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AN INFORMATION SYSTEM
FOR VIRTUAL HOSPITALIZATION MANAGEMENT

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Abstract

The virtual hospitalization can be considered as the telematic evolution of the Day-Hospital, implementing the integration between hospital care and home care. In this paper the authors describe characteristics, motivations and advantages of this proposal, as well as the interaction model. Then the medical problem is illustrated: the liver tumors, which are the more frequent malignant neoplasms, and, in particular, the hepatocellular carcinomas, which represent about the 50% of these tumors. The Organization Model, the Information System and the Modalities of Telemonitoring for Hepatocellular Carcinoma are illustrated and a brief conclusion is given.

Keywords: **Virtual Hospitalization**, Integration Model, Telemonitoring.

1. Introduction

The central problem in Health Care System management is the increasing of the cost of the health care resources. So, the health managers have two possible alternatives. One is the reduction of the public assistance and the other one is the optimization of the cost/benefit ratio reducing the wastes and optimizing the human and material resource use. In particular, by the business reengineering it is possible to improve the care quality, decreasing the service waiting and execution times and, then, to reduce the service costs. The new organization system will be based on a new information system, which will use new informatics technologies and methodologies, which will allow to reduce the number of accesses to public specialized structures and to optimize their use, assisting with continuity the patient everywhere he will be, allowing the control of the active diagnosis and care process on the patient and using, by teleconsulting, the medical expertise, distributed on the territory, in the different specialized medical centers.

A way to define these models is the redefinition of the existing ones, considering the present development of the telematic technology. The virtual hospitalization can be considered as the telematic evolution of the Day-Hospital (DH), implementing the integration between hospital care and home care and predefining an hospital system which "goes to the patient home".

In the phase of design and implementation of a new organization and information hospital system the authors refer only to the DH case, because its dimension is small but its social impact is strong (facility to accede to high technology services) with a substantial reduction of the costs (for example, the decrease of the hospitalizations). The business reengineering applied to the DH generates the virtual hospitalization, and, by the telemedicine system use, guarantees the synchronization, the integration and the optimization of the diagnostic, therapeutic and rehabilitative interventions.

2. Virtual Hospitalization: motivations and main characteristics

The virtual inpatientization is a solution technologically feasible which can be immediately implemented thanks to the evolution and the diffusion of the telematic techniques. In fact; by these techniques it is possible to develop an advanced integration between hospital assistance and assistance at home/working place: it is the hospital which follows the patient during his daily activity.

The main characteristics of the virtual inpatientization can be classified as the following [MRR95, Van92]:

- the day-hospital service intervenes on the patient also if he is physically into the hospital only for a brief period of time;
- the patient appears inpatientized prevalently in his home, so that he continues to carry out his daily activities;
- the physician is abreast regarding the patient status and the "actions" already carried out, in progress or to carry out on him (diagnostic examinations, therapeutical and rehabilitative protocols, etc.); moreover, he knows the structures involved in such phases;
- in order to intervene on the patient, the physician uses all the health care structures which are present on the territory (ambulatories, laboratories, car hospital, etc.), minimizing the moving of the patient on the territory and the waiting time, and maximizing the flow of the information;
 - in chronic situation, the patient can be monitored at his home and cured following the modality of the home care.

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The implementation of the virtual in-hospitalization allows to verify the applicability of the business reengineering in the hospital area with an easy demonstration of the advantages given by the telemedicine systems. In fact it is possible to demonstrate which the virtual hospitalization is an innovation which solves an important clinical problem. In such a way it is possible to start a cultural joint interest which, starting from the health care operators, will include all the agencies which influence the medical decision making, as well as the final users (citizens). The virtual hospitalization project is inspired by the present strategies of the firms which plan the use of distributed informatic and telematic systems, with particular regard to the quality. The virtual hospitalization is important because it has as priority the increasing of the service development depending on the distributed telematics criteria.

The medicine is essentially "hospital oriented" and the evolution of the day-hospital toward the virtual hospitalization can have a relevant social impact. The hospital has at disposal human and material resources which are integrated among them. They are usable also with a minimal time access and in a quick sequence so that they guarantee a quality which often is not obtainable in another way. At present the hospitalization has three fundamental defects, according to the present orientations: the cost per day of hospitalization, the cost per non-working activity, and the psychological-affective problems of the hospitalization.

