Integral Knowledge Management System in Health

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Abstract. This paper describes the results of the design of an Integrated Knowledge Management System in Health (IKMSH), including the description of a methodology for implementation; the system focuses on strengthening the provision of health services at the regional level and supported by knowledge management and information and communication technologies. This system allows the dynamic integration of existing or new information systems with knowledge management applications, supported in an interactive knowledge portal as an interface between the user and intelligent agents; the system is also supported by a knowledge repository integrated under specific data mining techniques and intelligent agents to provide reliable, secure and verifiable information and knowledge in the management of health decisions.

The proposed system is *integral* because it includes the necessary parts of the *General Social Security System in Health* at the governmental level: Assurance, management, provision of services, surveillance and control, supervision, evaluation and other components of *health care*.

Taking into account the magnitude of the system and that governmental support is required for its implementation, a series of strategies are proposed for its development, organization and implementation.

Keywords: Health · Information systems · Knowledge management
Knowledge management systems · Innovation · Technology

1 Introduction

In Colombia, the deficiencies of health information have been the constant during the more than twenty years of the General Social Security System in Health, to the point that even today there is not an adequate integral and integrated model of information management and knowledge health, involving and relating to all stakeholders, all processes and all results, standardized reports, in accordance with existing regulations, with the business demands of today's world and with the demands of users.

Current regulations in the country, which is very rich, very thorough and extensive health, has developed few aspects are essential for the proper functioning of the health system, but unfortunately these regulatory developments have not translated into

operational processes, so that, in real life, is not transparent to the end user (patient and family) the health service as a support for their conditions and quality of life.

Processes for attention, not only direct health services, but all assurance, the promotion and prevention, induction demand and worse as education and information, suffer from all kinds of failures and end they generate frustration, discouragement, restlessness and anxiety, both in patients and their relatives, increasing dissatisfaction, demands and guardianships that make the Health System inefficient, expensive and "deficient".

Although technology today provides all the possibilities to do things right, even its implementation is very poor and limited, especially for the optimal functioning of the Social Security Health System. Likewise, the technical capacity of health personnel for the use of ICTs is very deficient and does not allow their use.

For all the above reasons and the others explained throughout this document, the project aims for the integration of knowledge management, innovation, creativity and training at all levels (formal and informal), to correct and contribute to the overcoming of such shortcomings and the continuous improvement of the social security system in health.

2   Conceptual Framework for Knowledge Management and Health

Knowledge management aims to create structures and organizational dynamics based on knowledge, so that knowledge from the experience of each individual impacts the entire organization and becomes assets that are an integral part of the organization. The integration of these models privileges the organization, management and use of information, the creation of flow mechanisms and the tools that guarantee knowledge management in organizations [1].

Knowledge Management (KM), which is conceived as the process of capture, distribution and effective use of knowledge, promotes a comprehensive approach to all information activities in an entity to generate value and new opportunities [2].

The KM allows managing the asset - intellectual capital, turning KM into a social fact that occurs in formal networks and, above all, in informal ones, favoring the latter, and generating their integration that ultimately catalyses and normalizes them.

Another concept of European consensus defines it as the "Planned and continuous management of activities and processes to enhance knowledge and increase competitiveness through better use and creation of individual and collective knowledge resources" [3].

There are many concepts of well-known authors about what knowledge management means, but in practice we can summarize that it is a concept used in companies, which aim to transfer the knowledge and experience existing in employees, so that it can be used as a resource available to others in the organization.

The KM system in health aims to preserve knowledge, take advantage of the experience and expertise of the people within the system and make them available to the same organization and other institutions that require it. Facilitate innovation and organizational learning, generate connectivity among people within the system, as well

as interoperability between different health subsystems (public and private), and allow the generation and development of new ideas about their work performance, conditions of health, health management elements, etc., allowing to improve the identification and solution of complex problems.

The regulations related to e-Health have made it possible to focus on the use of Information and Communication Technologies (ICT), so that the different challenges in the health sector in Colombia can be dealt with more effectively and precisely.

3   Applied Methodology

The methodology that was applied to carry out the project of "Implementation of an Integral System of Knowledge Management in Health" required two fundamental, complementary and continuous phases in some of its activities:

(1) *A first phase properly research:* Where it was intended to achieve a diagnosis of the health sector and as a case study was taken the department of Boyacá, Colombia; for which it was necessary to design and apply surveys, interviews, questionnaires, observation, information and knowledge requirements techniques, and considered: selecting and applying measurement instruments in the health sector; which led to the theoretical formulation, characterization and modeling of an integral health knowledge management system for Boyacá department.

