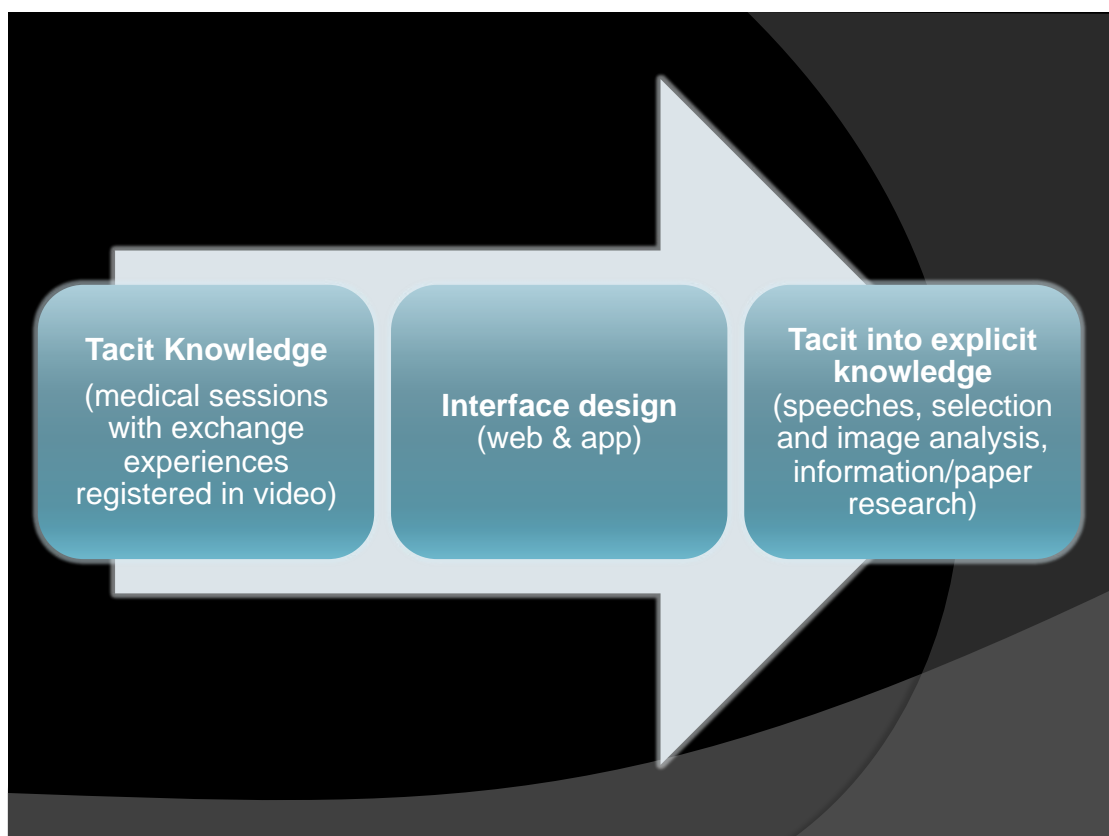


Figure 1: Schematic representation of procedures to tacit knowledge transformation into explicit knowledge. Firstly, a video recording of medical sessions, in which tacit knowledge is shared, is made. Then, videos are put into a designed website and app. Finally, tacit knowledge is crystallized so, it is transformed into explicit knowledge through speeches, image selection and analysis, and researched information.

¹ <http://www.1d3a.com>

In summary, the main purpose of this project is to develop a technological pipeline aiming at improving healthcare quality by transforming the tacit knowledge into explicit, as well as to allow healthcare professionals to inform other colleagues and the community about clinical procedures and link them to scientific evidences, expert consensus and local hospital constraints and regulations. Simultaneously, this information will be used as an educational material for physicians and nurses, and also, to promote effective and standardized clinical practice policies.

2. LITERATURE REVIEW

As Bose et al. [1] described, healthcare industry is increasingly putting resources on the integration and management of knowledge shared among hospitals, clinics, pharmacies and customers, since it significantly reduces administrative costs and improves quality care. Thereby, healthcare success strongly depends on these compilation, analysis and sharing processes.

Jaeschke et al. [5] argued that the main source of healthcare knowledge is based on clinical literature, e.g. scientific and research articles, clinical practice guidelines, reviews, and use case reports, among others. Nevertheless, there is more healthcare knowledge beyond the published one [6]. In fact, there is more **tacit** knowledge that is daily used in clinical organizations but it is not properly documented such as work experience of healthcare specialists [7,8], social knowledge [9], communication patterns within a professional community [10] and even, clinical episodes stored by patient electronic registers [11]. Although tacit knowledge definition does not imply that it is based on evidences, it is omnipresent and recognized as valid, valuable and essential for healthcare practice [12].

In consequence, healthcare knowledge can be categorized into **explicit** and **tacit** classes [6,13,14]. As well as described in some articles [14,15,16], explicit knowledge is based on best working practices and on how canonical knowledge available in clinical guidelines, studies, methods and reviews from the medical literature can properly be described and implemented in a given centre. Practically, explicit knowledge consists of facts, rules, relations and policies that can be faithfully codified and standardized, often (but not always) stored in electronic format, and can be easily shared. On the other hand, tacit knowledge is intrinsic to the healthcare professional, integrating her/his lived experiences, acquired knowledge, personal skills and intuitive judgment. Tacit knowledge is by definition individual-based and requires face-to-face communication for knowledge transfer. For this reason, many researchers have tried to explore the way to turn this tacit knowledge into explicit so that it could be stored as described below.

2.1 Nonaka and Takeuchi Model

Nonaka and Takeuchi [17] proposed a model whereby knowledge generation is based on a continuous and iterative process that turns tacit knowledge into explicit one and vice versa. Thus, it consists of four phases: 1) Socialization, which is the action to share tacit knowledge with other colleagues to debate a given topic and to implement it in other practices; 2) Externalization that is based on converting tacit knowledge into explicit in order to share it; 3) Combination, which is the process to synthesize the more complex explicit knowledge through several explicit knowledge sources; and finally, 4) Internalization, i.e., explicit knowledge assimilation, which occurs when explicit knowledge is understood and learned via the experience [Figure 2].

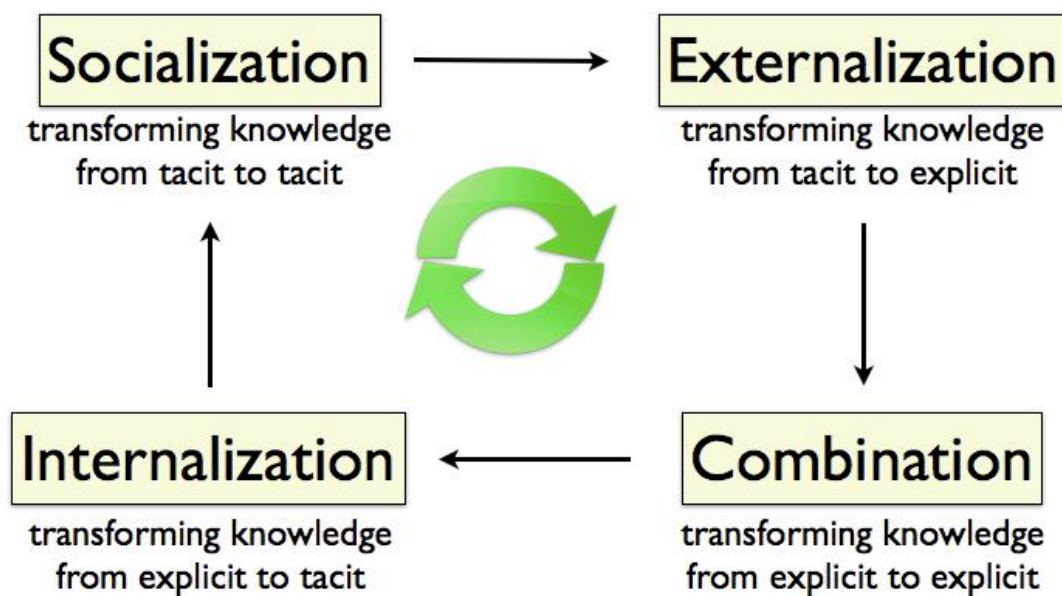


Figure 2: Knowledge creation model. Model proposed by Nonaka and Takeuchi [17] whereby knowledge creation is based on a continuous and iterative process that turns the tacit knowledge into explicit knowledge and on the other way around.

