Chapter 2

Applications of Telemedicine on the Integral Management of Chronic Obstructive Pulmonary Disease: A Systematic Review

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Abstract

Introduction: Chronic Obstructive Pulmonary Disease is a common, preventable and treatable disease. It is currently the 4th cause of mortality worldwide with an upward trend. It is a under diagnosed entity, which implies a high cost to Public Health, and a huge loss of quality of life for the people who suffer it. Currently, there is no effective screening program, and follow-up is a difficult task.

Methods: A systematic review was made of articles related to the management of COPD based on the use of the technologies. The databases used were: MEDLINE, Web of Science and Cochrane Library in addition to the websites of organizations such as WHO, SEPAR and GOLD. A total of 12 articles have been included.

Results: Of the total of 12 articles, 7 found statistically significant benefits of the application of these interventions in comparison with the usual healthcare. Among the benefits there is an increase in treatment adherence, an increase in quality of life, better control of their symptoms and a reduction in the number of acute exacerbations.

Conclusions: Telemedicine is a powerful tool that offers a wide range of possibilities for the management of COPD: telemonitoring, electronic coaching, early prevention of exacerbations, screening, telerehabilitation... However, the existing evidence is weak so it is required the development of powerful studies in order to establish firm conclusions.

1. Introduction

1.1. Chronic Obstructive Pulmonary Disease

Chronic Obstructive Pulmonary Disease (COPD) is defined by a chronic limitation to the flow of air produced by a chronic inflammatory process in the airways. This inflammation is secondary to exposure to harmful particles such as tobacco smoke (the main risk factor for the disease), environmental pollution, exposure to chemical vapors, etc. Also, there are multiple predisposing factors: genetic (alpha-1-antitrypsin deficiency), alterations in lung development, repeated infections of the lower respiratory tract in childhood ... The pathology of the disease is characterized by structural changes in the lung tissue that we encompass in two types: small airway disease (obstructive bronchiolitis) and parenchymal destruction (emphysema) [1].

The diagnostic process begins with the suspicion in an adult smoker of more than 10 pack-years, who presents respiratory symptoms. Diagnosis, prognosis and follow-up are based on pulmonary function tests, specifically spirometry. The diagnostic criterion is a post-bronchodilator FEV1 / FVC ratio, measured by spirometry, less than 0.7, although it underestimates the diagnosis in the youngest patients [2]. The main objectives of treatment are to alleviate and reduce the impact of symptoms, prevent exacerbations and reduce the risk of adverse events [3].

1.2. Impact of the Disease

Chronic Obstructive Pulmonary Disease is a common, preventable and treatable disease. It is currently the 4th cause of mortality worldwide (6% of all deaths in 2012) but due to the aging of the population and greater exposure to risk factors is estimated to occupy the 3rd place for 2020, passing from 3 million annual deaths to 4.5 in 8 years [3].

Regarding our country, the EPI-SCAN epidemiological study, following the GOLD classification, determined a COPD prevalence in individuals between 40 and 80 years old of 10.2%, which increased with age, tobacco consumption and low educational level [4]. This supposes a high economic cost with hospital care being the highest cost and above all in patients with severe COPD.

In a study conducted by Masa et al., Based on data from the IBERCOP study, it was estimated that the annual cost of COPD in Spain for the year 1997 was 238.82 million euros, assuming a prevalence in the population of 9 % and considering only direct health costs. Hospital care accounted for the highest cost (41%), followed by the cost of pharmacological treatment (36.6%) and that of outpatient consultations (18.8%). The average cost per patient per year was 198.17 euros, with the figure rising to 910.57 euros in the subgroup of patients previously diagnosed with COPD (22% of the subjects). Considering the severity of the disease, the average cost per patient with severe COPD was 3.6 times higher than the cost per patient with moderate COPD and more than seven times the cost of mild COPD [5].

A low therapeutic adherence is associated with an increase in morbidity and mortality, as well as an increased use of health services. In COPD, therapeutic compliance is between 29 and 56%. The therapeutic failure supposes an increase of the sanitary cost by the repetition of diagnostic tests, new treatments or labor casualties. In addition, it prevents adequate assessment of the suitability of the treatments. Among the factors that contribute to low adherence, chronicity is important since patients with COPD suffer constant symptoms that facilitate their adaptation, decreasing the perception of need for treatment. In addition, the comprehensive treatment of COPD often combines different types of treatments as well as changes in lifestyle (rehabilitation, smoking cessation ...) that make it a complex and difficult program to follow in the long term. Also, patients have no expectations of improvement, but being a chronic disease are aware that they can only control their symptoms [6].

1.3. New Technologies: Concepts

- Telemedicine: Direct provision of medical care, including diagnosis, treatment or consultation, through telecommunications [7].
- Telecare: Area focused on providing support and patient care at home.
- Domestic telemonitoring: Monitor the patient's status remotely without the need of a medical professional present in the taking of parameters [7].
- mHealth: Medical and public health practice supported by wireless mobile devices [8].

1.4. Origins of the Discipline

Most advances in the field of telemedicine have occurred in the last 20-30 years, concomitant with advances in information technology. However, its history is much older. A first example is in the Middle Ages, when information about the bubonic plague was transmitted remotely by signals with bonfires across the European continent. In the mid-nineteenth century, telegraphy was used in the American Civil War to transmit casualties and request medical supplies [9].

