

# The application of telemonitoring in different health fields: a bibliographical review

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**Abstract.** Telemonitoring is a telehealth service that has been increasingly used and that makes it possible to monitor the patient's state of health, through the monitoring of physiological changes, the evolution of the treatment, through the recording of patient information, and contacts with professionals of health. It can be performed both in simpler ways, such as through telephone calls, where a health professional talks to the patient, as well as through applications or medical devices developed specifically to assist the patient, taking notes and recording relevant physiological information or detecting anomalies. With the pandemic caused by covid-19, a way to accompany the patient without crowding or exposure to environments at risk of contagion has become very necessary. In addition to making this possible, telemonitoring also means that the patient does not have to go to the hospital or any medical center just to be evaluated, since in some cases the patients may be weakened, and it allows accompanying the patient in cases of rehabilitation. Telemonitoring is also a way to ensure access to medical care and reduce costs, queues and hospital admissions. It is a technique with a great potential for exploration, being, at the same time, a challenge and an opportunity for public and private health agencies.

**Keywords.** Telemonitoring, hospital, health care, pregnancy, heart diseases, rehabilitation.

## 1. Introduction

We can define telemonitoring as the use of information technology by professional health care providers to provide and support at-home health care to patients in case of long distances [1]. There are plenty of applications of telemonitoring in healthcare systems, such as monitoring cardiopulmonary disease, asthma, and heart failure in the home, fetal heart rate monitoring and infant cardiopulmonary, as well as coagulation, or the level of activity of elderly people, assessed by the intelligent home monitoring devices [2].

Telemonitoring allows doctors to remote daily monitor their patients' vital signs, making possible the previous detection of clinical deterioration and early clinical interventions [3]. This resource has also proven to be effective in the reduction of chronic disease complications, in the provision of health care services without occupying hospital beds, in reducing the time the patient would take to travel to the hospital and overall costs, besides, it has also been proving to be cost effective. Another advantage is that telemonitoring is a good response to the needs of home care with older people. By monitoring the

patients while still in the ambulance, the time needed to initiate the proper treatment is decreased, allowing emergency crew to prepare themselves better [2].

## 2. Applications of Telemonitoring

### 2.1 Telemonitoring in pregnancy

In the field of maternity, we have home-based telemonitoring, which can monitorate parameters of mother and child. This practice is seen as an acceptable and comfortable manner of antenatal care [4].

Telemonitoring techniques have the potential to contribute to the improvement of gestational outcomes. So it is possible to offer better healthcare due to closer attention, early detection of complications and prevention of intercurrents, providing local intervention even before hospitalization to the mother and the baby [5].

Due to some conditions, such as unhealthy lifestyle, obesity, advanced maternal age at conception and

concurrent comorbidities, there has been registered an increase in the number of complications in pregnancy. This ends up being reflected in hospital admissions or hospitalizations. Doctors can telemonitor fetal heart rate and uterine contractions thanks to a wireless portable cardiotocography system combined with a blood pressure monitor, saving the measurements in a personal profile using Bluetooth. Through a secured internet portal, those measurements are integrated in the electronic patient record system, where health care professionals can access the patients' data and observe the health of mother and baby [4].

## 2.2 Telemonitoring in heart diseases

We have been witnessing the advancements of healthcare systems and the development of biomedical equipments to fulfill the increasing demands of modern healthcare diagnosis and treatments. There is a request for real time monitoring patients with chronic diseases, especially heart diseases. Mobile based monitoring devices represent a major role in the task of monitoring and computing real time acquired physiological signals, receiving the health feedback of patients continuously and analyzing the risk related to critical health conditions [6].

It is possible to realize data storage through a mobile cloud computing approach. In this system, the physiological signals that were acquired by the mobile devices can be stored in large amounts of medical records through cloud services. Through an Internet connection, the data can be accessed by doctors or the hospital. For this case, a personal electrocardiogram monitor was developed for storing personal records about the health of patients, performing an ECG analysis based on artificial intelligence and allowing the data to be transmitted to locations through cloud services [6].

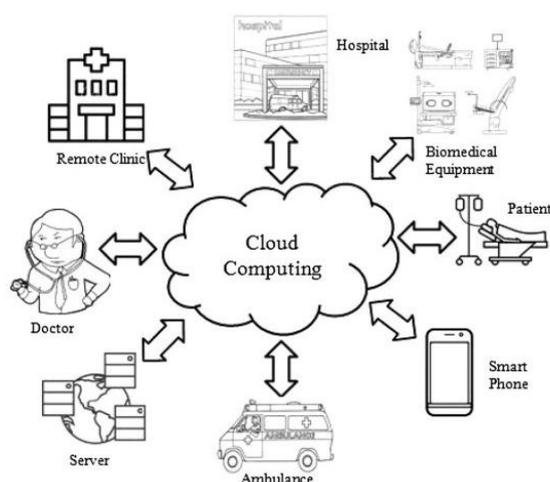


Fig. 1 - Working diagram of remote telemonitoring [6].

## 2.3 Telemonitoring in rehabilitation

Rehabilitation can be described as the aim to restore back the normal physical movement of any part of the human body that has been lost due to a stroke or

any accident-related injury [7]. Telerehabilitation is defined as the delivery of rehabilitation services (e.g. assessment, prevention, treatment, education, and counseling) via information and communication technologies [1].

