Telecardiology in Italy: current realizations and future prospects

Claudio De Lazzari\textsuperscript{1,2}, Domenico M. Pisanelli\textsuperscript{3}, Alessandra D’Ambrosi\textsuperscript{4}, Igino Genuini\textsuperscript{4}, Francesco Fedele\textsuperscript{4,2}.

\textsuperscript{1}CNR, Institute of Clinical Physiology, U.O.S. of Rome, ITALY
\textsuperscript{2}National Institute for Cardiovascular Researches, Bologna ITALY
\textsuperscript{3}CNR, Institute of Cognitive Science and Technologies, Rome, ITALY
\textsuperscript{4}‘Sapienza’ University, Department of Cardiovascular, Respiratory, Nephrological and Geriatic Sciences, Rome, ITALY

Abstract

Italy has a long tradition of telemedicine experiments that may be dated back to the early Seventies and currently many different telemedicine services are implemented in the country. Cardiology is the field of health care that currently gets the greatest benefits from telemedicine and it is also a very relevant field, since it is estimated that there are about three million people affected by chronic heart failure (5\% of the population). In this paper we review some of the most significant cardiac telemonitoring projects in Italy, then we show the future prospects for telecardiology and put in evidence responsibilities and legal aspects. We conclude that telecardiology, by enabling a better interaction between hospital and territory by means of teleconsulting, telemonitoring, telecare and remote access to clinical information, improves the quality of the whole health system. However, it cannot and should not replace the essential home care services, but it should be integrated properly and profitably with them.

Keywords telemedicine, telecardiology, telemonitoring, haemodynamics

1. Introduction

Italy has a long tradition of telemedicine experiments [1]. They may be dated back to the early Seventies, when the hospital of the Catholic University of Rome set up a teleconsulting service for treating intoxications by poisons. Initially set up for the local area, running on the telephone network, now is a telematic nationwide system.

In 1976 the University of Bologna realized a prototype system for ECG acquisition and transmission via telephone line. In the same year CSELT (the
research center of the public telecommunication provider) set up a
teleconsulting service between the hospital San Giovanni in Turin and the
nearby hospital of Susa.
In 1982 the Ministry of Research recognized the potentialities of telemedicine
for improving the quality of health care and reducing costs. Its role in
stimulating research both in medical informatics and on advanced diagnostic
and therapeutic tools was also emphasized.
In the late Eighties the Ministry conceived a national plan for research and
training in telemedicine. In the official documents, telemedicine was defined as
"A peculiar modality of health care assistance which allows providing
diagnostic services and medical assistance in an integrated way, by overcoming
the constraints related to the territorial distribution of competences and the
distance between physician and patient".
The aim of this plan was to facilitate the transfer of telematic technologies in
health care and to help biomedical companies to devise innovative solutions.
The Ministry of Health sponsored in 1988 the project Telecar for teleconsulting
of cardiac pathologies. The project became operative at the end of 1989 and
lasted three years [2]. The site of the experiment was the Latium region, the
reference center was located at the University of Rome 'La Sapienza' and 60
peripheral centers were established (hospitals, ambulatories, local communities
and the international airport).
Many “pilot” projects have consolidated the Italian experience. Without listing
them all, it is significant to remember the medical specialty areas in which they
have fallen:
- “Medical Emergency”: to which it was developed an “ad hoc” project;
- “Cardiology”: the ECG signal transmission over telephone lines that can
greatly minimize the movement of patients and/or physicians;
- “The Nephrology”: for which has been made and marketed systems for remote
monitoring of dialysis sessions.
In the most general diagnostic applications are placed two particularly
important: the Tele-consulting and the Tele-diagnosis. They represent the same
basic concept: connecting with a doctor and share with him information about
the patient conditions in order to realize a simple consultation or a real
diagnosis.
For obvious reasons, diagnostic imaging plays a key role in these applications,
because, in this area teleradiology service can be used by all medical
specialties.
The Italian experiences in telemedicine prove that:
• health care operators usually are willing to experiment telemedicine
  applications and interact with telematic based tools;
• there are good potentials for interdisciplinary cooperation among
  researchers;
there are scientific and technological competences (both in medicine and in telematics) which can be profitably employed in research and development of innovative solutions;
• satisfactory results are obtained.