NASA takes the next step by creating medical telemetry in 1960 by monitoring the constants of astronauts traveling in space. In the 70s, Telemedicine research programs were created in the USA with the aim of improving access to health. In the 90s with the creation of Internet opens the door to many investigations, since then appeared multiple applications in the healthcare world: remote consultations, online courses, telemonitoring, military medicine ... [10].

1.5. Telemedicine and Society

We live in a time of demographic change, where the birth rate is very low and there is an aging population. The development of new technologies applied to the healthcare world is modifying the natural history of diseases, increasing survival at the expense of increasing the prevalence of chronic diseases and palliative care. This translates into a change in health demand that challenges us to seek a more efficient assistance model that guarantees universal, quality, permanent coverage at an affordable economic cost.

In the Universal Declaration of Human Rights signed in Paris on December 10, 1948, it is stated that all people have the right to access health services anywhere in the world without having to make an economic effort to obtain them. The International Conference on Primary Health Care of the WHO-UNICEF meeting held on September 12, 1978 in Alma-Ata (Kazakhstan), supports this idea by initiating “The Health for All Agenda” whose objective was to achieve an “essential health care based on practical methods and technologies, scientific men founded and socially acceptable, made available to all individuals and families of the community through their full participation and at a cost that the community and the country can support, in each and every one of the stages of their development, in a spirit of self-responsibility and self-determination”.

That is why the European Committee of the WHO initiates the strategy “Health 2020” in September 2012, approved by 53 member countries, which establishes a community policy framework that aims to “significantly increase health and well-being of populations, reducing health inequalities, strengthening public health and patient-centered health systems in a universal, equitable, sustainable and high-quality manner [11]”.

The advance of Information and Communication Technologies (ICT), omnipresent in every area of today’s society, offers at this point a range of possibilities in the hands of Telemedicine. In the Health 2020 strategy, Telemedicine takes on a central role in achieving its objectives. The advantages of this discipline are multiple: it facilitates accessibility to the healthcare system, achieves greater effectiveness and quality of care, reduces costs, facilitates the storage and management of information, includes the patient in the therapeutic strategy in a proactive way and it increases adherence to treatment, reduces morbidity and mortality and contributes to a better quality of life for our population.

1.6. Applications of Telemedicine in COPD

The goal of eHealth implementation is to reduce hospitalizations, improve self-care and self-management of the disease and improve the quality of life related to patients’ health (HRQoL). In general, telehealth interventions include:

- Video or telephone calls with specialized medical attention in real time or through data storage and forwarding technologies.

- Telecommunication systems with health professionals through the Internet.

- Wired and wireless telemonitoring of physiological parameters such as lung function, heart rate, blood pressure or oxygen saturation.

- Pulmonary rehabilitation programs with exercises supervised by videoconference, telemonitoring of the exercises, telesoporte mediated by nursing or even the possibility of a therapist modifying the configuration at a distance according to the evolution of the patient.

- Telemonitoring of patients in the home with mechanical ventilation [12].

1.7. Determinants of its Implementation

Although in Europe 62% of the member countries have policies aimed at the application of telemedicine, their implementation is still heterogeneous and individualistic. This is because, since it is a very novel area, there are several factors that modulate its implementation in a generalized manner [10].

There are technological barriers: Age, education, experience in technological devices, domestic environment, comorbidities, cognitive functions, mobility and visual abilities or deficits in phonation and speech play an important role in the patient's ability to use technology in telemedicine programs [12]. Both health workers and patients need to receive training to use the necessary tools.

EHealth involves a change of roles, responsibilities, personal relationships, etc. A survey evaluated the degree of acceptance of telemedicine within the sector of Pneumology professionals. The results have described a high global acceptance among healthcare professionals, despite which, different initiatives based on ICT do not have the expected implementation. One of the main impediments is the idea by physicians of an increase in "work overload". Different works have shown that the protocolization of these programs and the previous training have positive effects in the control of this factor. Due to the volume of information obtained, there is also a need to select the patients who could benefit the most from telemedicine and not rely on "routine use". Likewise, it is essential to protocolize the clinical response and stratify the data according to its relevance. For this, it is necessary to have "specialized personnel" with specific training in telemedicine [13].

The security of the transmissions also has a fundamental role, since any leakage of information or modification of the same ones would suppose catastrophic consequences for the patient [10]. On the other hand, its implementation would require financial financing, which in the absence of conclusive evidence regarding the additional cost benefit makes it difficult to make decisions to achieve it. However, the incessant progress in the development of new data transmission technologies (4G) and the increasing use of smart phones, tablets and applications is an important reason to conduct this research, since the necessary devices are increasingly accessible to the public. general population.

Due to all these factors, telemedicine should be considered as another tool within a “package” of comprehensive care, in the context of other patient care services (home care, hospital care and social assistance).

2. Objective Study

We set out to evaluate the effectiveness of ICT-based interventions in terms of symptom control, increased adherence to treatments, prevention of exacerbations, improvement of quality of life and reduction of morbidity and mortality of COPD compared to traditional methods based on in the follow-up through periodic face-to-face consultations.