In this phase, a research methodology was applied that integrated the *type of exploratory research* and the *descriptive type* to emphasize the most relevant aspects of the problem and also define the appropriate *procedures and models* for the implementation of alternative solutions in the provision of health services, and also as a basis for characterizing the object of health study in Boyacá.

Specifically, the *exploratory method* sought to observe and evaluate aspects of:

- Normative environment and technical standardization.
- ICT infrastructure for the health sector.
- ICT for access to health services.
- Patient Information Systems.
- Patient safety.
- State of knowledge management and innovation.
- Education, training and dissemination.

To carry out the collection and analysis of the data to answer the research question and test the hypothesis, a quantitative approach based on the *deductive method* was applied. This approach allowed for the numerical measurement, the counting and the use of statistics to establish patterns of behavior in the health sector of Boyacá department.

Therefore, the type of *exploratory research* also allowed obtaining information and determining research aspects of health towards the future. And the *descriptive* type allowed to determine the fundamental characteristics of knowledge management in the health sector in the Boyacá department and ultimately achieve innovation in health care and provision.

(2) *A second phase of design and implementation:* Where the design and application of the integral knowledge management system model was required, supported in a technological platform that allows the future to conclude its applicability and replicability. In this phase, we continued with the application of a conceptual methodology for the implementation of the Integral Health Service through knowledge management with emphasis on Information Technology.

In summary, the project aims to implement a integral knowledge management system in health (IKMSH), from the perspective of "turnkey" technology transfer.

4   Integral Knowledge Management System in Health

4.1   Health Knowledge Management Model

The model is initially based and personified on a level of context or general level (Fig. 1), projected in a pyramidal structure, where the need to interrelate *Health* as the main node is represented, which is represented in the upper vertex of the pyramid and supported on a solid foundation for its effective functioning, that is to say that it rests on the lower vertices that constitute the bases of the pyramid, such as the *health management entities node* (Health Secretary, Healthcare Provider Institutions - IPSs and Healthcare Providers - EPSs) and the *technology node*, which facilitate the different health processes, through a management process based on knowledge. The intersection of these three components or nodes constitute their management through an Integrated Knowledge Management System.

This implies that, in order to achieve a balance between them, institutions and technology must show the capacity to adapt to the social, technological and economic changes of the health environment and in a timely manner or, even more, to induce them and/or anticipate them. through the support of a series of facilitating agents such as *training, development, innovation and research*, which are associated with the knowledge they generate and that they have to manage in an adequate and optimal way.

These three components or main units are represented as interrelated nodes, which also contain resources based on tacit or explicit knowledge, where knowledge is generated or transferred, and can perform various processing or treatment functions required internally or through the links or relationships in a network, which expands into other components or related sub-nodes [4].

The three interconnected nodes: Health, Health Management Entities and Technology, resemble the coexistence and dependence between them, increasingly complex, interconnected and changing, and with a horizon supported by the research they can generate. In addition, a central intersection between them is conceived, which is the core of the entire model: the knowledge management system, which aims to be the engine of inter-institutional strengthening. These nodes constitute vertices that could be called "inter-institutional vertices" in permanent contact and interaction where information and knowledge flows, supported by the technology that facilitates their process. This scheme is framed within the scope of a dynamic and increasingly demanding society.