2. What is Telecardiology?

Cardiology is the field of health care that currently gets the greatest benefits from telemedicine. Telecardiology applications can be divided basically into three types: pre-hospital, intra-hospital, post-hospital care. The main purposes of pre-hospital applications are the early diagnosis of acute myocardial infarction (ST above), in patients with chest pain, and the early communication to hospital services that have to admit the patient. This allows to transfer patients to centers better suited to their immediate treatment. The intra-hospital telecardiology services have mainly the aim of connecting the peripheral hospitals to excellence hospitals or district. In these cases the system can rationalize access to the operating units of haemodynamics, cardiac critical care and cardiovascular radiology. Finally, in the post-hospital applications the operational systems allow a constant connection between the patient and a telecardiology unit located in hospitals or private structures, allowing the detection and reporting of several parameters in real-time such as clinical signals as well as instrumental examinations like electrocardiogram, oxygen saturation of \( O_2 \), echocardiogram and so on.

Teleconsulting (i.e. a distance consulting between physicians) is widely applied in telecardiology, allowing the execution of a consulting between cardiology departments and remote services of the same hospital or other hospitals. This approach is particularly useful and used mainly by private medical care that can’t benefit of a specialist cardiology service available 24h/24h 7d/7d. It is also used in tourist resorts medical center or in remote communities, nursing homes or rest homes.

Of course the use of this resource must be not limited to cases of emergency, but, in predetermined time slots, it may allow distance diagnosis for periodic check-ups and monitoring of patients with chronic cardiovascular diseases. Health care is currently characterized as being "Hospital Oriented" in Europe, and especially in Italy.

The hospital integrates human resources and equipments that can be used in a minimal access time and in rapid sequence, which guarantees a performance quality not often otherwise achievable. The hospital recovery has, however, three negative aspects that can be alleviated by telecardiology: the cost of hospitalization, the cost of failure to work and psycho-emotional problems of hospitalization.
Day hospital is an effective answer to the problem, but even more telemonitoring which improves the quality of life being integrated with home care.

The future of health care can be represented by keywords such as: continuity of care, de-hospitalization, cooperation of structures and integration of networks of health services both nationally and internationally, intelligent environment for the patient, management of chronic conditions and emergency. These keywords describe a real revolution offering a variety of innovative services and a more harmonized activities carried out by independent and autonomous structures, aimed at improvement of the service as a whole.

Telecardiology makes it possible to achieve a virtual hospitalization: it is possible to anticipate the time of discharge and the patient can be remotely controlled by realizing cardiac telecare at home.

The main applications of remote monitoring are:

1) Cardiovascular monitoring systems. These systems require the presence of medical practitioners or nurse specialists in the place where they are provided.

2) Respiratory monitoring systems. The main parameters are: peak flow of the breath and volume per second of forced respiration that can be transmitted by means of a flowmeter via telephone to a unit center.

3) Blood glucose monitoring systems. There is a significant set of information for planning and conducting a monitoring organization: insulin doses to be administered, the composition of meals, general metabolic status and lifestyle.

3. Telecardiology applications

It is estimated that in Italy there are about three million people affected by chronic heart failure (5% of the population). Slightly less than 1/3 of them have a confirmed diagnosis.

The prevalence of chronic heart failure is growing especially because of the aging population.

The Italian Longitudinal Study on Aging, multicenter study conducted by the CNR on population over sixty-five, indicates a prevalence of about 5% in subjects between 65 and 69 years and over 12% in over eighty. The mortality of patients with heart failure is 6-7 times higher than the normal population of same age.

Population studies also reported a five-year survival of 35%. In terms of hospitalization and re-hospitalization data are similar for all patients with heart failure, regardless of left ventricular systolic function. The annual rate of re-hospitalization detected by most of the studies is very high, i.e. 40-50% and about half of these admissions are the direct result of an exacerbation. Episodes of clinical exacerbation are very frequent in patients with heart failure with
hypertension and diabetes mellitus. The heart failure, in the vast majority (60-70%) of subjects in older age classes is a dangerous complication of coronary heart disease, particularly in patients who survived an acute myocardial infarction.