A systematic search of scientific articles related to the application of ICT in the practice of Medicine and more specifically in the management of COPD is carried out. The MEDLINE, Web of Science and Cochrane Library directories were used as bibliographic databases for the search. Other sources of information have been the internet portals of WHO, GOLD, SEPAR and JMIR as well as articles from pulmonology journals. For the search process, a combination of keywords was made, including the following: “eHealth”, “telemedicine”, “telemonitoring”, “telehealth”, “telerehabilitation”, “telediagnosis”, “adherence”, “smart phone”, “Telephone”, “App”, “COPD”, “COPD”, “Chronic Obstructive Pulmonary Disease”, “Chronic Obstructive Pulmonary Disease”, “spirometry”, “telespirometry”, “emphysema”, “bronchitis”.

All types of articles evaluating the effects of remote interventions based on the use of ICT on different aspects related to COPD were included. The inclusion criteria were: 1) Publication in 2007 or later, 2) absence of biases, 3) originals, 3) sufficiently large populations and 5) consistent methodology.

In total, 12 articles were collected: 3 meta-analyzes, 3 literature reviews, 2 clinical trials, 2 case-control studies and 2 cohort studies.

3. Results

The total of 12 articles included are shown in **Table 1**.

The literature review published by Paré et al in 2007, evaluates the nature and magnitude of the results associated with telemonitoring in four types of chronic diseases: chronic lung diseases, diabetes, hypertension and cardiovascular diseases. The observed benefits (early detection of symptoms, decrease in blood pressure, adequate treatment, reduction of mortality ...) were not conclusive. However, they obtained more consistent results in pulmonary and cardiac studies than in diabetes and hypertension. The economic viability of telemonitoring was observed in very few studies and most did not perform in-depth economic analysis [7].

In another literature review published in 2017, Sobnath et al aim to evaluate the effectiveness of existing mobile applications for COPD and identify the characteristics that can be considered in the initial design of an EPOC management tool aimed at improving care services medical They include 38 articles and 20 smart phone apps that were downloaded to review some of their common features. Of the 20 applications, 13 (65%) had an education section, 5 (25%) consisted of guidelines and treatment, and 6 (30%) included a calendar or diary and other characteristics such as reminders or symptom follow-up. Other characteristics that could be very useful such as social networks, personalized education, comments section, electronic coaching, and psychological motivation were found absent in many of the applications. They conclude that all these characteristics can and should be incorporated into a single application, which should be designed primarily for elderly patients with an easy-to-use interface and easy access for health professionals **(image 1)**. On the other hand, there was little published material on the effectiveness of the identified COPD applications [14].

A meta-analysis conducted by Alwashmi et al. and published in 2016, studies the association between interventions with smart phones and the reduction of COPD exacerbations compared with usual medical care. From a total of 245 articles reviewed, 6 studies were included in the qualitative analysis and 3 in the meta-analysis. The studies were relatively small with less than 100 participants in each study (range 30 to 99) and the follow-up ranged from 4 to 9 months. The average age was 70.5 years and 74% were men. The odds ratio of The pooled random effects of patients with an exacerbation was 0.20 in patients who used a smart phone (95% CI 0.07 to 0.62), that is, a reduction of 80% compared to usual care. However, there was moderate heterogeneity in the included studies (I2 = 59%) [15].

In a prospective multi short study, published in 2016, Represas et al did a COPD screening program based on the use of a portable spirometer (COPD-6), which measures forced expiratory volume at 6 seconds (FEV6) instead of the FVC, with the objective of evaluating its usefulness for screening outside a specialized medical environment **(image 2)**. In total they included 437 participants, of which 362 were valid for the analysis. Three different cohorts were made, classifying them according to the area in which the spirometries were performed: primary care, emergency services and community pharmacies. The study population were people with COPD risk factors:> 40 years, smokers> 10 pack-years, symptomatic. COPD was diagnosed in 114 patients (31.5%). The area under the curve for COPD-6 for the detection of COPD was 0.8. The best cut-off point for the FEV1 / FEV6 ratio was 0.8 (sensitivity of 92.1%, specificity of 52.8%, NPV of 93.6%) using post-bronchodilator spirometry as a gold standard. There were practically no differences in the performance of COPD-6 in different settings, nor in terms of age, sex and smoking. The values measured with COPD-6 were FEV1, FEV6 and the FEV1 / FEV6 ratio. Subsequently, the participants underwent conventional spirometry in the hospital, using a post-bronchodilator FEV1 / FVC value <0.7 as a reference criterion for the diagnosis of COPD. The study shows that the COPD-6 device is a valid tool for the screening of COPD in non-specialized healthcare settings [16].

In another study published in 2016, Wang et al studied the FEV1 / FEV6 ratio, which would correspond to the greater sum of sensitivity and specificity for screening through the use of these portable devices. The study included a total of 767 volunteers recruited from 4 community centers in Xi'an, China, between July and August 2012. They measured FVC, FEV1 and FEV6 using a portable spirometer and compared the results with those obtained by conventional spirometry. Considering FEV1 / FVC <0.70 as the accepted standard for the diagnosis of COPD, the FEV1 / FEV6 limit that would correspond to the highest sum of sensitivity and specificity would be 0.72, with an area under the curve of 98% ($p < 0.001$). For the total population, the sensitivity, specificity, positive predictive value and negative predictive value of FEV1 / FEV6 is 96.9%, 98.8%, 95.8% and 99.2%, respectively [17].