The diffusion of the day-hospital (useful in case of exact indications, as the oncology, the minimal surgery or the serious chronic diseases) allows on the one hand the reduction of the cost per service, on the other hand the possibility to not interrupt the working activities, as well as to live permanently together own family.

The telemonitoring at home reduces the duration of the hospitalization and improves the life quality, integrating itself with the at home post-hospital assistance. Therefore, the technological innovation gives a further opportunity, which allows also to improve the quality of the assistance: the virtual hospitalization is then the virtual hospital at home.

Part of the day-hospital hospitalization can be done virtually, assisting telematically the patient at his home or at his working job. Such a situation allows an improvement of the assistance quality because the hospital continuity is assured also when the patient cannot reach the hospital, the social cost decreases both for the patient (if worker) and for his family (that often has to accompany him) and reduces the troubles deriving from the moving of the sick and/or disabled people.

The main areas of interest for a first application of the virtual hospitalization are:

- **emodialysis**
- **cardiology**
- **oncology**
- **endoscopy**
- **surgery**

The advantages offered by the virtual hospitalization are briefly reported in the following:

- **a better use of the different competences and of the health care resources;**
- **-availability in real time of specialistic advices for minor health care centers;**
- **-a better assistance to the communities which are territorially distributed;**
- **-a capability to support different pressures deriving from demographical changes;**
- **-a possibility to carry out in a better way the new diagnostical, therapeutical and adjuvant protocols;**

- **a reduction of the hospitalization times of the patient and of the pendularism home-hospital;**
- **a reduction of the public and private cost regarding the health care assistance.**

The virtual hospitalization has an high innovative potential both for the health care assistance, and for the productive context. For the first point, it concurs to improve its quality and effectiveness, to increase its accessibility and to decrease its cost. For the second point, it goads the research for the implementation of network services at added value and for the production of new software, creating new possibilities of use of the biomedical technologies and of health care information systems, assuming an exact strategic function, also in the productive area of the telematic services for the health care and of the medical software. The European scenario of the end of this millennium foresees the population ageing so that many countries are trying to comply with the WHO resolutions in order to provide themselves as soon as possible (for example, within 1995) of information systems able to support effectiveness and efficient health care strategies.

3. The Interaction Model

The "actors" whiche are involved in the diferent phase of patient treatment are:

- the patient (object of the treatment);
- the responsible (a physician, a team of physicians) that follows all the process of diagnosis and care relative to the patient;
- the supplier (the responsible, a specialist, a nurse, the same patient, a relative of the patient) that carries out the diagnostic, therapeutic and rehabilitative activities;
- the specialist (a physician, a team of physicians) that offers consultation in the evaluation of the data regarding the diagnostic examinations, in the definition of the diagnostic and therapeutic protocol.

In Figure 1 is shown the interaction model of such actors.

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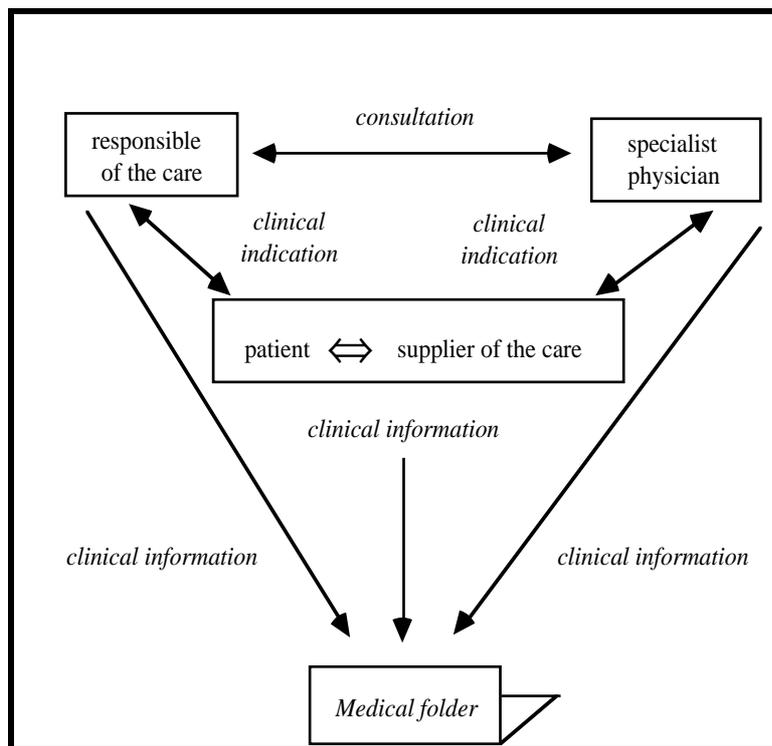