In general, however, patients with heart failure cannot be properly and adequately controlled, despite the increasing number of ambulatories, especially because of the long waiting lists for cardiology visits both at hospitals and at local health units.

The hospital emergency room, then, is often used as a "shortcut" for the assistance, and, for legal problems (the so-called "defensive medicine") it tends to be used also in non-critical situations, with a waste of economic resources.

Heart failure accounts for 1 to 2% of total health expenditure in Italy. The main factors causing such costs are: hospitalizations, representing the largest component (about 70%), medications, outpatient specialist visits and mechanical cardiac support devices.

Hospitalized patients, according to the NYHA (New York Heart Association) classification are divided into four classes according to the gravity of their symptoms: worsening. In class I the symptoms are absent during normal physical activity, whereas in class IV symptoms are present also at rest state.

Consider, then, that patients in class I do not need inpatient treatment, while patients in class IV (3% of the population examined = 20,000 subjects) are at high risk for these clinical and need a quick hospitalization. About 69% of patients belongs to class II (approximately 465,000 subjects), 28% to class III (about 190,000 people). So far about 655,000 is the number of patients in Class II and class III, considered together, which can be assisted by means of a telecardiology program at home, limiting hospitalization to cases of real emergency.

In addition, many of the patients in class IV could receive a huge advantage in terms of psychological support and therapy because of the sharp reduction of days spent in hospital. Cost savings are estimated in the order of several hundred million euro per year.

An example of home telemonitoring application after hospitalization was “Rete Roma Città del Cuore” (2006-2009). Our hospital Group (Policlinico Umberto I “Sapienza” University of Rome) joined this project together with other three hospitals in Rome (S.Giovanni, S. Filippo Neri and Policlinico Tor Vergata); the project had the follow primary goals: reduction of hospitalizations number and length, reduction of rehospitalization and of cases of Sudden Cardiac Death. Were enrolled patients aged under 75 with diagnosis of heart failure in class NYHA III or IV, with EF < 40%, without indication of PMK-ICD and with at least one hospitalization for heart failure. The actors of the project were the patients with the families, cardiologist, nurses and GPS. Each patient, with the possibility of video-call, received ECG at 12 lead, an oxymeter, the digital sphygmomanometer, and an Automatic External Defibrillator (AED) [3]. The home management of patients is done daily with the acquisition of the principal
vital signs included in an electronic medical. Results show a reduction in the average duration of hospital stay of nearly 2 days; the actions taken by the cardiologist were distributed as follows: 85% change / adjustment of therapy and monitoring vital signs over time; 12% required by the cardiologist for screening tests; 3% required hospitalization again. Furthermore, was evident that home telemonitoring reduces inappropriate admissions (offered by 40% of patients). Finally, a very interesting result was the training of family members of patients to use the AED.

It is evident, by considering these socio-economic and health issues, that telemedicine tools, are essential. All major guidelines for the diagnosis of chest pain/acute coronary syndromes consider telecardiology systems as central tools in several programs integrating hospital and territory. Patients with STEMI (ST Elevation myocardial Infarction) are still too often lately submitted to the treatment for myocardial revascularization. Therefore, even if they survive acute coronary thrombotic event, they suffer from extensive post-necrotic lesions and myocardial contractility and, for months and years, despite of drug therapies, they are affected by heart failure. Many serious complications can be avoided by means of a telecardiology system providing teleconsulting in emergency situations. Such system must also allow telecardiology remote sensing of significant changes in heart rhythm (arrhythmia telemonitoring), often causing (or being effect) of acute heart failure, even in patients with pacemakers or pacemaker/defibrillator. Another relevant application of telecardiology systems is in the field of cardiac re-habilitation. As well known, this kind of therapy, in addition to drug therapy is very useful in the post-acute cardiovascular functional recovery for various categories of heart patients. It consists in several activities, particularly in physical training, either free or by means of instruments like tapis-roulant. The physical training in the first 4-6 weeks after the acute event had obviously to be carried out under strict cardiological control at specialist outpatient facilities. Moreover, in many cases, it has to be implemented for extended periods even at the patient's home. Of course, since the patient, even if properly instructed, is not able to understand and detect dangerous anomalies, a telecardiology monitoring of vital parameters must be implemented.