Many articles [18,19,20] argue that one of the main problems of this method is the strong opinion against poor methodological quality of many published papers, stating that a lot of them cannot be used to inform or have any influence on clinical practice. Much of the published studies relied on personal and local experiences without scientific, standardized and rigorous experimentation, generating validity, applicability and ownership issues. The use of semantic field standards, i.e., a system in which the terminology was related semantically, such as the existing UMLS system or Galen system, was contemplated as a possible solution. Nevertheless, these methods require complex search algorithms and high storage capacity that at that time were not available, preventing a widely spread adoption of Nonaka and Takeuchi model.

2.2 Abidi Model

In 2001, Sim et al. [21] also emphasized the important role of tacit knowledge to complement explicit one for the improvement of healthcare quality and delivery. A clear example where explicit knowledge is not sufficient involves many rare medical problems since their treatment is not represented adequately in medical literature in order to support evidence-based clinical decisions. Additionally, as Cimino et al. asserted [22], tacit knowledge in this particular field is extremely difficult to articulate, describe and spread.

Abidi [23] also stated that tacit knowledge was difficult to scan and formalize in terms of procedures, algorithms and directives due to its personal and intuitive nature. Then, they affirmed that the generation of the appropriate context and expert information/knowledge was paramount to generate tacit knowledge. For doing so, one needs to consider several operational factors: the experts' motivation to share knowledge; to convince them that it is better to share their intellectual knowledge to progress; and the availability of knowledge reviewers in order to generate new knowledge acquisition techniques. The latter is a factor that was already stressed by Matheson [24]: "The overarching informatics grand challenge facing society is the creation of knowledge management systems that can acquire, conserve, organise, retrieve, display and distribute what is known today in a manner that informs and educates, facilitates the discovery of new knowledge and contributes to the health and welfare of the planet."

According to Panahi et al. [25], we must remember that the use and optimization of information to facilitate the tacit knowledge sharing is almost unavoidable. Nevertheless, there is still nowadays a lack of management techniques for tacit knowledge. Techniques to capture or record healthcare knowledge have not evolved as much as the field of medicine in the last decades. In 1996, the Strategic Healthcare Decision-Support Services (SHDS) was created as a set of services for knowledge management based on strategic and decision-support data, incorporating Healthcare Enterprise Management (HEM) information. The main goal of SHDS, presented in [26], was to improve the delivery of healthcare services and included independent computer systems to acquire, share, reuse and operationalize the various healthcare knowledge modalities. Nevertheless, this service was simple in the sense that it just provided information at the right place and time in the appropriate format. Some years later (1999) the WAX software appeared as a KM tool aiming at providing intuitive support for clinical decision making in general practice. Heathfield et al. [20] claimed that the WAX software offered an open architecture for KM, helping clinicians to create, organize and browse through electronic documents (e.g. scientific papers and books), requiring minimal technical skills. Even though established healthcare systems generated massive amounts of data, unfortunately they were not able at that time to cover all healthcare fields. From the 2000s, Data Mining (DM) techniques, coming from the machine learning community, started to be applied in the clinical domain to improve the use of healthcare databases, data and knowledge storage, as well as to formalise knowledge derived from experience and contribute to the optimization of clinical decision-support strategies and planning. At that time, the

combination of the SHDS system with DM techniques was proposed [27] to ease the automatic transformation of healthcare data into a set of knowledge services.

Despite technological advances for healthcare knowledge acquisition, traditional techniques that were used in healthcare systems were only effective to acquire explicit knowledge. Cheah and Abidi [28] described how the acquired knowledge was mainly based on interviews with healthcare experts, clinical observations and analysis/reviews of methodologies to solve problems, as well as by obtaining knowledge from clinical literature and databases. Tacit knowledge could not be integrated yet into these systems due to the intrinsic characteristics and origin of tacit knowledge, which were not considered in the knowledge acquisition process. They commented that for this reason, in 2001, a new tool, so-called Healthcare Scenario Composer (HSC), was developed to help healthcare experts to make a decision in a given healthcare scenario through the use of electronic application forms. It was a better tool because facilitated healthcare experts to respond to a given scenario through the use of a series of electronic forms whose attributes corresponded to components of a healthcare scenario, i.e. meta-scenarios, scenario-constructs, and healthcare episodes/events. These forms prompted healthcare experts to provide information or suggest values to the various scenario-defining attributes presented.

2.3 TKAI Model

Still in 2005, healthcare knowledge was not fully exploited, especially tacit knowledge from experts' experiences, due to several operative and technique reasons. Abidi et al. [23] proposed some solutions and strategies to acquire tacit knowledge. One of them was the Tacit Knowledge Acquisition Info-Structure (TKAI), which was based on a combination of KM techniques and could be divided into three different steps: 1) Acquisition of tacit knowledge from experts; 2) Computational representation of this knowledge; and 3) Validation. In the TKAI system, the user filled in several electronic application forms to create an scenario, providing a set of functionalities such as: recording routine experiential knowledge of an expert with respect to the built scenario; modifying the "explained-scenario" created a priori to generate tacit knowledge; and recording tacit responses based on healthcare expert knowledge in challenging situations, leading to a solved scenario generation.

2.4 Euzenat Five Requirements

Nevertheless, it was not until 2010 that Nonaka and Takeuchi [4] talked about the "Knowledge Transfer Network" (KTN) concept as a reference element of knowledge and information diffusion. However, a strong communication infrastructure needs to be in place so that people can communicate effectively and therefore without it they are not able to effectively transfer knowledge. Such an infrastructure of adequate communications includes Internet and Intranets for KTN generation, as well as discussion classrooms, bulletin board meetings and appropriate tools for the display of information [4, 29-31]. In 2012, Euzenat [25] postulated the

five main requirements that have to be present in tacit knowledge sharing: social interaction, experience share, observation, informal/networking relation and mutual confidence.

3. METHODOLOGY

3.1 Motivation

More recently, Kotari et al. [32] described different ways to acquire tacit knowledge such as: direct observation, interaction and debate, narratives, steps for making tacit knowledge explicit (using metaphors, linking to larger analogies, and creating a formalized model) or interviews. A more proactive model is based on the use of complex theoretical clinical scenarios, where a healthcare professional is asked to take clinical decisions; subsequently these are transformed into the tacit knowledge.

Typical clinical sessions in medical organizations are one of the most appropriate environments where tacit knowledge can be acquired. A clinical session in a healthcare department/unit can be defined as a meeting of a group of physicians and other medical professionals that exchange points of view about clinical cases or issues of their specialty in order to find new solutions for several problems or to provide specific information to attendees. There is a large variety of types of clinical sessions such as bibliographic or review sessions, clinical case discussion, quality and ethics sessions, among others. Several objectives are sought in these sessions such as: to reach consensus and agreed solutions for difficult clinical cases; to increase patient-specific information to group members; to improve the general healthcare knowledge of attendees; to collaborate in inter-personal knowledge and encouraging a camaraderie and friendly environment; to relieve the responsibility of some members, specially youngest ones; to talk about clinical study perspectives or clinical trials; and to debate about the team itself to improve their performance and solve organizational problems. According to Gracia [33], prudence and deliberation are two key factors for these clinical sessions since both are the basic conditions of «practical reasoning», in the same way that «demonstration» and «certainty» are for theoretical reasoning. A pleasant clinical history is always the basis of a great clinical session [34]. Additionally, Ordoñez [34] argues that in order to ensure their effectiveness they need some flexibility and informality. We have to bear in mind that they consist on colleagues meetings who work together everyday and they comment several aspects related to their work. Besides, the optimal timing is in the extremes of the working days, at first or last hour.

Regarding the structure of clinical sessions, they should be quite similar to the one used in clinical case articles. Two types of sessions can easily be distinguished depending on their implementation and/or their structure. On the one hand, there is a clear template for clinical cases: introduction of clinical case; history; treatment and diagnosis; discussions and conclusions; and the subsequent professional discussion. On the other hand, there does not exist a defined template for the remaining types of clinical sessions.

In order to generate a knowledge management database, we have designed a standard pipeline that shows the different steps. As can be seen in Figure 3, the starting point is the availability of individual tacit knowledge, which is basically obtained through professional experience. This knowledge is exposed weekly during the clinical sessions, where not only professional experience is shared, but also a series of clinical questions are made by different healthcare professionals and are discussed among all of them. Then, these sessions are recorded, thus tacit knowledge is crystallized and converted to explicit one with the developed computational pipeline. Finally, recorded sessions are processed and then uploaded into a database.