Figure 1. L'interaction among the "actors"

Depending on the disease and on the type of activity to carry out on the patient, this last can be identified as the supplier of the health care (for example, for the taking of some biological parameters, such as the temperature, or of the giving of some drug by oral way, etc.). The intervention of medical and nursing staff as health care supplier can, in every case, obtain a more direct relationship between this staff and the patient because this last is even more aware of the therapeutical and diagnostical phases to which he is subjected.

The exchange of information among the different actors can happen both directly and by the access to the information which are in the medical folder of the patient. This information are supplied by all the actors according to well defined procedures of privacy and protection of the data. A further possibility of interaction between the health care responsible and the specialist consists of the teleconsulting which allows the discussion at distance of the results regarding diagnostic analyses and the definition of the following therapeutic interventions.

Contrary to the classic hospitalization, in the virtual hospitalization the patient is sometimes "physically" distant from the responsible of the health care. In order to guarantee the continuity and the quality of the clinical process, it is necessary that the responsible of the health care has always the up-to-date situation of the patient. This fact is obtained by the clinical folder which consists of both the clinical information and of managing information for the work organization and for the interaction among the different health care structures involved.

The clinical folder has to have both the clinical information and the list of the clinical activities suggested, planned and carried out (clinical protocol), as well as the execution state of the single activity (managing procedures) and of the information flows among the structures involved in this activity. This means that in it is stored also the clinical protocol which the responsible intends to follow in order to assure the coherence of the clinical acts.

In this context it is necessary to manage in a federate way among all the health care services involved in the virtual hospitalization the medical folder. It will guarantee also the

storing and the transmission of the biomedical images at high definition. Respecting the single autonome organization of the structures involved, the advantage of a federate management consists of the immediate availability of the medical folder of a given patient on all the territory, reducing the moving of the patient, of the medical and nursing staff, avoiding the repeating of already made diagnostic procedures.

4. The Co-Operation

The day-hospital interacts with other health care structures (for example, the hospital diagnostic department, the hospital specialistic department seen as supplying of specific advices, the territorial poliambulatory, etc.). Such structures are based on autonomous information systems. The co-operation among these units is very important, because they are independent systems with a common goal: the patient health care.

For this reason the input of a patient into the day-hospital involves the start of different processes (both in parallel and interacting among them) in other health care structures connected to it. In this way the problem of monitoring these processes in order to know the status of progress of each activity connected with the diagnosis and care of the patient arises.

This fact defines the following goals:

- -federation of health care service information systems in order to put in common all the informations of the patient that uses the services of different structures;
- -monitoring of the clinical work flow in order to manage the interaction among the processes activated in each health care structure for single activity;
- integration with the specialistic service booking center in order to know the status of occupation of the services and then to book specialistic examinations and consultations.
- integration with the
- allocation of health care resources in order to optimize the use of mobile resources (car hospital, ambulance, etc.) to carry out examinations *in vitro* (blood examination, etc.) and *in vivo*, which are not highly specialistic (ECG, etc.), across the patient.
- systems for the monitoring and the evaluation of the population health status and for the planning of the health care interventions at the level of a large urban area or a rural area.

5. The Integration

The clinical protocol is the representation of a suggested sequence of activities, described at different levels of abstraction. It has to be adapted to the patient and to the health care context, and for its implementation it requires a synergy of the multidisciplinary activities of different groups of specialists that work in one or more different structures. The managing of the protocol assures the coherence of the health care operator goals that work at the same time on the patient and produces the best information exchange among the above mentioned operators.

The clinical protocol management system has to implement the following goals:

- management of multimedia medical records (to know the patient status);
- management of diagnostic, therapeutical and rehabilitative protocols (to define the intervention modalities regarding the single clinical case);
- ipermedia report of the specialistic services carried out (to improve the interaction with the specialists and to guide the eventual teleconsultation);
- standardization of the medical terminology;
- integration with the teleconsultation to obtain the exchange of opinions on a given clinical case without moving the patient;

8.

- integration with the telemonitoring, to evaluate signals clinically important or in particular situations (dialysis, pregnancy, etc.).