4. Telemonitoring

In this paragraph we will review some of the most significant cardiac telemonitoring projects in Italy. “Telmed Platform” is one of the most relevant realizations. It is a health care platform supporting telemedicine services realized by HTN [4]. HTN (Health Telematic Network) is a company active in Brescia (Northern Italy) since the 1990s which is able to implement efficient and effective telemedicine services. By means of Telmed Platform it is possible:
- to enable health care operators on the territory to access health information,
- to integrate hospital information systems for data exchange,
- to acquire data from devices and monitoring systems,
- to allow interoperability with local structures for administrative and reporting tasks,
- to manage the interaction with patients,
- to perform teleconferenze.

This platform is accessible through any web browser and can be customized according to local needs. It can support all the different phases of patient management, i.e.:
- acquisition of vital parameters,
- contact with a call center operator,
- referring to the specialist physician with automatic access to clinical data,
- archiving of information and biosignals,
- report generation,
- communication to external systems (e.g. local health systems, hospital information systems) of relevant information.

HTN is also able to offer wireless solutions in modular systems composed by three elements:
1. “HTN Bee-P Mobile”, an application installed on a mobile telephone which transmits the patient’s vital parameters to the telemedicine service center.
2. “Bee-P Services” for the acquisition of such data.
3. “Bee-P Web” for optimal data visualization.

HTN is a relevant example of a private company offering practical and effective solutions, active on the market and also involved in several national and international projects. Of course, also the public sector plays a significant role in implementing telemonitoring services in cardiology.

For example, the “Lancisi” hospital in Ancona carries on a project on heart failure and telecardiology aimed at the palliative treatment of patients not eligible for transplantation [5]. The focus of the project is on remote monitoring and follow up of patients at home.

Four different cardiology units are able to monitor the patients 24/7 and a teleconsulting service offering a second opinion is also available. Patients with an implantable cardioverter defibrillator or a pacemaker are remotely monitored also by an arithmologist.

Data collected are also used for statistical and scientific purposes. This approach guarantees a high appropriateness in the supply of medical care. Obviously, the on-line teleconsulting shortens the waiting time and increases the percentage of patients treated with beta-blockers and angiotensin-converting enzyme (ACE) inhibitors according to guidelines.
Another supported application is home care featuring inotropic therapy in selected patients who need palliative care.

The “San Giovanni-Addolorata” hospital in Rome is also offering a telemedicine service by providing patients with a briefcase containing biomedical equipments. In such a way, a sort of “virtual hospital bed” is realized at patients’ home [6].

The case (Figure 1) is equipped with a blood pressure measurement system (BPMS), a 12-lead electrocardiograph, a pulse oximeter and a blood glucose meter that are connected to a palmtop computer. The use of a palmtop computer allows patients to be trained step by step in their self monitoring. Such a computer, actually, not only acts as a data collector to be sent to the server, but provides a series of information to patients among which their current treatment or the measurement protocol to be carried out. Patients with vascular ulcers of lower limbs or pressure sores can use the handheld camera to send images of their injuries. The clinical data transmission is compliant with privacy regulations and in any case does not report patient personal data. Since 2007, the telemedicine service offers, for selected diseases and patients, a real alternative to hospitalization without reducing the accuracy of diagnostic and medical treatment. Most patients come from the cardiology hospital emergency room, others by wards, clinics, someone from the territory. To be operational, such telemedicine service needs the interaction of different professionals with complementary skills.

The health care operators are the following:

- n.1 physician responsible of the service
- n.3 specialists consultants
- n.1 chief nurse
- n.3 nurses.

The technological part is guaranteed by the following professionals:

- n.2 clinical engineers especially involved in software development
- n.1 technician in charge the maintenance and proper functioning of the equipments
- n.1 ICT system manager

The hardware at the telemedicine center consists of:

- n.2 clustered servers containing a database of data history.
- n.3 blade containing 20 virtual machines each of which acts as the server for a single specific service activities (receiving server data, server, sending alerts, view web server, etc.).
- n.2 ethernet switch capable of communicating with the rest of the hospital LAN.
- A Storage Area Network of 3TB for the data history.
- A Tape Library for data storage products.