In the study conducted by Jarad and Sund published in 2011, they compare the use of telemonitoring in patients with chronic obstructive pulmonary disease (COPD) and adult patients with cystic fibrosis (CF). A total of 70 patients (51 with cystic fibrosis and 19 with COPD) were included in two six-month studies. The patients used a PDA connected to a portable spirometer to introduce their symptoms and perform a daily spirometry. All patients were trained to perform spirometry. The criteria for the diagnosis of exacerbations of COPD and CF were predefined. When the exacerbations were detected, they were offered treatment according to a pre-designed protocol. Hospitalizations were compared with the same six months in the previous year. The total number of exacerbations could not be compared with the previous year because most were diagnosed and treated by family doctors and reliable data could not be obtained. Patients with COPD achieved a greater follow-up (5% dropout compared to 63% of patients with CF) and more days of study (139 versus 113 days, $p = 0.03$). The median of exacerbations detected was higher in COPD than in patients with CF, although it was not statistically significant. The median number of exacerbations detected with the device was significantly higher in the COPD group ($p = 0.024$). Compared with the same period of the previous year, the number of hospitalizations due to exacerbations of COPD was reduced, while there was no difference in the number of exacerbations requiring intravenous antibiotics in the CF group compared to the previous year. The adherence to telemonitoring was much greater for COPD than patients with CF and the results seem to be more favorable for patients with COPD [18].

A clinical trial conducted by Farmer et al, published in 2017, compared the daily use of a monitoring and self-management system (EDGE) to improve quality of life and clinical outcomes in patients with moderate to very severe COPD. serious, with standard medical care for 12 months. The specific health of COPD was measured with the St George's Respiratory Questionnaire for COPD (SGRQ-C). The study included a total of 166 patients, who were randomized (110 intervention, 56 usual care). All patients were included in an intention-to-treat analysis. The estimated difference of SGRQ-C at 12 months was -1.7 with a 95% CI of -6.6 to 3.2 (p = 0.49). The relative risk of hospital admission for EDGE was 0.83 (0.56-1.24, p = 0.37) compared to usual care. The generic health status, estimated by the EQ-5D, differed significantly better health status for the EDGE group (0.076, 95% CI 0.008-0.14, p = 0.03). The median number of visits to the primary care physician for the EDGE group compared to usual care were 4 versus 5.5 (p = 0.06) and for nursing were 1.5 versus 2.5 (P = 0.03) [19].

A literature review by Gregersen et al, published in 2016, evaluates the effect of different telemedicine tools in improving the quality of life of patients with COPD compared to a control group. Of the 18 studies that met the inclusion criteria, three found statistically significant improvements in quality of life for patients assigned to telemedicine interventions. However, all other included studies did not find differences, probably because the control groups were not pure (they received some degree of education about COPD). On the other hand, it was observed that the greatest potential for improvement in quality of life was in the group of patients with the lowest score at the beginning of the study. They also observed that the quality of life scores deteriorated in the control group while they remained stable in the intervention group [20].

A randomized controlled trial, published by Burgos et al, evaluated the effectiveness, acceptability and usability of a website aimed at promoting high-quality spirometry in primary care with three main functions: 1) educational material for continued professional learning; 2) remote support to guarantee the quality of the tests; and 3) remote assistance for the interpretation of pulmonary function. Six intervention units (PCi) and six control units (PCc) were compared during 12 months. A total of 4,581 patients were included (3,383 PCi and 1,198 PCc). The 34 participating nurses (PCi and PCc) received identical training. The PCi units had access to educational material and remote support from experts. The quality of the spirometry and the usability of the web application were evaluated. At the beginning of the study, the quality was similar (PCi 71% and PCc 67% high quality tests). During the study, PCi showed a higher percentage (71.5%) of high quality tests than PCc (59.5%) (p, 0.0001). The satisfaction of the health professionals was high. The remote support by specialists through the internet had a positive and sustained impact on the quality of the tests carried out in AP [24].

In the research and innovation project, called "Telecare, chronic patients and the integrated health system" (from its initials in English the TELEKAT project), they take on the challenge of developing an interdisciplinary telerehabilitation program for patients with severe or very severe COPD . The telerehabilitation program can be carried out in the patient's own home in collaboration with several health professionals. An interactive monitor is installed in the patient's home, which is responsible for collecting and transmitting data on blood pressure, pulse, weight, oxygen saturation and lung function of the patient to a web portal or electronic health record patient's medical Health professionals (family doctors, nurses, pulmonologists and physiotherapists) can evaluate patient data, monitor the disease and its training and provide advice to the patient (Images 3 and 4). The results were very positive, observing a modification of the interpersonal relationships, with a more proactive character of the patients towards their disease. Likewise, it meant greater learning for both the patient in the management of his symptoms and the doctor to provide treatment and help patients to recover functionality, stay active and avoid rehospitalization. They observed that patients felt well cared for and safe knowing that health professionals were there to assist them "at the end of the line" [21].