Classical rehabilitation is done by an observer-rated method at the rehabilitation center and it can be both time-consuming and cost-intensive. Patients can often live in remote and rural areas and face limited access and difficulties in attending rehabilitation centers, where it is necessary to come back periodically. Home-based rehabilitation has shown as an exceptional solution to overcome such limitations, allowing the patient to rest at home, do the rehab-exercises as a self-treatment and follow instructions given by their remote observers immediately. Combined with the Internet of Things (IoT), the observer can monitor the situation continuously and in real-time, propose necessary medications and suggest appropriate activities based on the patients' conditions and limitations [7].

As examples of home-telemonitoring rehabilitation, we can bring a few situations, such as: home-based pulmonary rehabilitation (PR) [1], rehabilitation system for knee injuries [7] and hand rehabilitation [8].

Chronic lung diseases and Covid-19 lead causes of disease, death and disability worldwide and entail a substantial burden on the individuals and in healthcare systems. Pulmonary Rehabilitation (PR) is defined as a supervised program that includes exercise training, health education and breathing techniques for people who have certain lung conditions or lung problems due to other conditions and it is recognized as an important treatment for patients suffering from chronic respiratory diseases, being recommended as a potential beneficial intervention for post-Covid-19 patients [1].

PR provides statistically and clinically significant improvements in physical activity, exercise capacity, self-efficacy, and health-related quality of life and also a increase in healthcare use in patients who suffer from lung diseases. In spite of the multiple benefits identified, there is a very low access to PR programs. Home-based PR programs are shown as a promising alternative to overcome PR barriers such as symptom severity, acute exacerbations, transportation, financial difficulties, disruption of daily routines and access to care in remote locations. Covid-19 has also evidenced the need for delivering PR programs remotely, safely and efficiently [1].

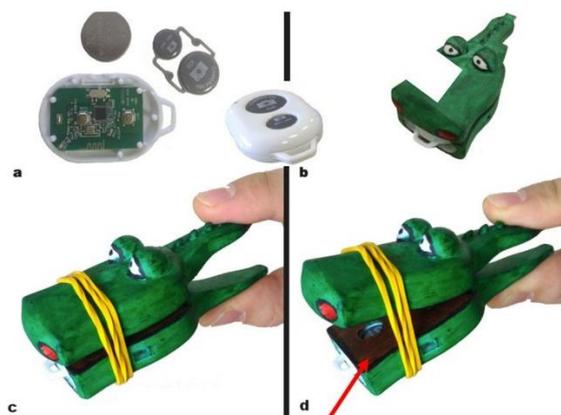
Most strategies for telemonitoring patients at home were based on collecting information on symptom changes and physiological measurements and storing those data, so the health professional could supervise the patient properly [1].

Several knee injuries can affect people. For example, athletes can face knee fracture, anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), or any other type of ligament injuries. There are

rehabilitation tools that make it possible to help recovering from such problems, reducing the muscle stiffness, and supporting a range of motion. In the last few years, there has been suggested a number of IoT-based solutions for knee monitoring systems, such as a lighter, portable, and adjustable continuous passive motion machine with a user-friendly interface, where an android-based application is used for interaction between users and the introduced tool so that data can be stored and recorded in the patient's smartphone via Bluetooth communication [7].

The patient is able to use the machine for adjusting her/his leg movement without any external help, being a lighter, cheaper and less bulky alternative compared to traditional machines. A mobile application was developed as a monitoring method that tracks the patients' progress, reports the current status of the rehabilitation process to the health professional, and provides patients with immediate feedback accordingly [7].

As a last example, we have a prototype developed for the pediatrics area to help with hand rehabilitation and telemonitoring through smart toys. The hardware used to capture, digitize and transmit (wirelessly) samples of pressure measurements in real time to a mobile device is inside a toy. When squeezing the toy, the sensors send data from the pressure exerted to the operating system of smartphones and tablets. Such devices allow families to receive support to carry out the rehabilitation of their children. Whenever the exercise finishes running, the data is transmitted to a server which, in turn, processes the data to compute the results and show them to the doctors [8].



**Fig. 2** – Prototype of a pressure sensor for children hand rehabilitation [8].

### 3. Methodology

In order to gather material for the present study, a search for articles on the subject was carried out, using mainly the Google Scholar and ResearchGate tools, looking for reunite relevant and reliable information about the theme. A lot of articles were read and after filtering, it was chosen the ones more appropriate.

It was also discussed with professors about the subject, so they helped me being better instructed about what to search for.

### 4. Results and Discussion

The situations presented showed that telemonitoring proved to be effective in following up on patients' health situations. In addition, the practice reduces trips to the hospital, queues and waiting time.

Patients also experienced greater physical and mental comfort in being at home in a familiar environment. It also enables early detection and intervention in high-risk cases.

In addition, costs are reduced for patients and healthcare providers.

### 5. Conclusion

It is undeniable that telemonitoring has shown to be very promising and an innovation in the field of technology applied to medicine. Several benefits result from the application of the technique and the number of investments to optimize the process is increasing. Telemonitoring also presents its challenges, being at the same time a great opportunity for health development. The subject has also drawn more attention and gained more notoriety, having a great chance of having a very positive impact on the lives of thousands of people.

### 6. Acknowledgement

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### 7. References

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