Figure 2 shows the number of patients treated with home telemonitoring starting from 2007.
5. Implanted devices

In the last five years Italian biomedical companies have focused their efforts in research and development in order to realize implantable cardiac devices which can be controlled remotely. These new tools, which allow remote monitoring of implanted patients, are referred as Remote Patient Management (RPM).

In 2006, the Heart Rhythm Society has recommended to develop devices for cardiac rhythm management using wireless technologies and remote monitoring in order to:

- immediately identify abnormal behavior of the device;
- reduce the incomplete reports of malfunctioning of the device, checking more often and more accurately the state of its functions [5].

RPM has been shown to have positive effects on clinical outcomes and economic management of patients with heart failure. An analysis, conducted by the New England Healthcare Institute, has estimated that the probability of re-hospitalization in patients followed up with RPM, are down 32% compared to patients followed by normal standards [7].

In the prevention of re-hospitalization also weight monitoring has been proved useful. Some researchers [7, 8] demonstrated the existence of a statistically significant correlation between weight gain and hospitalization due to cardiovascular failure (p <0.001).

Medtronic CareLink® Network service is a RPM system for the management of patients with Implantable Cardiac Devices (DCI), Pacemakers (PM), Implantable Cardioverter-Defibrillator (ICD) and Monitor (ICM), manufactured by Medtronic, Inc. The system consists of three components: the CareLink® Monitor, the CareLink® Website, and CareLink® Server. Using CareLink® Monitor, the patients with DCI are able to send via analog telephone line or via mobile GPRS network, directly from home, all data stored on your DCI. The data sent and received are stored on a centralized server, called Server Carelink® and it shall be made available on the CareLink® Website for the medical specialist.

For devices with non-wireless telemetry, the data transmission can be performed only with the involvement of the patient who must perform a sequence of simple steps to complete the process of transmitting data. This transmission is called "manual transmission".

For devices with wireless telemetry, the patient can perform a “manual transmission” or "automatic transmission" that does not require any action by the patient.

The “automatic transmission” may be made for periodic check for specific situations and for programmable DCI alarm. The automatic transmission can be of two types: scheduled and triggered by an alarm event. This second type is referred as Transmission CareAlert.

CareLink® Network has been activated in the United States in August 2002, while in Italy has been introduced for the first time in December 2006 in a
limited number of centers, through a pilot project [8-9], which involved a small
number of patients with biventricular ICD. The project's aim was to test the
feasibility of remote monitoring via Carelink® Network and evaluate the
usability of the Carelink® Monitor by the patient, as well as the satisfaction and
acceptance of the CareLink® Network system by both the patient and the
medical staff. The evaluation of the follow-up remotely service system were
involved: the Department of Management of “Politecnico” of Milan, the “San
Raffaele” hospital IRCSS of Milan, the “Niguarda Ca 'Granda” hospital
(Milan), the “San Carlo Borromeo” of Milan, the “Policlinico San Matteo” of
Pavia and the “San Filippo Neri” hospital of Rome.
In Italy, CareLink® Network has been adopted by about 150 hospital-structures
with more than 7,000 patients followed in remote mode. Each month there are
about 350 new patients.
LATITUDE® system produced by Boston Scientific S.p.A. from 2009 is
available in Europe and currently it is used in Italy. LATITUDE® Patient
Management system permits to monitor in remote mode patients assisted by
ICD or Cardiac Resynchronization Therapy-Defibrillator (CRT-D). This
system can remotely control the implanted device and the patient's clinical
status. LATITUDE® provides accurate diagnostic information for optimal
management of heart failure (HF), allowing to predict the progression of HF
and to take preventive treatment decisions. LATITUDE® incorporates a scale
and a blood pressure monitor, both wireless and therefore can meet the Class 1
ESC recommendations for heart failure [10]. Daily measurements made using
the balance and the blood pressure are recorded and has been sent to the
database of the patient. These data are recorded into the daily report on the
health of the patient. The progression of heart failure involves drastic health
consequences and constitutes a burden on the healthcare system.
LATITUDE® collects data regarding HF from various sources (i.e. external
sensors for the assessment of the weight and pressure) that help to prevent the
onset or the progression of HF to determine the moment where action is
needed.
Diagnostic tools from implantable devices provide information about:

- Level of activity, to monitor accurately the percentage of patient's daily
- Heart Rate Variability (HRV), with measurement of heart rate average,
  minimum and maximum on a daily basis. These parameters are used to
  identify changes that may have a significant impact on the health of
  patients. An increase in the average heart rate (HR) is associated with
  poor outcome in patients with heart failure [12].
- SDANN -Standard Deviation of the Averages of NN (Normal Sinus to
  Normal Sinus) Intervals-, to better monitor the heart in patients with
  HF. Patients with lower SDANN indexes are at increased risk of
  cardiac events, hospitalization and mortality [13-14].
HRV footprint, to provide a clear visual assessment of HRV in the long term. HRV footprint proved to be a significant prognostic indicator of mortality in correlation with the SDANN [15].

Taken individually, the values of these parameters have not the same value than when evaluated together in the prevention of HF, reducing costs and time of hospitalization and improved quality of life for patients.

It is no longer necessary that a patient goes to the clinic to take action to solve a problem. Data from the LATITUDE® system and reports on patient health status allow you to monitor, instantly, the status of the patient. The alert system can notified to the physician the level exceeded of some selected parameters.

6. Future prospects

In our laboratories at National Research Council (C.N.R.) the researchers are studying the realization of wearable devices equipped with sensors and a microprocessor on which can be implemented mathematical models able to simulate pathophysiological phenomena and/or able to reproduce a series of physiological and pathological conditions for a certain set of human physiological organs [16].

Numerical models that could be implemented on the microprocessor are:

- Numerical models of the cardiovascular system.
- Numerical models of the respiratory system.
- Metabolism of bilirubin.
- Metabolism of glucose.
- Glucose-insulin control system.
- Models to study the drug effects on different circulatory districts.

Some numerical models can be used to evaluate the effects of drugs in different pathological conditions. Other models (developed at Institute of Clinical Physiology CNR) as the numerical models of the cardiovascular system permit to analyze the interaction between the heart and circulatory system and to study the pathophysiological conditions of a patient. These models, created as research tools have evolved to use in clinical and educational environment (“Sapienza” University, Department of Cardiovascular, Respiratory, Nephrological and Geriatric Sciences, Rome). In a clinical setting are used to reproduce the pathological condition of a patient from easily non-invasively measurable parameters. The realization of personalized modular numerical models permits:

- to implement accurately the districts affected by cardiovascular disease afflicting the patient under observation,
- to use easy numerical implementation to simulate "non-pathological" districts.

It follows that the parameters measured on a patient may varying with the type of pathology. The measured parameters can be used to estimate, through the
use of numerical models, those parameters of clinical interest that are not easily and directly measurable.

A possible application concerning the use of numerical models of the cardiovascular system is one that can be achieved for patients affected by chronic left ventricular (LV) failure due to idiopathic or ischaemic dilated cardiomyopathy associated with electromechanical dyssynchrony \[17-18\]. This pathology causes irregular muscle contractions in the heart resulting in inefficient pumping of blood. Cardiac Resynchronization Therapy (CRT) improves the coordination of the contractions using technology similar to that used in pacemakers and implantable cardioverter devices.

Regular (daily or even continuous) transmittal of data regarding heart rate, blood pressure, ECG, weight, body temperature, oxygen saturation, or transthoracic impedance (for control of fluid overload) can provide a basis for disease management decisions regarding patients affected by described pathology.

All these data together with data regarding pacemakers temporization could be measured using integrated sensors into device (T-shirt of hypoallergenic material, band, belt or otherwise) worn by the patient. The same support could be equipped with a microprocessor in which a simple numerical simulator of the cardiovascular system could be implemented. The simulator could estimate some haemodynamic parameters (not directly measurable) from measurements performed on the patient. In addition the implemented simulator could be estimate, using the measured data, the best pacemaker temporization \[19,20\].

The measured and predicted data may be sent to a Medical Center Unit (MCU) in which trained physicians could use complex simulator of the cardiovascular system to identify from the parameters measured and simulated the best therapy for patients\[21-24\].