A Cochrane review evaluated the effectiveness of computer interventions and mobile technology to facilitate, support and maintain self-management in people with COPD. The objective was to evaluate different aspects: the number of acute exacerbations, hospitalizations, quality of life related to health (HRQOL), self-efficacy, cost-effectiveness, pulmonary function, anxiety and depression. Three studies with a total of 1580 randomized participants were included. After excluding some subgroups that did not meet the characteristics of the study, the total population available for the analysis included 557 participants. The average age of the participants was 64 years. These studies measured five of nine defined outcomes. None included results of self-efficacy, cost-effectiveness, functional capacity, pulmonary function, anxiety or depression. The three studies included health-related quality of life (HRQOL) as measured by the COPD Clinical Questionnaire (CCQ) or the San Jorge Respiratory Questionnaire (SGRQ). One study reported hospital admissions and acute exacerbations. Two studies included physical activity measured by counting daily steps. One study addressed smoking by providing a narrative analysis. Only one study reported adverse events and detected significant differences between groups, with 43 events scored in the intervention group and eight events in the control group (P = 0.001). For studies with results measured per month, atfour months and at six months, the effect of intelligent technology on HRQOL was significantly better than when participants received support for face-to-face, digital and / or written self-management (SMD -0.2, 95% CI: -0.40 to -0.03; P = 0.02). The only study that included HRQL at 12 months did not find significant differences between the groups (SMD 1.1, 95% CI -2.2 to 4.5, P = 0.50). Hospitalizations (OR 1.6, 95% CI: 0.8 to 3.2, P = 0.19) and exacerbations (OR 1.4, 95% CI: 0.7 to 2.8, P = 0.33) did not differ between the groups in the only study that evaluated at 12 months. Activity was significantly greater when technology was used than when face-to-face, digital and / or written assistance was provided (DME 864.06 daily steps between groups, 95% CI 369.66 to 1358.46, P = 0.0006). At 12 months there were no significant differences between the groups (mean: 108, 95% CI: -720 to 505, P = 0.73). The only one study that included smoking cessation did not find significant differences (OR 1.06, 95% CI 0.43 to 2.66, P = 0.895). The meta-analysis showed no significant heterogeneity between the studies (Chi^2 = 0.39, P = 0.82, I^2 = 0% and Chi^2 = 0.01, P = 0.91, I^2 = 0%, respectively). However, they caution that the evidence in this review comes from three studies of low quality, the number of RCTs available is limited and the follow-up periods are insufficient, so they conclude that the quality of the studies is insufficient to allow firm conclusions. based on these data and that research is required for the definitive confirmation of its true effects [22].

Another systematic review evaluated the effectiveness of home telemonitoring to reduce the use of medical care and improve the health status of patients with chronic obstructive pulmonary disease (COPD). A total of 9 studies were included in the meta-analysis. Patients who had received telemonitoring at home had a significantly lower risk of hospitalization than those receiving usual care (RR = 0.72, 95% CI = 0.53-0.98, p = 0.034, I2 = 4.73%). There were no significant differences in the mean number of hospitalizations per patient (SMD = 0.06, 95% CI = 0.32-0.19, p = 0.617, I2 = 16.42%) or the average duration of hospitalizations (SMD = 0.06, 95% CI = 0.19-0.31; p = 0.635; I2 = 0%). Regarding the number of visits to the emergency department, no significant differences were found (SMD = 0.20, 95% CI = 0.49-0.88, Z = 0.56, p = 0.576) but there was great heterogeneity among the studies (I2 = 74.81 %), so a subgroup analysis was made, finding a significantly lower mean number of emergency department visits in the intervention group (SMD = 0.51, 95% CI = 0.4-0.88, p = 0.007). However, this trend was not observed in the RCT (SMD = 0.19, 95% CI = 0.78-0.39, p = 0.515). Three studies suggested that telemonitoring reduced related costs with medical attention, although the difference was not significant (p = 0.21), while one of the studies found a reduction in hospitalization costs (29,686 USD) and a reduction in the total cost of 6,750 USD compared to usual care , including the costs associated with the implementation of the intervention. The mortality rates were not different between the groups (RR = 1.43, 95% CI = 0.40-5.03, Z = 0.55, p = 0.582, I2 = 0%). The control group had a higher incidence of exacerbations (p = 0.152). Finally, significant differences were found in the total SGRQ score (SMD = 0.53, 95% CI = 0.97-0.09, Z = 2.35, p = 0.019, I2 = 17.74%), although this trend does not it was confirmed in the subsections of the SGRQ ($p > 0.05$, I2 = 0.00%) (23).

4. Discussion

With the exponential growth of technology telemedicine is expanding to almost all fields, especially in the case of chronic diseases that are the most costly for Public Health. Paré et al, in their review, study the nature and magnitude of the results associated with telemonitoring in chronic diseases, which despite being inconclusive, show more consistent results in pulmonary and cardiac studies comparing them with other types of chronic diseases , with decreased visits to emergency services, hospital admissions or average hospital stay [7]. It is true that since the publication of the study in 2007 the technology has advanced a lot, but even then it indicated that its application in the field of pulmonology was very promising. Since then it has continued to grow, and more and more studies are being conducted to study its effects on aspects such as the reduction of exacerbations, hospitalizations, costs, etc. There are multiple potential applications of technology in aspects such as diagnosis, treatment or rehabilitation of COPD among others. Next, we will describe each of them.

4.1. Diagnosis

The under diagnosis of COPD is one of the major problems of this disease. The EPI-SCAN study estimates figures of 73% [4]. The problem lies in the difficulty of implementing an efficient screening program and low cost, since the performance of a spirometry (which is the basis of diagnosis), today, requires the referral of the patient to a specialized unit. Taking into account the large numbers of prevalence of the disease, the screening would involve large waiting lists, saturation of specialized consultations, need for transfer by the patient, increase in costs, etc. The solution to the problem would start with the design of a screening program based on primary care, looking for simpler and more accessible alternatives than conventional spirometry. Screening would be applied to patients at risk of developing the disease: > 40 years, smokers of> 10 pack-years, with symptoms of COPD. Recently portable spirometers have been designed that can be connected to a smartphone and allow to obtain a simplified spirometry in any place. The device uses an alternative parameter to FVC, the forced expiratory volume at 6 seconds (FEV6), which simplifies the spirometric technique. It has been shown that this device is a valid tool for the screening of COPD in non-specialized healthcare settings. Considering FEV1 / FVC <0.70 as the accepted standard for the diagnosis of COPD, the FEV1 / FEV6 limit that would correspond to the highest sum of sensitivity and specificity would be 0.72, with an area under the curve of 98% ($p < 0.001$). . For the total population, the sensitivity, specificity, positive predictive value and negative predictive value of FEV1 / FEV6 is 96.9, 98.8, 95.8 and 99.2%, respectively [17,18].