Finally, another component is outlined that is the reason for the whole model: *the community,* which perceives the different benefits of an adequate health service.
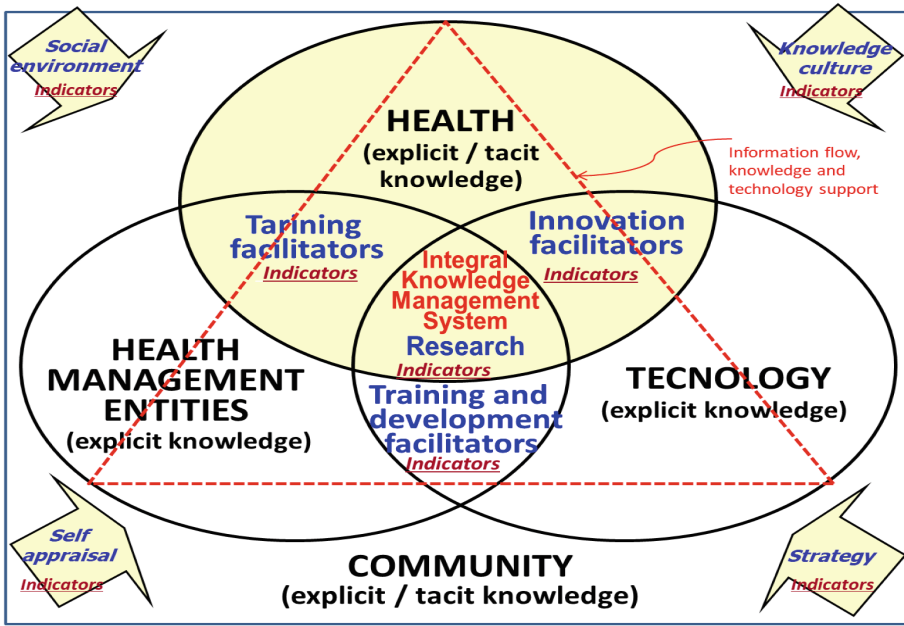

Fig. 1. Health service model basado on knowledge management. Source: The authors.

Conceptually, in the model, organizations obtain results that are arrived at through the behavior of their facilitating agents, that is, the actions of their personnel and the functioning of their processes [5].

In the *Health node* and the *Health Management Entities node*, the *facilitators* are the elements that will allow us to promote the actions of the health organization policy, and the management or fulfillment of said actions it is evaluated according to the behavior of a series of indicators that will facilitate the identification, development and retention of knowledge, and that ultimately will allow to maintain or fulfill the mission of the organization.

As seen in the model, the *facilitators* are associated to a specific node in order to provide a delimited area of knowledge and they can be grouped into different indicators that facilitate decisions on the proposals for the achievement of the strategy. Also, indicators can be understood as units of measurement that allow registering the dynamics of processes and performance, and, therefore, verify compliance with the objectives of an institution, in compliance with its mission [6].

In practice, the model presents an abstraction of the relationships that can be generated between health, health management entities and technology and at the intersection or confluence of the three nodes, knowledge is conceived as a source of power and a central axis capable of adding value to the organization and supporting actions, in the fulfillment of an adequate knowledge management.

4.2 Technological Architecture of the Integral Health Service Based on Knowledge Management

The form of technological integration that was applied, it was that used specifically in the applications functionality, through what can be called application integrator or integrating component of a knowledge management system and information systems, which helps users in the evaluation, interpretation and adaptation of knowledge to a new context, domain or application. This application integrator, as shown for example in Fig. 2 (database/knowledge), supports the sequential flow of explicit knowledge outside the repository. It also provides the means to share knowledge exchange, where members of the user community (for example: employees, doctors, researchers, patients, etc.) share, understand and contribute knowledge through their experiences.

Therefore, the following architecture of the integral health service is detailed through knowledge management and ICT support for the Boyacá department (Fig. 2).

Another very important aspect from the point of view of data, is data storage or "Data Warehousing", online analytical processing (OLAP), and data mining are three of the most important technologies in the field of Business Intelligence [7]. Data storage can be defined as a "large" repository of historical data relating to the organization that supports decisions [8]. OLAP is a technology that is based on the multidimensional analysis of data and data mining is the process of identifying and interpreting patterns in the data to solve a specific business problem [9].
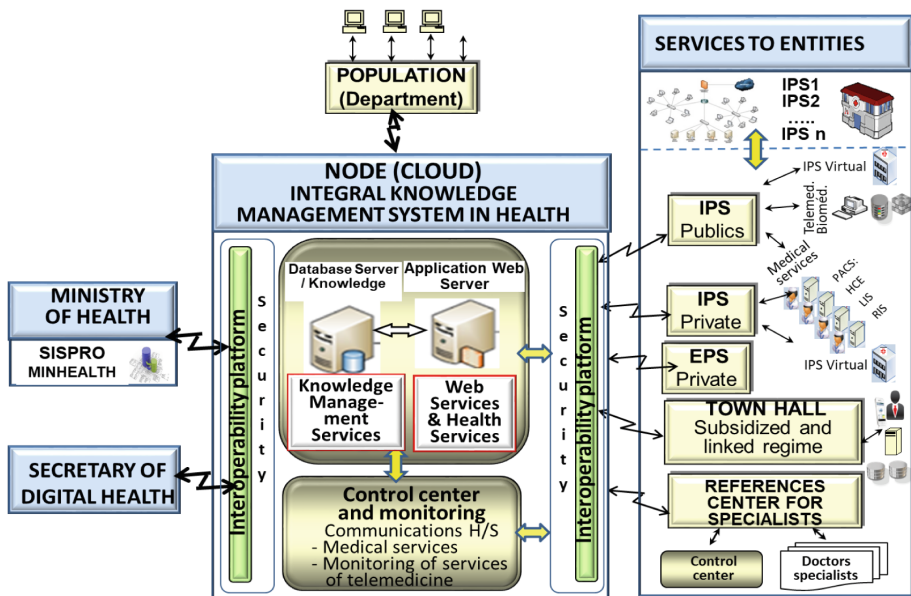