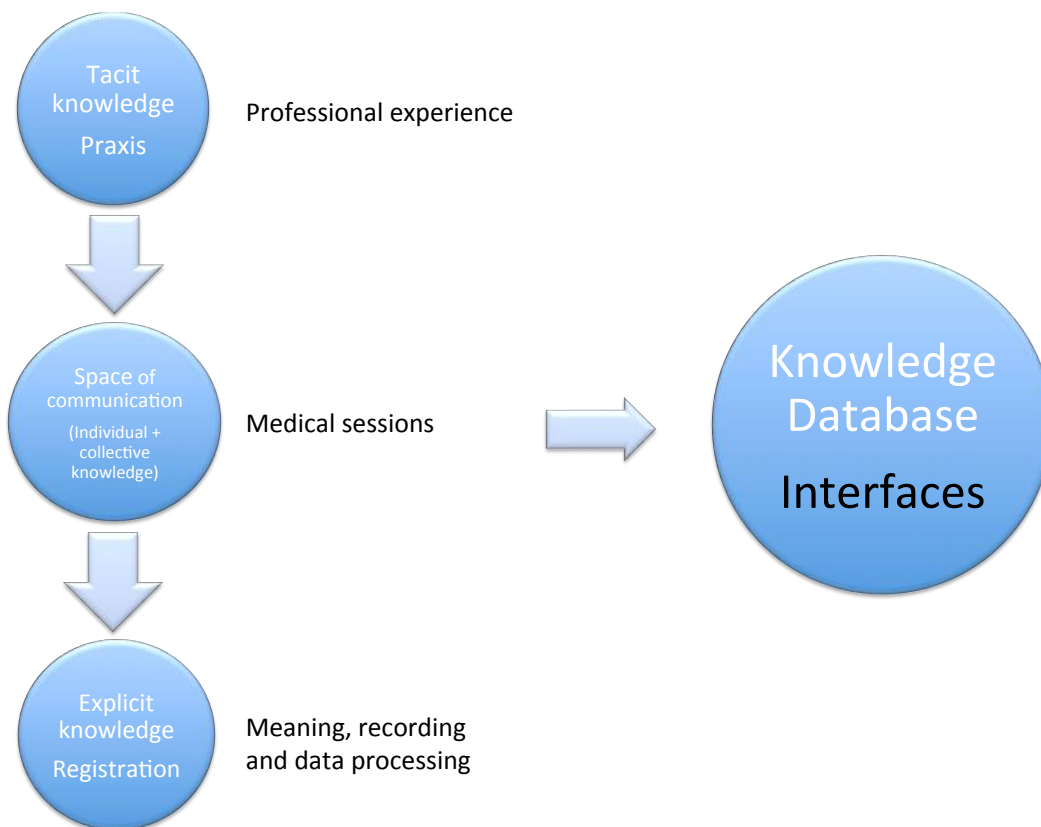


Figure 3: General scheme of transformation process of tacit knowledge to explicit. It is important to see that all of the integrated knowledge is related.

A successful achievement of this project required the merging of advanced technologies, professional talent, collective intelligence, and praxis. As a consequence, having all these elements, a healthcare knowledge management platform was created to increase collective and individual knowledge and to be a consulting tool for healthcare personal and students.

3.2 Design Phase

3.2.1 Analysis

The main goal of this project was to implement a technological pipeline to record, analyse and visualize clinical sessions performed at the Hospital Sant Joan de Déu de Manresa as well as to integrate them into their information system as tacit knowledge (Figure 4). To accomplish this goal, two software tools were used for video recording and analysis (MED1C AND SkillCatch). In addition, web and app tools were implemented to visualize the resulting tacit knowledge. Before implementing the web and app tools, it was necessary to understand and analyse the interface specifications, and which techniques and utilities had to be integrated. Therefore, a study was performed to define the functionalities required for the website asking several healthcare professions at Hospital Sant Joan de Déu de Manresa (HSJDM). Subsequently a technological pipeline was designed and implemented where clinical sessions are chosen as the reference to extract information. This includes the generation of a template for the structure of the different type of clinical sessions, which significantly helped to collect information in a standard way. Directors of the different units at HSJDM (Surgery, Gynaecology, Internal Medicine, URG, SEM) were asked to get permission to attend and record their clinical sessions, finally obtaining permission for Internal Medicine and Surgery. A validation stage was also performed to gather feedback on the developed tools from healthcare professionals.

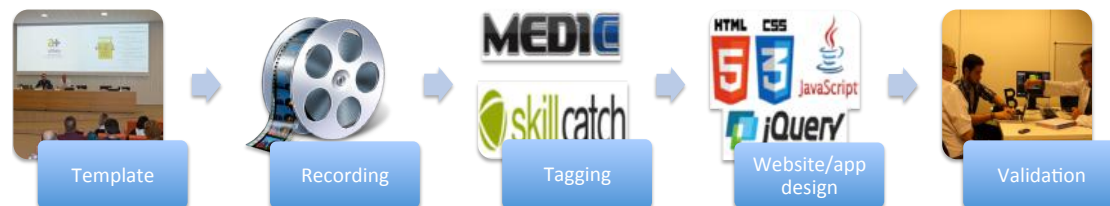


Figure 4: Technological Pipeline. First of all, a standard session template is generated in order to improve and facilitate the sessions' recording. Then, the videos are analysed and processed, adding tags. A website and a mobile applications are designed and implemented to visualize information and knowledge acquired during the medical sessions. Furthermore, a validation stage to gather feedback on the developed tools from healthcare professionals is performed.

3.2.2 Clinical session structure

Clinical sessions were given weekly; sessions of Internal Medicine and Surgery are usually performed every Wednesday and Friday, respectively, both at eight o'clock. Each session has a different structure. On the one hand, in the Internal Medicine sessions, speakers give the talk in the "Sala d'Actes", which is located at the educational part of the Hospital (Figure 5). These sessions can be quite diverse depending on speakers, session type and the clinical problem exposed. After the main presentation by the speaker, attendees have not only a discussion about the investigation papers related to the presentation, but also a professional discussion about different professional experiences. On the other hand, Surgery sessions are performed in the Surgery department (Figure 6). There are discussions of different clinical cases of hospitalized surgical patients, so in this case, the debate is focused on figures with

medical data such as medical images or ECGs from the relevant clinical field. Then, a clinical case is presented for debate with other professionals. In this case, since all sessions are focused on a clinical case, presentations follow a specific structure.



Figure 5: Auditorium of Hospital Sant Joan de Déu. Example of an internal medicine session.



Figure 6: Surgery department. Medical team of Hospital Sant Joan de Déu in charge of surgery clinical sessions.

3.2.3 New design for clinical session structure

Clinical sessions should follow a similar structure like high-quality scientific articles in order to generate a homogeneous template. Therefore, we performed an exhaustive bibliographic review among more than fifty papers of Pubmed from several high-quality clinical journals (i.e. BMJ, The New England Journal Medicine, Clinical Infectious Diseases, International Journal of Medical Science, among others) in order to investigate the standard structure and type of clinical articles available in the literature. According to the experience acquired during the clinical sessions of Hospital Sant Joan de Déu and the bibliographic review mentioned above the main sessions are: clinical cases, bibliographic reviews, values and ethics, assistance procedures and quality. These different classes of sessions do not share a common structure, different templates being used even for the same type of session. In order to standardize the

whole procedure and ease the acquisition of tacit knowledge (and also guide the preparation and execution of the session) we developed standardized templates. Two types of templates were developed (Figure 7), one for sessions discussing clinical cases and a different one for the remaining types of sessions. Both have been designed to advise speakers when they prepare the presentations and also to create a more practical and ordered methodology of the sessions. On the one hand, the clinical case template is divided in the following parts: clinical case presentation (e.g. patient description, clinical history, etc.); diagnosis and treatment; results (e.g. is it useful?); conclusion (e.g. what it is provided, next steps); and discussion/evaluation (e.g. subsequent questions). On the other hand, the template for the remaining sessions is divided in the following items: introduction (e.g. topics to be discussed and goals); methodology (e.g. what and how the research is done, and what data is used); discussion (e.g. why it is done and what it provides); results (e.g. is it useful?); conclusion (e.g. what it is provided, next steps); and professional discussion (e.g. subsequent questions). These general templates substantially helped the processing of the recorded sessions such as the tagging step, as described below.

Clinical cases	Others
Case presentation	Introduction
Diagnosis and treatment	Methodology
Results	Results
Conclusions	Discussion
Discussion/Evaluation	Conclusions
	Professional discussion

Figure 7: Standard templates for clinical sessions. One for sessions on clinical cases and one for the remaining types of sessions.

3.3 Data Acquisition

Data acquisition began with the attendance to several clinical sessions of the hospital. The presentation file was obtained from these sessions. Then, the main contents of the sessions were integrated into the web template together with a set of manually selected images from the presentation itself. Simultaneously, the sessions were recorded with a high-quality Sony RX100-II video camera. The resulting videos were subsequently post-processed and also included in the web. Videos need to be short so that a quick review of the session could be

done. Finally, textual information about the clinical problem treated in the session is gathered including related clinical guidelines, the bibliography cited in the presentation and related papers in the literature to complement knowledge generated at the clinical session.