6. Hepatocellular Carcinoma: a case study

The liver tumors are the more frequent malignant neoplasms, with over one million of new cases/year in the world. The hepatocellular carcinomas (HCC) represent about the 50% of these tumors, with a ratio M/F of 4:1. The incidence is low in the USA (1.9 deaths per 100000 inhabitants/year), medium in Europe and South Africa (4,9 - 20), high in China, Korea and Mozambique (23,1 - 150), with a mortality at 5 years of the 80%. In the last ten years this incidence in Europe and in Japan is strongly increased, as well as the hepatitis C, which at present has to be considered as the main etiopathogenetic factor (or co-factor), in case is high the synthesis of DNA [TO93], and the chronic active hepatitis B (relative risk = 10-21.3%, risk that can be attributed = 31.1-56.3%, risk which is 98 times higher respect to patients HbsAg negative).

The recent progresses in the non invasive diagnostic by imagines have brought a changing of scenario: the ultraeterography (which allows an easier discrimination between HCC nodule and regeneration nodule with cirrhosis in progress), the echo-color-doppler, the computerized tomography (spiral, porto-TC) and the new method for the NMR with epato-specific means of contrast and evaluation of the enhancement curves allow at present to carry out a early diagnosis and a careful staging. Essential complements to the minimal criteria of standard staging (TNM) with regard to the therapeutical planning, are the vascularization, the histologic type [YM95] and the human epato-specific alpha-fetoprotein dosage (HAFP-mRNA) [KFS95] in the peripheral blood, correlated ($p < 0.001$) to the presence of the intra-epatic microdiffusion, portal thrombosis and metastases.

The liver neoplasms which are not treated have a survival less then three years in the 87% of the cases. Their association with the chronic hepatitis can contra-indicate an invasive surgical approach and can vice versa suggests miniminvasive acts which, associated to a constant monitoring of associated diseases, obtain results of life expectancy and quality which are equivalent or superior to those of the resection or of the transplant.

The epatic percutaneous ethanol injection (max three modules, Child A-B, max volume 3 cm) presents the 98% of survival at one year and the 48-56% at five years [EbK95]. The consequence of this fact is that the number of patients with primitive cancer of the liver that have a longer life expectancy and, then, need a continue monitoring and specialistic and multidisciplinary cares is in a strong increase. The solution to the high costs of the abovementioned situation is the virtual hospitalization which reduces such costs improving the life quality. The DH allows the virtual hospitalization by the management of the Medical Record of the patient by therapeutical and diagnostical telemonitoring.

6.1. The Information System and the Modalities of Telemonitoring for Hepatocellular Carcinoma

The system architecture consists of the following integrated units: Medical Epatology Service, Surgical and Oncological Epatology Service, Day Hospital (DH, Surgical and Oncological), Listening Center, Hospitalization Department. The Operative Unit of Medical Epatology (OUME) carries out the screening of the new cases and, if there is the suspect of HCC, the patient is sent to the Operative Unit of Epatic Oncology which chooses among three different procedures: a) periodical controls in cooperation with the OUME; b) ultraeterography with biopsy; c) hospitalization in the DH.

If the HCC is strongly probable or histologically confirmed, all the procedures for the final confirmation of the disease or for the staging and the evaluation of the therapeutic options regarding the state, the operative risk and the associated diseases. In case of indication to the resection in DH, a neoadjuvant chemo-therapy and then the patient is sent to the surgical department for a regular hospitalization. The palliative treatments are made in the DH with associated the virtual hospitalization. When the patient is accepted, his Medical Folder is open. This Medical Folder is based on a Minimum Basic Data Set which is common to all the the operative units.

The analyses of laboratory are carried out or verified, as well as the liver ecography, the thorax radiography, the electrocardiogram with cardiologic examination, the spirometry with pneumologic consultation (optional), the anesthesiologic examination (optional); in case of necessity of other examinations, another "hospitalization" is planned. In general, within 2-7 days all the results of the diagnostic procedures are available, so that the following five situations can happen: 1) the surgical act is confirmed and the patient plans the hospitalization date (as conventional hospitalization); 2) the surgical act is not confirmed (high operative risk, presence of other more serious diseases, etc.); other mini-invasive procedures are activated (PEI); 3) the surgical act is confirmed, but it is necessary to put off it and to carry out a particular therapeutic protocol in order to reduce the operative risk; 4) there is an indication for palliative chemiotherapeutic procedures; 5) the indications are only palliative (advanced disease).