On the other hand, another possibility would be the performance of diagnostic spirometry directly in health centers by primary care professionals. For this, it would be necessary a training program that establishes technical bases for the spirometric technique, as well as continued assistance by the specialist to correct technical errors and improve the quality of measurements. This assistance could be made through the use of ICT without the need for coordination of schedules between professionals, travel, etc. One study evaluated the effectiveness, acceptability and usability of a web application aimed at promoting high-quality spirometry in primary care with three main functionalities: 1) accessibility to educational material for continued professional development; 2) remote support to guarantee the quality of the tests carried out by the inexperienced; and 3) remote assistance for the interpretation of pulmonary function. Obtaining a higher percentage of high quality tests than the control group (p, 0.0001) [25].

4.2. Telemonitoring for the Prevention of Exacerbations

As previously mentioned, exacerbations of COPD pose a great economic burden, as well as a deterioration in the quality of life of patients. Reducing the impact of exacerbations through the early recognition of symptoms and the introduction of early treatment can reduce the risk of hospitalization and improve the quality of life related to health (HRQoL). Based on the fact that each exacerbation of COPD has a phase of gradual increase preceding the symptomatic peak for several days, it is suggested that an early detection of such tendency could prevent it from occurring and redirect it to a significantly milder clinical presentation. Therefore, the use of a system for the early diagnosis of exacerbations during their evolution could be very cost-effective and lower the cost of severe cases [15]. Home telemonitoring allows obtaining information non-invasively using electronic devices and allows a routine and regular collection of clinical data. Portable spirometers would not only be useful in the screening of the disease, but could also help prevent and reduce the number of exacerbations of patients. Alwashmi et al in a meta-analysis on the effect of interventions using smart phones in the reduction of exacerbations in patients with chronic obstructive pulmonary disease, found a reduction in them, although they warn that the included studies are very heterogeneous [16]. Telemonitoring using a portable spirometer connected to a PDA or any other device has obtained promising results in reducing the number of hospitalizations due to exacerbations, with good results of adherence to the program [19].

4.3. Design of Predictive Models

Home telemonitoring of chronic diseases seems to be a promising patient management approach since it produces accurate and reliable data that allows us to observe long-term trends, offers the opportunity to perform personalized interventions, empowers patients, influences their attitudes and behaviors making them more proactive, and potentially improving their medical conditions [15]. Although some studies have shown that telemonitoring can improve some outcomes and reduce health care costs [26], its effects on reducing visits to the emergency room, hospital admissions, duration of admissions, HRQOL, costs and mortality are less convincing. The limited effectiveness of the interventions could be due to the lack of useful predictive algorithms.

Developing accurate predictive algorithms with demonstrable clinical reliability is a priority for the future consolidation of telemonitoring in the management of COPD. Telemonitoring allows the collection of large data sets, from which, through the application of predictive analysis (systematic use of statistical methods or automatic learning to make predictions and support decision making) we could obtain effective algorithms that increase the efficiency and profitability of telemonitoring. To interpret all the data that would be obtained, it is necessary to go a step beyond conventional statistics and use computational techniques covering several domains including statistics, database administration, artificial intelligence, machine learning, pattern recognition and data visualization.

Machine learning is the basis of this type of analysis, is more data-centric and is geared towards generating hypotheses and constructing predictive models using algorithms. There are three stages involved in machine learning: training, validation and testing of the algorithm. The model needs to be validated and tested to quantify its performance. Experimental validation using an external data set is the best method to validate a model and ensure generalization. However, in telehealth interventions, acquiring samples is expensive and the amount of data available is small. In this scenario, when there are large data sets available, the data can be randomly assigned to three groups: training, testing and validation.

Currently, predictive analysis is being applied in many fields, such as public safety, cyber security and social networks. In the field of Medicine, the development of accurate predictive models, with acceptable sensitivity and specificity, has not yet been achieved.

New predictive models are being tested in pilot studies with positive results. However, the algorithms have to be validated in large samples of patients, with longer time periods and well-established protocols [26].

The results related to diagnostic applications were contradictory with respect to time spent and diagnostic errors. For educational interventions, no clear evidence of benefit was found. In another trial reporting increased adherence to malaria treatment guidelines by health workers in Kenya (however, the evidence comes from trials in high-income countries where the control group may be very different) . In addition, they found several problems to perform the analyzes: low quality trials, dubious blind, variable devices, very heterogeneous interventions, lack of data ... In addition, the devices have evolved a lot since the study, so new tests must be performed to evaluate the effects and the profitability of these technologies [14].