3.4 Video Tagging And Processing

Once a recording of a clinical session is available, it needs to be processed, adding tags and comments to different parts of the session in order to facilitate posterior video mining and search in the developed tools. The tagging process has been performed following the sessions' template detailed before. Therefore, tags were divided into two groups: the bibliographic session tags and the clinical case tags. This decision was taken since most sessions have similar tags to bibliographic sessions, while clinical sessions presented more different features. Therefore, tags finally used in bibliographic sessions were the following: introduction, methodology, discussion, results, conclusion and professional discussion. In parallel, for clinical cases these were the used tags: case presentation, diagnosis and treatment, results, conclusion and discussion/evaluation (see Figure 7 and Figure 9 right).

The website is complemented with keywords, bibliographic references and clinical questions that are not labelled since they are not mentioned during the presentation. But once a given clinical session is uploaded into the web, some relevant tags are added since they help to better understand the presentation. Firstly, keywords can help professionals to know if a specific session talks about an interesting topic or not. Secondly, bibliographic references are useful to know which papers are used during the session study and it gives access to more information about the session. Finally, clinical questions can be helpful to know what are the topics talked during professional discussion. These tags set up the recommended structure to be followed by presentations to have a high-quality presentation compatible with the developed system. Nevertheless, this is not a compulsory requirement since healthcare professionals must have maximum flexibility to prepare their presentations.

Two commercial softwares, MED1C and SkillCatch, have been used for the transformation of tacit knowledge into explicit one, without altering the culture and structure of the clinical sessions, which was an important requirement in our application.

3.4.1 MED1C

Once videos from the clinical sessions are registered, a video tagging software was used to process, tag, add comments and upload them to the web. This software is called MED1C (<http://www.1d3a.com/productos/med1c/>). MED1C has been designed recently by a high-technology company based on sports, which is called 1d3a. The main software tool of the enterprise is ER1C that was created for football training and match analysis but finally, it has been used for many other sports. Because of its success, this software is currently used by Futbol Club Barcelona (FCB) to prepare training and football games. During the last years, this company has adapted the developed video-processing tools for medical applications.

Features of this new software such as the analysis, tagging and sequencing of the videos were quite appropriate for the needs in our medical application. We were in contact with the director and founder of 1d3a, Jesús de Pablos, and the product manager to get information on the software. We then adapted its functionalities to apply them to process the video recordings of the clinical sessions. The following subsections give details on each of the processing steps using the MED1C software.

Homepage

It contains an initial interface that is composed by the video analysis, the laboratory part, a report generator, and the configuration part (Figure 8).

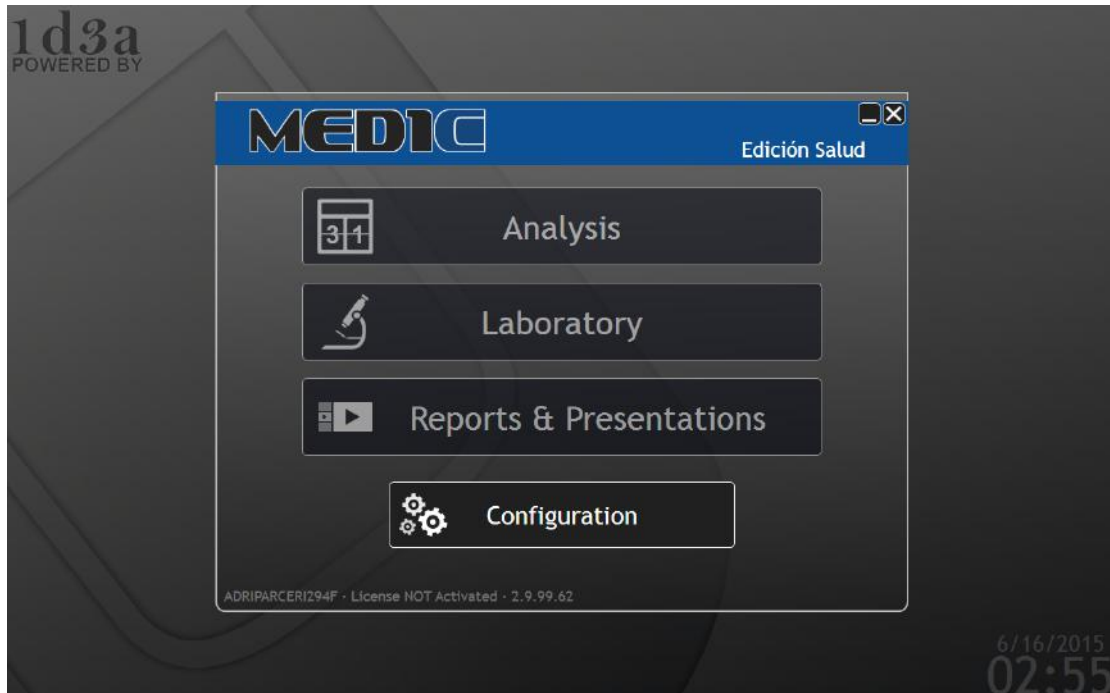


Figure 8: MED1C Homepage. Visualization of MED1C interface, which is composed by analysis, laboratory, Reports/Presentations and configuration sections.

Configuration

It is the first part to tackle, in which the video, its analysis, and the subsequent report characteristics are determined, being quite a fundamental step since the tagging model is created (Figure 9 left), based on the studied template for the clinical sessions (see Section 3.1.2). This step is quite critical, long and complex since the tags to be added need to be chosen, but it needs to be performed just once to set up the whole protocol. Figure 5B shows the selected tags (Figure 9 right).

As described above, we used the same template for the tags as for session presentations to facilitate compatibility and generate a more comprehensible tagging. In this configuration step, video duration can be chosen, which by default, lasts ten seconds. This means that once a tag is selected during video reproduction, it includes the previous five seconds and the following five seconds. However, this duration can be modified and, it can even be configured

manually; it is useful when video recording and tagging are performed simultaneously.

Additionally, the video and audio compression methods can be also selected and configured. Once tags are generated, they are saved and the tagging template is created, which will be later selected in the analysis menu of the MED1C software.

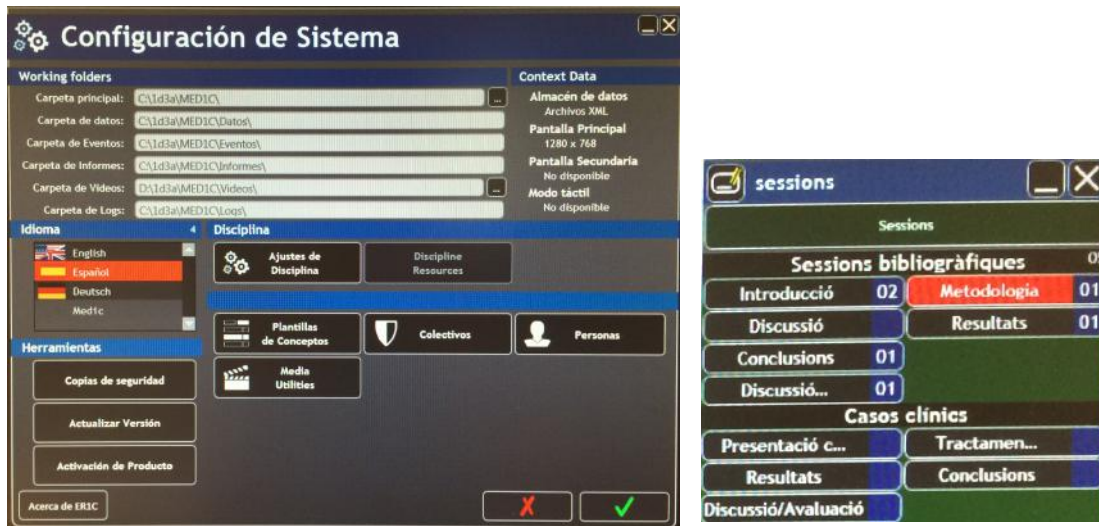


Figure 9: Configuration part of MED1C software. Left: General configuration screen where user can choose the parameters of the video including the tagging. Right: Tagging generated and chosen.