In the third case a monitoring and a therapy is proposed. This one will be carried out at home of the patient or across other health care structures on the territory, which will be controlled by telemedicine tools.

At the dismissal from the DH (second hospitalization) the patient will be equipped with a cellular phone and/or a small suitcase of "telemedicine" which are connected to the Listening Center. He will have also the prescription of his therapy and a set of instructions for the correct use of the telematic system. The cellular phone (or a textual teledrin) is useful to communicate with the patient in every moment and everywhere he is. The small suitcase of "telemedicine" contains the instrumentation for the monitoring at distance, by telephone network, of the patient (for example, "cardiobip", or teleECG, etc.). The Listening Center, working 24 hours a day, consists of the same operators that work at the DH, and carries out by telematic way all the planned interventions (periodical verify of the patient conditions, suggestions to the patient and relative control, reservation of other controls, definition of the surgical act date, storing in real time of the information on the patient in his medical record, emergency management, etc.). In this way the patient will be accepted in the hospital for the surgical act only a few of hours before it (all the information is already available) and can be precociously dismissed because he will be continuously in contact with the Listening Center which will guarantee urgent assistance actions at home or a new hospitalization. The patient, in such a way, will do only a few of accesses to the DH (some controls reserved telematically). Only when the patient will give back the small suitcase of "telemedicine", he will be considered "dismissed" from the hospital.

The virtual hospitalization manages also the *emergencies*, which can be a consequence of a complicate depending on medical or surgical therapy, on mini-invasive procedures (PEI, etc), which can enter in the possible unforeseen complication; non classified a priori emergencies are those depending on unknown pre-existent or sopraggiunte diseases. The change of scenario when new diseases appear, or for the progression of neoplasms or of associated diseases (hepatitis, etc). In acute new problems or in emergency due to complications, the patient calls the physician. Different answers can be given: a) the problem is solved by phone (complications of low entity which the patient, assisted by phone, can solve by himself); b) nursing staff is sent to the home of the patient to take physiologic parameters which cannot be tele-transmitted

10.

or for necessity of infusional therapies or other home cares; c) if the situation presents a problem, a physician is sent; d) in case of strong gravity or for necessity of urgent diagnostic laboratory or instrumental procedures, the DH (or conventional) hospitalization is carried out.

A design methodology proposed and followed by the authors for the implementation of the first phase of this experimentation consists of the definition of the different phases of this design, which are briefly listed in the following:

- 1) the clinical protocols and, in particular, the role of the *distance*
- 2) the evolutive scenarios of the disease and, in particular, the role of the *vital parameters*
- 3) the clinical-managing functionalities and, in particular, the role of the *medical examination "at the bed" of the patient* and of the *emergencies*
- 4) the organizing-information model and, in particular, the role of the *Listening Center*
- 5) the systems and the technologies of the telemedicine and, in particular, the role of the *integration*

7. Conclusions

The possibility to offer solutions and services based on the telematic technologies linked to the health care (telemedicine solutions) arises from a reality in which the request of social and health care systems more qualified, efficient and effectiveness is more pressing. Some elements which stimulate the need toward such solutions are:

- **the complexity of the management systems which require external consultations and quick communications for the decision making;**
- **the isolation of the citizens that are living in remote or isolated place, or in metropolitan areas but that have particular needs (alone elderly people, handicapped people, people with chronic diseases, etc.);**
- **the possibility for the handicapped people to reach to the telecommunication services by solutions which allow to exceed the architectural barriers.**

In Italy a national project called *Telemedicine* is started in 1994. In it, among different goals, the following have been considered very important: Urgency medicine, Hospital teleconsultation and teleservices, telemonitoring at home, tele-education. To obtain all this the networks, the telematic nodes, the intelligent networks, ISDN, LAN, etc. are necessary [Tel91, Ab91, Gre88].

A recent research of the Home Care Society quantified in about 1,900 billion of Italian liras (equivalent to about 300 millions of US dollars) per year the saving on the hospital expenses for the elderly people, if on the Italian territory services as the day-hospital or the home hospitalization were spreaded in a generalized way.

In conclusion, it is to be hoped that the virtual hospitalization can favour the staff work and the interdisciplinary collaboration of the physicians, seen not as a decreasing of own professionalism, but, on the contrary, as continuous increase of own culture and expertise.

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