Fig. 2. Technological architecture of the Integral Health Service through knowledge management. Source: The authors.

4.3   Methodology Applied to the Development of Integrated Health System

Once the problem and vision of health is conceptualized in the department of Boyacá [10–12], it is necessary to define what initiatives and in what order they will be implemented. Since the region needs to define and adapt its own knowledge management model, an implementation *methodology* is required.

Based on the analysis of the most widespread methodologies and especially the proposal in the European standard [3], the American approach of Tiwana [13], and at the national level Medina [14], proposes a *personalized methodology* that seeks to involve, in addition to the organizational aspects and technological details, the articulation and support required to adequately manage knowledge in the health sector, taking into account the study and analysis of the recent Departmental Strategic Plan for Science, Technology and Innovation of Boyacá [15].

Conceptually, the personalized methodology (Fig. 3) consists of *phases* that include the initial approach to the situation, with the entire chain of actions that must be carried out until the desired new situation is reached. These phases facilitate the development of a modular procedure, in such a way that in the course of time parts of the system are carried out as independent subsystems that cover their scope of action, but oriented towards an integration of all of them.

The phases are formed by a set of stages that must be carried out when the phase is executed. The stages are disaggregated in turn into *activities,* which do not necessarily have to be carried out successively, but its structure has been proposed as a concurrent and continuous development by groups, which provides savings in terms of execution and costs.

The *activity* is the basic unit that has a content and actions to perform. In general, each activity can be structured in a series of actions such as: available *information sources*, *steps or processes* to be performed or factors that may have an impact on its execution, support tools, *products* or results and *recommendations* to facilitate execution of each activity.

In turn, the methodology *emphasizes a spiral approach that represents the infinite and continuous cyclic development* between its different phases, stages and activities that lead to improvement through an *iterative and incremental* process. It is *incremental* because new plans can be added to achieve the goal(s), it is *robust and stable* since by maintaining the goal it admits changes in behavior if the same goal is maintained and it is modular because the plans are modulars.

In addition, the methodology is based on an abstraction of *"life cycle knowledge"* or *"knowledge value chain"*, the most general those to *identify, create, store, share and use knowledge.*

This cycle is considered as an integrated process that supports the processes of the organization and wider service provision. Its integration and performance will be supported by appropriate knowledge management methods and tools aimed at improving the provision of health services.
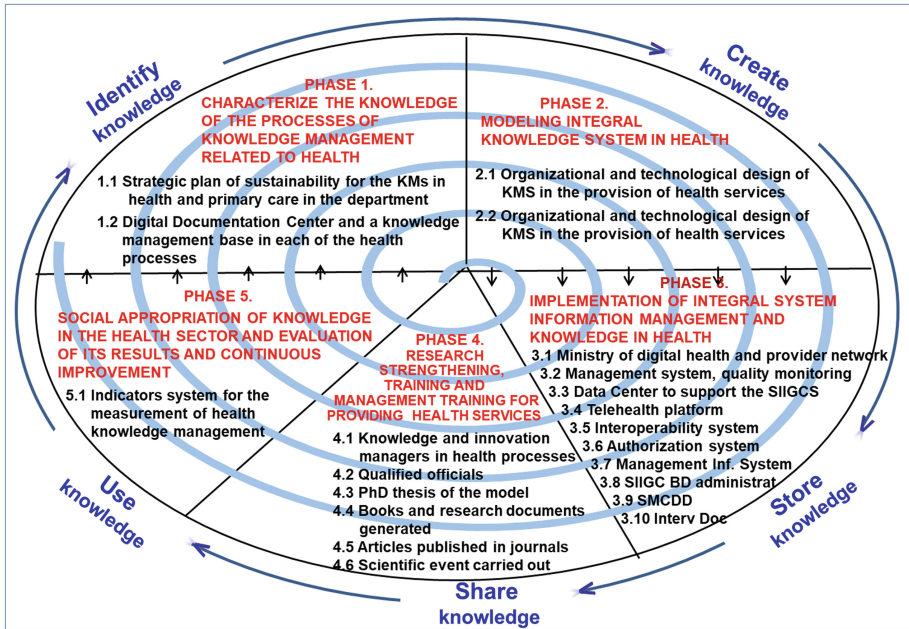
Fig. 3. Conceptual methodology for the implementation of the Integral Health Service supported by knowledge management. Source: The authors.