4.4. Self-management of the Disease

The management of COPD requires a multidisciplinary approach that involves many different treatment modalities. At present, the system is very segregated, preventing a correct integral approach to the disease. Sobnath et al, in their systematic review, evaluate the effectiveness of existing mobile applications for COPD and describe the possible characteristics that a potential mHealth system should have (Telemedicine based on mobile technology) designed for the WELCOME project of the European Union whose The objective is to develop a support tool for patients with COPD. The application should be designed primarily for elderly patients with an easy-to-use interface and easy access for health professionals. This tool should include:

- Telemonitoring functions for the early detection of exacerbations

- A personalized education section with adapted information on the disease and self-management of this

- Treatment guidelines

- Symptom monitoring calendar

- Social networks to share their personal experience, and encourage support among the community of patients with COPD, as well as exchange of information with medical professionals.

- Comments section

- Electronic coaching

- Psychological motivation to encourage good adherence to the program [15].

However, studies that have evaluated the efficacy of these interventions have not shown long-term benefit. A Cochrane review reported that the use of self-management support technology in people with COPD proved to be more effective in improving quality of life when compared to face-to-face education or support materials at four weeks, four months and six months, but not at 12 months, suggesting that the effects of the intervention can be mitigated over time. Similar effects were found in the level of physical activity. One possible explanation for this is that during the maintenance phase no updates of educational and motivational content were included. In addition, when performing a subgroup analysis they found that age and educational level could be important factors for the success of interventions. It is not clear if this is the result of a decrease in physical capacity, or a lower consumption of these technologies with age. However, existing studies were scarce and of poor quality, with insufficient follow-up periods, so it is not possible to draw firm conclusions based on these data [23].

4.5. Effect on the Quality of Life

The preservation of the quality of life is one of the fundamental objectives of the treatment of COPD, since it is a very limiting disease, which has many repercussions in the daily life of patients. Telemedicine could contribute to the improvement of the quality of life since it promotes the proactive character of the patients, obtaining a better adherence to the treatment and to the programs of rehabilitation and abandonment of the smoking habit, with better control of the symptoms and prevention of the exacerbations . However, the scientific evidence does not show significant evidence on the specific health status of COPD (SGRQ-C) compared to usual medical care. However, there seems to be a benefit in the generic health status measured by the EuroQol 5 [20]. It was also observed that the greatest potential for improvement in quality of life was in the group of patients with the lowest baseline situation at the beginning of the study. Therefore, it can be speculated that patients with severe COPD will benefit more from active telemedicine interventions than other groups of patients with COPD. They also observed that the scores on the quality of life deteriorated in the control group while they remained stable in the intervention group. This supports the argument that the absence of impairment could be a perhaps more realistic success criterion. In addition, it could be considered that the achievement of results comparable to standard care can also be considered a relative success, although some other advantages of the use of telehealth should be obtained to replace routine care [21].

4.6. Interdisciplinary Support

As previously mentioned, COPD is a disease that needs an interdisciplinary approach that involves all types of health personnel (primary care nurses, family doctors, pulmonologists, physiotherapists ...). This approach is often hampered by the impossibility of coordination among professionals due to lack of communication, impossibility of holding joint sessions due to time and geographical limitations, etc. In the research and innovation project, called "Tele care, chronic patients and the integrated health system" (from its initials in English the TELEKAT project), they take on the challenge of developing an interdisciplinary telerehabilitation program for patients with severe or very severe COPD . The program can be carried out directly in the patient's own home in collaboration with several health professionals. An interactive monitor is installed in the patient's home that is responsible for collecting and transmitting data on different physiological parameters (blood pressure, pulse, weight, oxygen saturation and pulmonary function) of the patient to a web portal or the electronic medical record of the patient. Health professionals can independently evaluate the patient's data, monitor the patient's illness and training and provide advice to the patient. The results were very positive, observing a modification of the interpersonal relationships, with a more proactive character of the patients towards their disease. It also meant greater learning for both the patient in the management of his symptoms and the doctor to provide treatment and help patients recover functionality, stay active and avoid rehospitalization. They observed that patients felt well cared for and safe knowing that health professionals were there to assist them "at the end of the line" [22].

5. Conclusions

- The use of portable spirometers could be useful for the screening of COPD in non-specialized healthcare settings. In addition, it could be a useful tool for telemonitoring and the early detection of acute exacerbations.

- New technologies could be the basis for the development of training tools to improve the skills of primary care professionals for the performance of quality spirometry, without the need for inter consultations to specialized consultations and shortening waiting times.

• Telemonitoring allows a continuous and very cheap collection of patient data that allows the development of predictive models for the prevention of exacerbations, with the reduction of costs that would take into account that most of the burden of disease is owe to them It is necessary to develop advanced computer tools for the correct interpretation of this large volume of data.

• Telemedicine allows a more effective interdisciplinary approach to the disease through the design of computer applications that include different functionalities: telerehabilitation programs, daily symptoms, treatment guides, coaching, social networks, etc. This allows the synchronization of the different levels of care simultaneously and without the need for travel.

• Quality of life in patients with advanced COPD is maintained over time in comparison with the control groups, due to the adoption of a proactive attitude of patients that achieves greater adherence to treatment with better control of symptoms. The effects of these interventions seem to diminish over time but could be due to a lack of educational and motivational updates on the eHealth platform.

• Patients feel better served as they perceive greater control of their illness, both on their part and on that of the professional.

• Currently available telemedicine tools have not been able to demonstrate their effectiveness due to the absence of powerful studies, with sufficiently large groups, homogeneity of measurements and definitions, and adequate follow-up times to draw firm conclusions. It is necessary to carry out new more powerful studies that allow us to describe the benefits of these tools consistently.