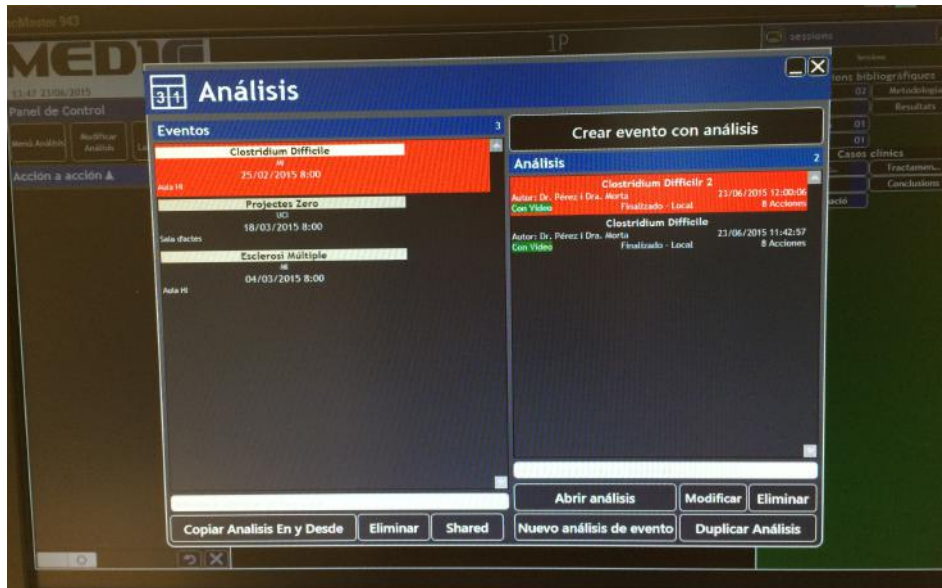


Figure 10: MED1C analysis section. Users can generate an event (clinical sessions) in order to study, edit, modify, and label it. In this example Clostridium Difficile session is going to be analysed.

Analysis

Once the tagging template is generated, the analysis section in the MED1C software homepage is selected (Figure 10). In this section, session characteristics are defined, videos are imported and tagging is carried out.

Firstly, information about the session to be processed is filled in such as the name of the speaker, the room and the time where/when it was given. Subsequently, the videos that will be edited and imported are selected. In this part the user chooses whether videos are serially or simultaneously reproduced. At the same time, the tagging template that will be used is selected. After videos are structured and imported, the tagging is performed. In this section, videos are reproduced while tags are marked and then, some comments of each part of the presentation can be associated (Figure 11). For that, it is necessary:

- To click the “1P” button that will initialize the new sequence.
- After that, the “play” button has to be clicked to start the reproduction.
- Once initialized, the software allows selecting the tags. Since each part of the session has different durations, the tags have been predetermined to put a manual duration in order to facilitate the tagging (remember that it was chosen in the configuration section). Therefore, when a new video section is initialized, the corresponding tag is clicked.
- Once this part is finalized, the same initial button is clicked again to finish the sequence.
- Upon tagging finalization, the “1P” button is clicked again to finalize the session.

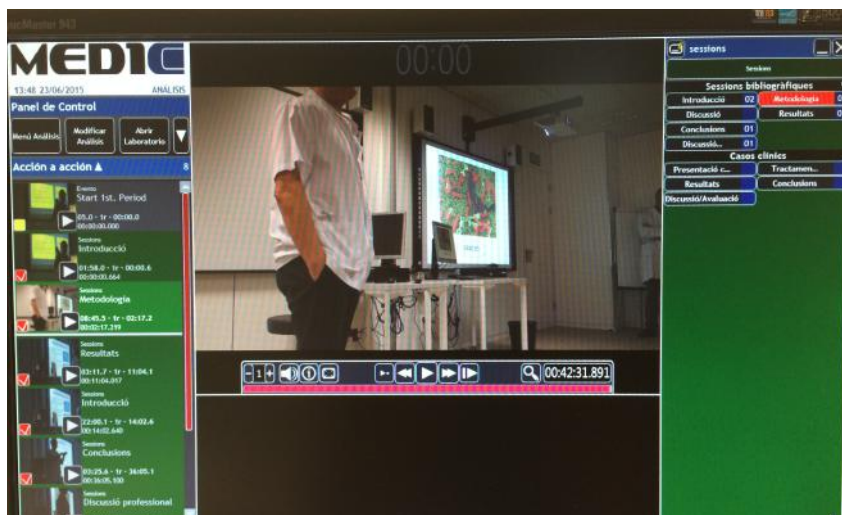


Figure 11: Features of the analysis section. Box filling section to provide information about the session. Videos are reproduced (centre in the image) while tags are marked (right in of the image) and then, some comments of each part of the presentation can be associated (left in the image).

Laboratory

Video tagging is analysed in this section and then, a report is generated. It is useful to add notes in every tagging phase and to add key points or to emphasize the most relevant items. Once this step is performed, all processed video clips are selected and then, they are stored in the report section. Finally, a report is generated.

Reports

The last part is based on the generation and saving of reports, which can then be exported. First of all, the report that will be exported is selected. Report features can be chosen (speakers, visualization methods, type of compression) as well as the parts used to perform the tagging that are going to be exported. Once exported, the user navigates through the "Downloads" folder in which the results are downloaded.

3.4.2 SkillCatch

The MED1C software did not provide the possibility of recording a session from a mobile device (at least in the current version). This prevented performing the tagging process during the clinical session, which is quite convenient. Thus, an application called SkillCatch was explored as an alternative. It is an app in which different reports can be generated. First of all, tagging and included sections are selected (Figure 12 left), and then the recording starts (Figure 12 right). While recording, the desired presentation section of the video is selected. Once the video is recorded, it is sent via e-mail and the report is generated.

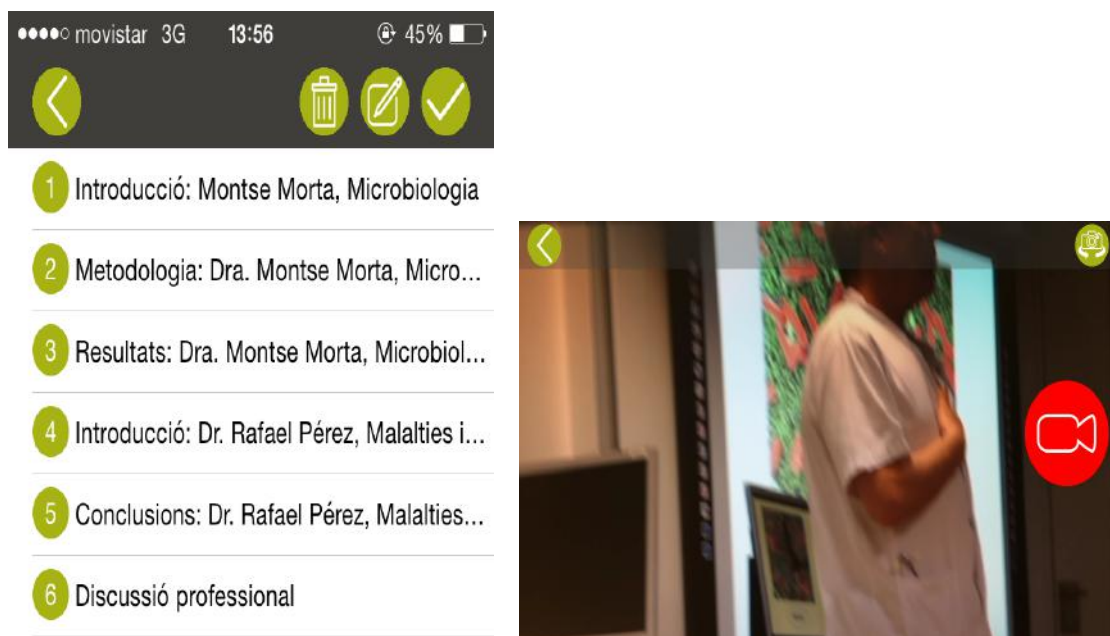


Figure 12: SkillCatch app version. Left: Tagging example of SkillCatch application. Firstly, user generates the tagging and then video can be registered. Right: Example of video recording. Once the tagging is done, then the video is recorded and user can select the part of the session that speaker is explaining.

The main drawback of this app is that the templates are individual and thus, a new tagging has to be generated for every report. However, it is a feature that can be improved. This

software allows recording everywhere at anytime, individually or collectively, and without a professional camera because a smartphone is enough. Therefore, the complementarity of these two softwares provided, on the one hand, the great level of sophistication given by MED1C, especially for organizational purposes, and compatible with a high-quality video-camera; and, on the other hand, SkillCatch is more practical and informal in order to crystallize the explicit knowledge into tacit one; in this case it is achieved with a mobile phone.