The phases of the personalized methodology for the implementation of the integral health service supported by knowledge management and supported by information and communication technologies are briefly described, which has been structured in five coherent phases with the general objective raised in the project:

PHASE 1.   *Characterization of ancestral knowledge of the processes of knowledge management related to health:* Involves characterize and verify that the entities providing health or Departmental Secretary of Health and hospitals or health centers in each of the 123 municipalities of Boyacá, known or it has relied on knowledge management, and if not, raise awareness of its benefits, the effects and advantages it represents for it; and with the perception and motivation from the top management and thus achieve define strategic plans and plan the organizational integration for its implementation.

PHASE 2.   *Modeling of Integral Knowledge Management System in Health:* One of the most useful ways to understand, study and represent the strategy of knowledge management in any type of health organization, is through a model that offers a unified vision and complete about what you want to abstract from reality about knowledge management.

PHASE 3.   *Implementation of Integral System Information Management and Knowledge in Health:* For the acquisition of software to support the knowledge management system, different techniques must be applied, both software engineering and web engineering and, of course, knowledge engineering.

Information and knowledge management applications must be acquired and implemented, designing interfaces for their interaction and integration, as well as intensifying and integrating the different repositories of information and knowledge, which were described in the Technological Architecture of the Integral Health Service.

PHASE 4.   R*esearch strengthening, training and management training for providing health services:* In this phase it is intended that researchers make public and promote the findings obtained and the knowledge achieved, is socialized and becomes the heritage of the scientific community and the public in general. The dissemination of the results of the research will be carried out through its publication in scientific journals or in the form of books. It also contributes to the socialization of the research results, the presentation in scientific events, although with a more local and perishable character. In addition, training and training will be carried out in the effective management of health.

PHASE 5.   *Social appropriation of knowledge in the health sector and evaluation of its results and continuous improvement*: Once the integral health knowledge management system has been implemented, either as a pilot project or a specific area, it will be scaled and implemented in the different public IPSs of the department, municipalities with incidence in each of the processes of health knowledge management, for which it is necessary to evaluate their respective management.

The adage that "it is well known that what can not be measured can not be managed" is applied, a measurement model based on the quality of knowledge and continuous improvement must be developed.

5   Methods and Tools for the Evaluation of Knowledge Management in the Health Sector

Given that health organizations obtain results that are arrived at through the behavior of their facilitators, that is, the actions or actions of their personnel and the functioning of their processes, the method that will be applied for their evaluation is based on the concept of *indicators associated with these facilitators*.

By *indicators* is understood the systematic process of measuring and valuing the knowledge of the organization in relation to its results in health care, social, training and intellectual production and compliance with its strategic objectives of the organization.

It is necessary to develop a set of indicators that can be incorporated into the organization's usual scorecard and that provide periodic information on the functioning of the processes put in place. These indicators will be a source of additional information to the periodic diagnosis of the state of knowledge management in the organization.

We can also understand the *indicators*, as units of measurement that allow recording the dynamics of processes and performance and, therefore, verify compliance with the objectives of an institution, in compliance with its mission.

The indicators are constructed in order to record the significant events of a specific area of performance and thus have a rational and concrete argument, a clear and precise vision of the management of each unit. They allow an adequate control of the activities developed, so that they are carried out in accordance with corporate interests; they also serve to define policies, objectives, strategies and goals that ensure the consolidation of the objectives of the Institution, in the medium and in the sector that corresponds to it.