6. Figures

Image 1: Application example for self-management of COPD. Source: MyCOPD

Image 2: Portable spirometer model that shows a flow-volume curve on your screen.

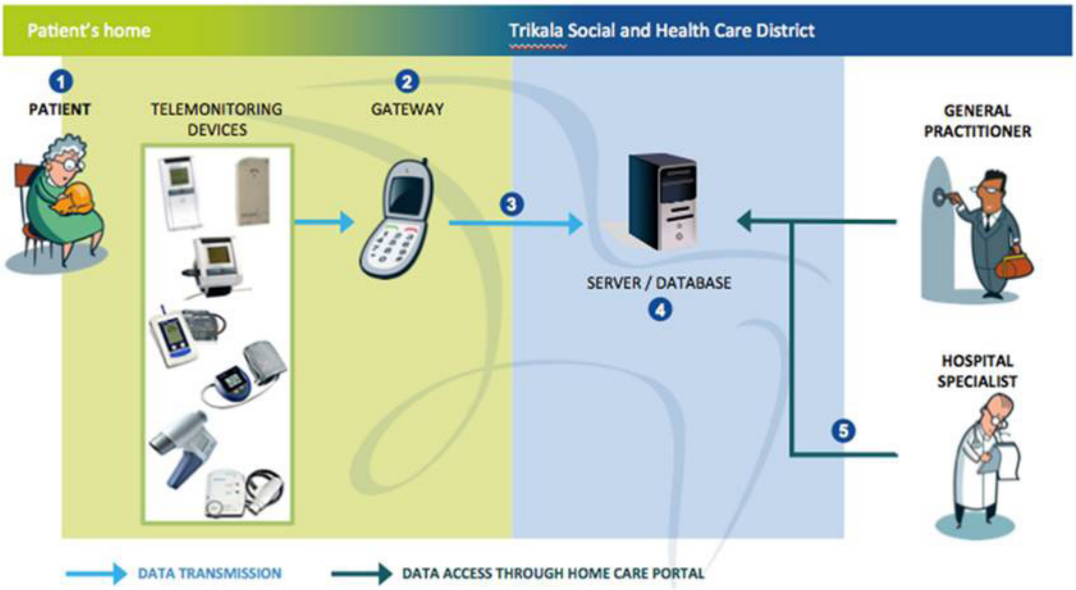

Image 3: Prototype of home telemonitoring program.

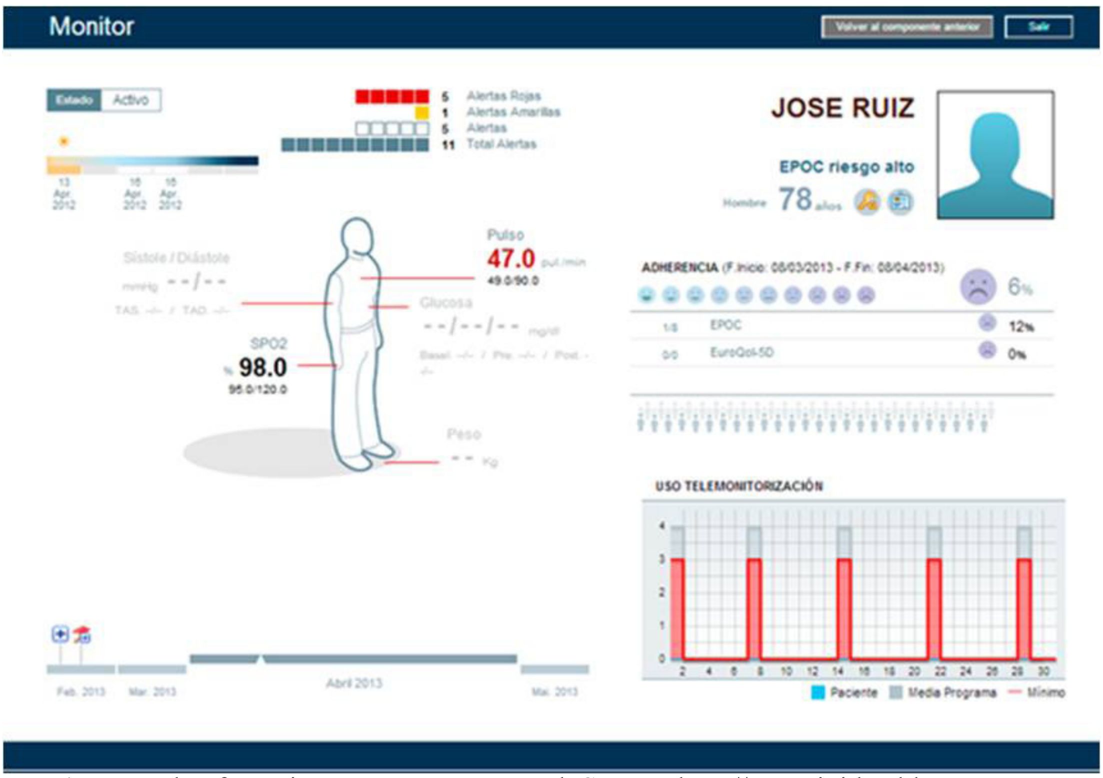

Image 4: Image 4: Example of a patient management portal. Source: http://www.inithealth.com

7. References

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