This process can basically be performed by a healthcare professional, training or quality head or any clinician responsible, without strong knowledge on technology. The user can give his/her opinion and choose the optimal tags for a given type of clinical session.

3.5 Development of Website and App Tools

Compatible web, Android and iOS applications were implemented in order to integrate all knowledge acquired from the recorded and annotated clinical sessions into a secure website. This knowledge consists of a summary of recorded speeches, annotated videos, and additional information from other sources related to the session like papers, related sessions, etc. The web application has been created in parallel both to the Android and iOS mobile apps that have been implemented in mobile processing language.

On the one hand, an interface was implemented in a standard notebook, called TextWrangler, to design the web. The programming languages used to generate the code were: HTML5, which allows adaptive mobile websites; CSS to determine the web style; and, finally, Javascript to create the software functions. First of all, a HTML5 template was created and then, data was introduced gradually whenever medical sessions were being performed. After that, a format adaptation of the web into the clinical institution environment (Althaia) was required, i.e., introduction of Althaia header and logo, To do that, an exploration of the corporate Image of Althaia document had to be done in order to find the style and font size and colours that were used.

On the other hand, the app design was generated with the "jquery mobile" language that is quite similar to JAVA, but in mobile version. Thus, many of its functions are similar to those used for web. Besides, the MySQL search engine could be re-used for the app as well.

Another important functionality of the developed web and app is the search engine, which was a priority from healthcare professionals. Creating a MySQL database, linked to the generated web and app, solved this complex task. Another reason for using a MySQL database was the required control of the web access with user registration and identification due to the presence of confidential patient data. Users are registered via e-mail and they can choose their username and password. Finally, there is also a geo-localization visualization system associated in the website to know where different sessions were performed. This feature was developed using Google maps tools and can be quite useful when sharing clinical sessions from different hospitals or clinical units in different buildings.

3.6 Evaluation Forms

An electronic questionnaire was created to evaluate the developed tools, which was useful to obtain the professional/user's feedback on the website and application mobile.

a) *Healthcare professional point of view for the tagging process*

A meeting with speakers of every session was arranged to receive medical feedback about the session tagging. Therefore, an electronic form was generated for speakers to verify its utility and practicality (Figure 13).

Formulari 1d3a

Experiència amb el programa 1d3d d'etiquetatge de vídeos

Ho considera de fàcil aplicació?
Valora del 1(molt insatisfactori) fins al 5(molt satisfactori)

1
 2
 3
 4
 5

Considera que són adequades les etiquetes?
Valora del 1(molt insatisfactori) al 5(molt satisfactori)

1
 2
 3
 4
 5

Opinió personal
Omple l'espai amb alguna consideració sobre les dues preguntes anteriors i dona una opinió sobre què t'ha semblat l'experiència, i si cal, comenta algun suggeriment o alguna aportació

Figure 13: Questionnaire for public speakers. An electronic form to validate the tagging software utility was created.

b) Functionality test of web/app

Additionally, a first demo/presentation with healthcare professionals and the educational director of the HSJDM was organized once a first version of the computational pipeline was available. The objective of this meeting was to show the initial results and receive their feedback and possible suggestions for improvements.

4. RESULTS

4.1 User interface

4.1.1 Homepage

In both formats of the application (web and mobile app), there is a menu in the homepage where users can access all sections of the website. On the one hand, the menu consists of the following sections:

- Access to all given sessions in an ordered manner based on session type or on medical speciality
- Section to visualize all cited scientific papers, which can be searched by keywords, authors, journals and/or years
- Section in which recommended sessions are integrated according to views and punctuation of professionals
- The search engine to quickly find each recorded intervention; in this search engine the user can search by papers, authors, keywords, and years

Besides the general menu, there is a content description of the webpage (Figure 14A), a section of most visited sessions (Figure 14B), and in the right part of the interface the recorded sessions in the last days are shown (Fig 14C). Additionally, there is a contact section at the top of the interface where the user can send an email to the Althaia technical department in order to ask questions; and at the bottom, there is a link to Althaia's Facebook account for the user to follow the Hospital events. Finally, in the same bottom section there is a translator for foreigners of forty-two languages.

4.1.2 Search engine

In the first menu column there are different search engines available: search by authors, by years, by papers, and by sessions. All recorded sessions by speakers are put in an author's search engine; all sessions given in a specific year are integrated into a year search engine; all related papers are found in a paper search engine; and finally, the session search engine includes sessions categorized by medical speciality. Besides, there is a universal search engine in the final part of menu bar so that the user can search any word and then, this search engine will search all information by authors, years, keywords and papers (Figure 15).

4.1.3 Session categories

This section is located in the second column of menu bar, where the user can both click the "Sessions" button to visualize all sessions ordered by day (Figure 16) or to breakdown the column in order to select the session category from which information can be extracted: clinical case, clinical management, care procedure, quality, review, bibliographic research, and values and ethics. Within this section, clinical sessions from a specific category are

alphabetically found. New sessions of the same department are put in the right part of the website.



Figure 14: Principal homepage content. (A) Initial webpage description. (B) Most viewed sessions' section. (C) Column of new performed sessions.

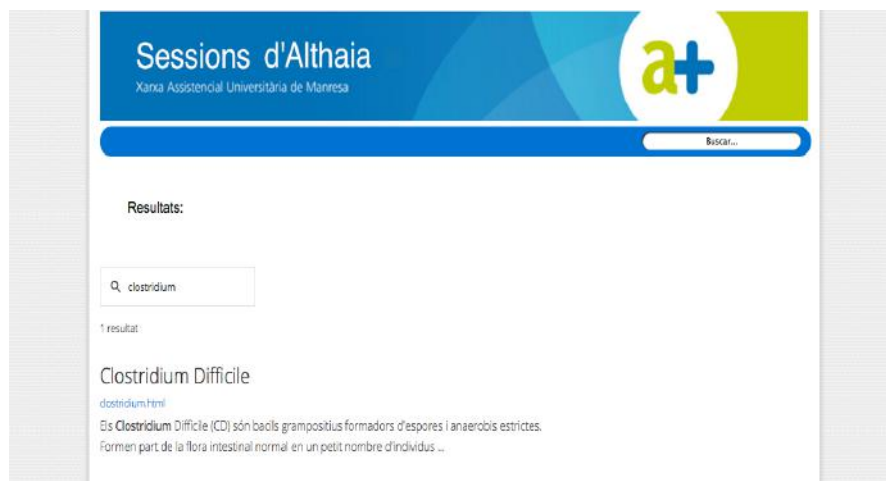


Figure 15: Search engine page. Here users can search all sessions by authors, years, keywords and titles.

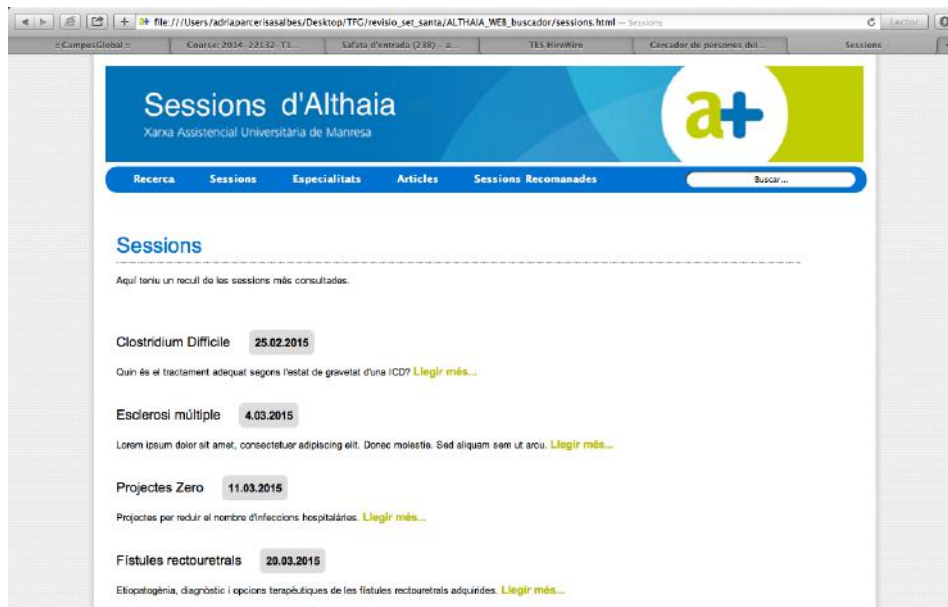


Figure 16: Sessions section. Visualization of sessions interface when users click “Sessions” button of menu bar.