7. Responsibilities and legal aspects

The telematic different way of organizing healthcare has created new responsibility levels. Healthcare facilities in general are responsible for the information systems used for patient clinical data transmission and for ambulatory patient access, whereas the clinicians have to guarantee the process supervision by providing prompt medical assistance if alarm signals are received \[25\].

The use of telemedicine, however, may engender technical problems of varying difficulties \[26\]. In terms of responsibility, service providers are not liable for damage deriving from technical default, except in the case of willful misconduct or gross negligence. No less important are the legal issues concerning permissions, conflicts of jurisdiction among nations, problems of service inaccessibility, as well as the identification of medical liability in relation to the activity of a multidisciplinary team, besides issues relating to
informed consent and privacy protection. The achievements of information technology greatly contribute to the quality of diagnostic and therapeutic processes [27]. The existence of many unclear and ambiguous rules and opinions makes it necessary to establish legal regulations specifying the principles of distant exchange of medical data. As far as legal aspects are concerned, we have to point out the essential role of the electronic medical record. It has to be precise, reliable, referred to individual patient and complete [28].

8. Conclusions

Telematics application must ensure the electronic medical service quality (QoS, or Quality of Service”). The task of measuring the quality according to certain parameters created in a strictly technical and relates to the validity of the transmission of signals over telephone lines or via satellite. We must consider also the chain that allows the connection between two computers is a complex system consisting of connectors, cables, interfaces, routers, bridges, radio, data acquisition systems, data software, telecommunications and other components. Therefore, to ensure the quality of the overall system, it is necessary that each component of the system to ensure the desired level of performance: just one link in the chain to degrade the entire system. Moreover, it is necessary to adopt standards to enable interoperability of heterogeneous systems [29].

Telemedicine applications, in general, and telecardiology, in particular, have their own specific clinical application field, which, of course, is not limited only to technological issues concerning data transmission. Other parameters must be taken into account and can be formalized [30].

The international standards organization (ISO) has developed a grid of six key factors (themselves split into different characteristics) that a telemedicine/telecardiology service must provide [31]:

a. Trustworthiness
   - Maturity
   - Error tolerance
   - Recoverability
   - Availability
   - Degradability

b. Efficiency
   - Operation time
   - Operation of the resource
It is now clear that telecardiology, by enabling a better interaction between hospital and territory by means of teleconsulting, telemonitoring, telecare and remote access to clinical information, improves the quality of the whole health system. However, it can’t and should not replace the essential home care services, but it should be integrated properly and profitably with them. The evaluation of the operational scenario of telecardiology must be made by studying and identifying the parameters and technology models most appropriate to the various clinical situations and therefore more useful for medical and cardiological intervention.
Patients with advanced chronic heart failure and/or abnormal heart rhythms, also monitored with implanted devices, represent the most appropriate categories to be included in programs of continuous cardiac telecare. However, for a valid result, an interaction between the specialist and the general practitioner is always required. In fact, telecardiology added value is especially detectable in the possibility of rationalizing the health intervention during both the acute and the chronic phase, by fully exploiting the synergy between the general practitioner, who knows in detail the patient, and the specialist cardiologist, who will identify and estimate the cardiovascular clinical aspects. The implementation of such an integrated system between general medicine and cardiology medicine can represent a relevant mode of assessing cardiac patients over time and avoid inappropriate hospital admissions. Finally, the general practitioner and medical personnel, in any way involved in the system, may see their level of specialist education increased, whereas patients and their families can learn to collaborate in the management of their disease by having the opportunity of understanding the clinical significance of different symptoms and of executing, even if under medical/nursing control, medical acts such as simple detection of blood pressure, heart rate and blood oxygen saturation of O2, ECG performance, blood chemistry testing. Telecardiology is also highly relevant in emergency services. In fact, by enhancing communication, it can help the treatment of patients with chest pain/STEMI with a rapidity that can preserve in most cases the patient's life and drastically reduce the acute and chronic complications. The ability to shorten the response time is an ethical value even more than a better resource management factor. In conclusion, we can say that it is definitively proved the validity of telecardiology in terms of reducing health expenditure for cardiovascular disease, since there is a significant reduction of days of hospitalization and cut of improper and/or surplus medical acts. It is also evident the improvement of patient's life both for clinical and psychological factors [32].
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