Consequently, the indicators for the health sector must be integrals, complex, of quality and not simply or exclusively of efficiency and effectiveness. In the project, different conceptions and proposals of the indicators model were researched and designed and will carefully examine these issues.

Therefore, the approach of the proposed indicators is conceived from the base of integration in the pursuit of the same goal: *the strengthening of the Intellectual Capital of the health organization.* Special clarification is made, which is not about applying only indicators to carry out an exhaustive description of the management of all possible human, structural, relational or technological assets, but also to determine those that are really capable of adding value to the organization and support actions, in the fulfillment of adequate knowledge management.

In order to determine *the tools* that will be applied, it is necessary to bear in mind that it is often very difficult to directly measure the impact of KM activities. However, this could be useful in making the efforts of the organization (rather than the results only) in the KM area more transparent, for example, when transmitting information, managers of a health organization should indicate the effort that has been made to support KM processes, more specifically these should indicate what has been done to stimulate the processes and the correct organization, to build a supporting (technological) infrastructure and, what is more important, to inculcate the appropriate culture and the appropriate system of behaviors of the organization. Another example is related to managers trained in two ways: one in the awareness of the effects and benefits of knowledge management, and the other direction is addressed in the training of the use of technology to strengthen the processes of provision of the different health services (in every sense: services and patient care).

Initially, a *diagnostic tool for knowledge exploration* should be applied to measure how the organization is currently situated with respect to the processes of basic knowledge and attention to health services that are part of the KM framework, for example, in the cycle of the coherent knowledge process with methodology applied to project development: identify, create, store, share and use knowledge. For each of these five processes, a series of diagnostic questions are asked, which are related to the "7S model" where the Institute [16] focuses on Strategy, Shared vision, Style, Personnel, Skills, Structure and Systems.

In addition to this, questions are asked that relate to the organization as a whole, that is, without focusing on aspects of knowledge in isolation, so that it can be observed if the knowledge aspects of the organization are relatively strong or weak points.

Finally, for each knowledge process, it is asked how their personal attitude and behavior at that time are questioned and related to knowledge processes.

Each respondent is asked for a score on questions ranging from one to five (1 = does not agree at all, 5 = totally agree).

In the analysis of the questionnaire it is important to identify the questions scored more positively and negatively and compare the responses of the different individuals, teams, departments, etc. It would be wise to conduct the exploration on a regular basis, so that progress can be monitored and corrective actions can be initiated.

In *the final stage of the project*, the knowledge exploration tool will be re-applied with the relevant adjustments, evaluating its results and defining strategies for continuity and sustainability of the model applied in the project.

Through the *verifiable indicators* of the beneficiaries, the system (109 of IPSs, in 123 municipalities and the Ministry of Digital Health, the coverage and compliance of the beneficiary population of the department of Boyacá will be guaranteed.

6   Considerations for System Validation

For the system validation, time and evaluation of results in the medium term is required, which is being implemented, why cannot yet present in this paper.

In the system presented in this research, the dynamic analysis of systems with knowledge management methodology proposed by the European Guide is combined and aims to create an assessment instrument of knowledge management network in the introduction incremental innovations in product, service and process for a enterprises, that deploy a range of possibilities for development and innovation of social technologies. Therefore, that leads organizations, increase their competitiveness and reduce socio-economic difficulties that afflict both.

Furthermore, it is possible to deduce that the competitiveness of an organization it increase when the lines of knowledge and methodologies act synergistically in conjunction with contextual factors as the country's trade policies, tax policies, investment security and others, achieving an economic and productive development in the organization.

7   Conclusions

In this research work, a health management model supported by knowledge management was proposed, which demonstrated the need to change or improve traditional or classic structures by a more functional, agile and efficient operating model that allows resizing spaces for the production, diffusion and transfer of knowledge, with the support of new information and communication technologies.

Health depending on the health management entities; and undertake organizational and financing reforms. In other terms, the model raises in essence the need to generate an adequate relationship between health, health management entities and technology all this in order to strengthen knowledge management in order to obtain benefits of impact for the community.

With the development of this model, the administrative, logistic and academic components are integrated, seeking to consolidate a scientific and technological research center in engineering of a higher institution, taking as reference other existing research institutes.

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