4.1.4 Medical specialties

Medical specialties are found on the third column of menu bar, where the user can both visualize all sessions of each specialty by clicking the “Specialties” button and select a given medical specialty from which a concrete session is chosen. As in the previous section, all sessions on a specific medical specialty are alphabetically found. And in the right part, the new sessions in this specialty are also shown.

4.1.5 Papers

In the next column we can find the paper section, which consists of another search engine using keywords, authors, journals and years. But, in this case, papers cited in the clinical sessions are included in the search. Moreover, by clicking on the “Papers” button the user can access to all papers of each imparted session, which are alphabetically ordered.

4.1.6 Recommended sessions

Finally, the last menu column includes a list of recommended sessions. These sessions are selected through counter visits. The recommended sessions are the ones having more visits in the website. By clicking on the “Recommended sessions” button the user can also access into a space where all recommended sessions are ordered by counter visits.

4.1.7 Sessions

In this section all information collected during clinical sessions is included. These sessions can be visualized in different ways: from the search engine; from the menu, in which they are ordered by specialty or session type; or selecting one of the recommended or given sessions. In this case, the webpage shows all information corresponding to the selected session. Users can visualize the title of the sessions, the authors that have given this session, an abstract of the session, the introduction of the presentation, the methodology, results, references of application, discussion, conclusions, speaker comments and bibliographic references. There is also a part in which the user can download not only the material used in the presentation, but also the images and the annotated video of the recording. Besides, there is also a comments section in order to gather the opinion of users and professionals. Finally, all related sessions are visualized in the right part as well (see Annex Figure S17).

4.2 Mobile app implementation

Apart from website design, a mobile application has been created. The main features are the same as the website interface, but in this case the programming language used is jquery mobile in order to generate a compatible environment with website and app. The implementation for mobile devices provides access to physicians to the webpage in order to find information from a mobile device (smartphone, tablet) in a quick and portable manner. For instance, a surgeon could be doing an intervention and at some point he/she doubts about next procedure and he/she could use the mobile app for consulting purposes. Another utility could be to show clinical cases and real situations to medicine students. It is expected that this will be quite a useful tool for assistance and educational purposes (Figure 18).

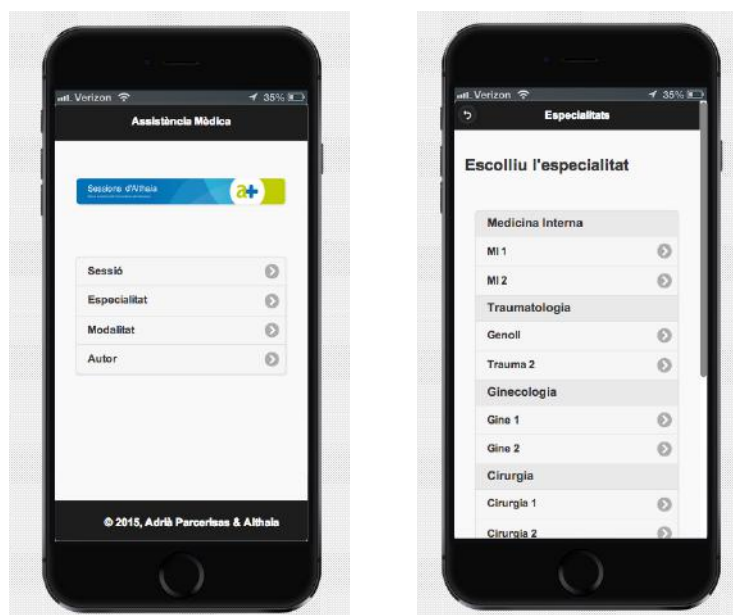


Figure 18: Mobile devices tool's result. (Left) Homepage visualization of mobile devices tool implementation. **(Right)** Representation of one of the homepage sections.

4.3 Feedback

Healthcare professionals at HSJDM that were asked for feedback on the developed tools basically considered that they had a lot of potential and that could be very useful. However, it was suggested that the number of sections should be reduced, roughly into: introduction, information, results, discussion and conclusions (Figure 19).



Figure 19: Feedback. Meeting with speaker professional helpful to adequate the tagging in a more productive manner.

5. DISCUSSION

After conducting an exhaustive literature research on healthcare knowledge management, the need for developing a system to extract, integrate directly and easily healthcare professional tacit knowledge was clear. In this project we developed a very promising solution to this problem, recording tacit knowledge that is acquired during medical sessions in hospitals. In these sessions a lot of knowledge is produced and orally shared but, so far, there was not a protocol for recording and storing it into explicit knowledge, thus being lost.

In particular, regarding the Hospital Sant Joan de Déu de Manresa, we have already observed some improvements since the beginning of the project. Before the project, every physician was following their own direction if there was not access to the tacit knowledge shared by professional speakers in past medical sessions. After the first promising preliminary results in this project, these are the main changes in the hospital induced by the developed system in the clinical sessions (so-called "Sessions of Althaia"):

1. The Hospital has now a tool to acquire tacit knowledge shared during clinical sessions, which is transformed into explicit knowledge (presentation, bibliographic research, professional discussion, etc.).

2. There is not a breakdown with the culture of the sessions established, assuring a more homogeneous format for all sessions.
3. New physicians, nurses and also students have now an educational tool where to consult and learn how different clinical procedures are performed in the hospital.
4. The relation with the company 1d3a has been substantially strengthened, both with Althaia and with the UPF, thanks to the use of the MED1C software, paving the way to new research and development collaborations between these institutions. All in all, MED1C has been a useful (but also expensive) tool, providing many benefits such as: unifying the methodology to present the session type; facilitating the communication of tacit knowledge into explicit; allowing to include more than one author when a session was given by more than one speaker; and including additional information (with the tagging note feature) such as a brief curriculum summary and the medical speciality of the speaker.

Furthermore, there is a lot of room for improvement in the developed system:

1. Being a new technology to be used in a clinical environment, it needs to be properly validated. In addition, more feedback from healthcare professionals is needed to improve the usability of the developed tools.
2. The responsibility for updating the website is an important issue. It is clear that the website needs to be up-to-date since new clinical sessions are given every week. Therefore, a member of the hospital must be responsible for keeping the site up-to-date.
3. The tools need to be easily accessible by different type of users. For doing so, several improvements could be implemented. For instance, Wordpress templates could be created for every type of session (remember that the sessions have been divided in two types: clinical cases and bibliographic reviews) and then, integration into the website will just be performed through a link. It could also be useful to provide the speakers with an established template for their presentations. Additionally voice transcription technology could be used to translate the recorded speech in the medical sessions. This will help with the task of video annotation during the clinical session since it should be more automatic. Currently, the session content is manually annotated and integrated into the database.

6. CONCLUSION

In the literature there are some theoretical papers to integrate tacit knowledge but most of them cannot be easily integrated in a clinical environment and just present hypothetical scenarios. In this work we have developed a system to transform tacit into explicit knowledge considering the constraints in a clinical environment, providing a practical solution to an existing problem. In consequence, this study has contributed to enrich healthcare KM in three different ways: optimization of information flows with engineering tools; documental

management with methodologies for processing information; and use of information technology for the transmission of tacit knowledge (i.e. web and mobile app interfaces).

A computational pipeline using video processing and web/mobile technologies has been implemented where healthcare professionals, including physicians and nurses, can consult all given medical sessions in Hospital Sant Joan de Déu de Manresa. With the developed pipeline we have set up a protocol to avoid losing tacit knowledge by storing it in a database that can be accessed anytime, allowing a more effective clinical practice and simultaneously identifying practices that do not provide any value to other healthcare professionals. The developed system can also be useful for professionals to inform colleagues within or outside the hospital (including hospital managers) about the current procedures and associated benefits or drawbacks in relation with the local environment but also linked with clinical evidence and expert consensus. Finally, this is a tool with huge potential to be used as educational resource of healthcare professionals.

It is expected that the implemented tools will have a significant impact in the daily life in hospital in a long-term basis since it represents a substantial cultural change in a fundamental process in the institution. Moreover, this project started from scratch and there is a certain degree of uncertainty on how healthcare professionals are going to interact with the system (e.g. enough visits in the website, adoption of the mobile app). At least we can state that the designed and implemented system can record and analyse clinical session content, which has direct applicability for assistance tasks, generally improving healthcare quality based on procedures previously performed. After this project, tacit knowledge generated from each clinical session (e.g. questions, comments, suggestions from colleagues) that was lost is transformed into explicit, is recorded and subsequently is available to be downloaded by any user. This provides very rich material support for assistance and/or consultation and educational purposes, e.g. high-quality guaranteed teaching material for medicine students. The implemented interfaces are attractive to readers and students but also practical, effective for physicians, with the added value of being compatible with mobile devices, allowing the users to access it in different hospital areas.

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ANNEX

Example of clinical session

The screenshot shows a web browser displaying a clinical session page for Clostridium Difficile. The page header includes the Althaia logo and the text 'Sessions d'Althaia Xarxa Assistencial Universitària de Manresa'. The main title is 'Clostridium Difficile' with the author 'Pérez R, Morta M.' and date '25/02/2015'. The page is divided into several sections: 'Informació de l'autor', 'ABSTRACT', 'Background', 'Paraules clau', 'Història', and 'Població estudiada'. The abstract and background sections provide detailed information about the bacterium, its symptoms, and treatment. The 'Paraules clau' section lists 'Clostridium Difficile, diarrea, antibiòtics, tractament'. The 'Història' section provides a timeline of the bacterium's discovery and epidemiology. The 'Població estudiada' section includes a bar chart showing the number of cases from 2008 to 2013, with 29.5% community-acquired and 18.6% hospital-acquired. On the right side, there are links to download a PPT, video, and images, as well as a list of 'Sessions associades' and 'Articles'.

Sessions d'Althaia
Xarxa Assistencial Universitària de Manresa

Clostridium Difficile

Pérez R, Morta M. Data: 25/02/2015

© Informació de l'autor

ABSTRACT

Background: Els Clostridium difficile (CD) són bacils grampositius formadors d'espores i anaerobis estrictes. Formen part de la flora intestinal normal en un petit nombre d'individus sans i de pacients hospitalitzats. Els CD són productors de dues toxines causants d'inflamació i diarrea: A enterotòxica i B citotòxica. I a més, són la causa més important de colitis pseudomembranosa, una infecció del còlon, degut a l'ús extens d'antibiòtics.

Objectius: Intentar trobar el tractament òptim segons el tipus d'infecció per Clostridium Difficile.

Resultats: El factor de risc més important pel qual es desenvolupa el CD és l'antibiòtic. S'ha fet una taula amb totes les característiques del tractament segons cadascuna de les etapes d'ICD.

Conclusió: Veurem els criteris bàsics de diagnòstic per a la ICD, una classificació de la ICD segons la seva gravetat i el tractament segons el tipus d'infecció.


Discussió: Per què no utilitzar transplantament fecal?

Background

Els Clostridium difficile (CD) són bacils grampositius formadors d'espores i anaerobis estrictes. Formen part de la flora intestinal normal en un petit nombre d'individus sans i de pacients hospitalitzats. Els CD són productors de dues toxines causants d'inflamació i diarrea: A enterotòxica i B citotòxica. I a més, són la causa més important de colitis pseudomembranosa, una infecció del còlon, degut a l'ús extens d'antibiòtics.

S'originen brots per infeccions hospitalàries o relacionades amb l'Assistència Sanitària (RAS). El tractament en general està basat a suspendre els antibiòtics amb excepció d'anticostridials.

Hi ha un 30-40% que no tenen una relació estricta amb els ATB, l'origen de les quals és comunitari i es manifesta de forma greu.



Paraules clau

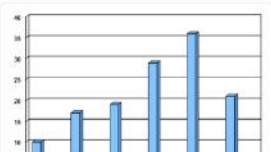
Clostridium Difficile, diarrea, antibiòtics, tractament

Història

1935: Aïllament Bacillus difficilis.
Dècada 60: Descripció diarrea associada a antibiòtics (ATB).
1978: Identificació CD com agent etiològic (DACD). Inicialment DACD atribuïda a Clindamicina. Posteriorment betalactàmics.
1989-1992: Epidèmia soça associada Clinda "soça" a USA.
2003-2006: Disseminació soques més virulentes, resistents i recidivants (ribotip 027)[1].
Actualitat: presència elevada de morbiditat en pacients institucionalitzats > 65 anys i una taxa de mortalitat de 0,6-1,5%.

Població estudiada

136 casos d'Althaia del 2008 al 2013.



Any	Comunitari (%)	NO ATB (%)
2008	29.5	18.6
2009	29.5	18.6
2010	29.5	18.6
2011	29.5	18.6
2012	29.5	18.6
2013	29.5	18.6

29,5% comunitari.
18,6% NO ATB.
Factors de risc: Neoplàsia, QT, Mil.
Prob. d'infecció infradiagnòstica.

Sessions associades

Colitis isquèmica 27.02.2015
Estudi d'un cas clínic de colitis isquèmica.
[Llegir més...](#)

Articles

Vancomicina/Metronidazol 01.08.2007
Comparació entre Vancomicina i Metronidazol pel tractament de la ICD.
[Llegir més...](#)

Tractament d'una ICD 01.07.2013
Resolució en pacients amb diarrea associada a Clostridium Difficile amb tractament de càncer mitjançant Fidaxomicina o Vancomicina.
[Llegir més...](#)

Disseny de l'estudi

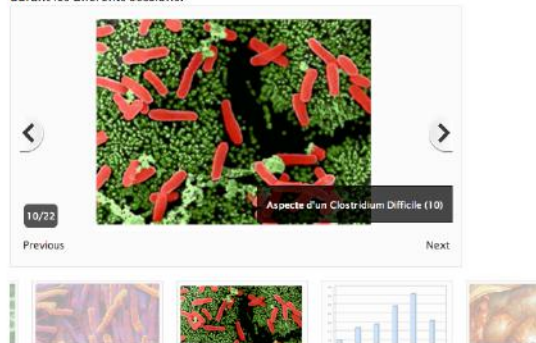
Revisió de les últimes guies de l'any 2014 de la Societat Europea de Malalties Infeccioses i se'n ha fet un protocol.

Vídeo



Galeria d'imatges

Aquí podeu veure un recull de totes les imatges relacionades amb el CD i les obtingudes durant les diferents sessions.



Opinió: Resultats

El factor de risc més important pel qual es desenvolupa el CD és l'antibiòtic. El consum d'antibiòtics (fins 2-3 mesos abans) en el 90% casos. Els més comuns són les quinolones, cefalosporines, clindamicina i penicil·lins.

Com a factors de risc també hi ha l'ingrés hospitalari o SS prolongat, la comorbiditat i l'edat major a 65 anys.

Altres: Alcalinització gàstrica, nutrició enteral, QT antineoplàstica, Immunosupressió i Cirurgia gastrointestinal.

S'ha observat pacients que compleixen novament criteris d'ICD en un període comprès entre 3 i 60 dies d'un episodi previ de diarrea per ICD clínicament resolt amb una taxa de recurrència d'un 10-25% després d'un episodi. S'ha trobat una relació amb l'estat immunològic (nivells Ac antitoxina). Fins 33-60% després d'una primera recurrència.

Recidiva versus reinfecció (exògena) fins el 2n més del 88% són recidives. A partir del 3r més de 65%. Els factors de risc que causen aquesta recurrència són l'edat > 65, la comorbiditat i els nous tractament d'antibiòtics.

Discussió dels professionals


1) Si un pacient ha tingut recurrències i ha estat sotmès a un tractament correcte i llarg, no estaria indicat en una situació d'immunosupressió?

- Si li has de tornar a donar antibiòtics, pot ser una situació en que ho puguis fer. Si el malalt està curat i no pren antibiòtics cap problema. Ara bé, si ha d'estar sotmès a un tractament antibiòtic, el risc si que pot augmentar. De totes maneres, si es realitzar, fer-ho amb Vancomicina per via oral, no és recomanat Metronidazol perquè en absència de diarrea, els nivells del colon són molt baixos i podria generar resistències.

2) El tractament més òptim per la ICD és el tractament fecal, però no està ben vist. Un exemple n'és la malaltia del Chron. Avui en dia, les infeccions per cucs són molt menors i això és degut a que som massa nets, això per exemple als gorilles i als conills no els passa ja que es mengen la seva pròpia femta.

El professional conclou en que en la nostra cultura sembla impensable aquest tipus de tractament, però recomana que si tinguéssim un familiar donant es podria dur a terme i seria una bona opció.

Referències bibliogràfiques

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DOI: 10.1503/cmaj.2004.171.5.466-72

Comentaris i suggeriments

* Dades obligatòries

Nom:

Email*:

Missatge*:

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Figure S17: Example of clinical sessions. This image shows an example of an internal medicine session performed during the practicum. In this case, the speaker talks about the Clostridium Difficile issue. There is exposed every part of the guideline session established as mentioned before. In the top of the image user can see the title of the sessions as well as the authors and the date that the clinical sessions has been performed. Then all parts of the session are put it also such as a background, the keywords, the results, the conclusion, the professional discussion, the literature review, etc. In the right part the sessions and papers related with the specific sessions are shown.