

TELEMONITORING OF PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE IN PORTUGAL: A CASE STUDY

TELEMONITORIZAÇÃO DE DOENTES COM DOENÇA
PULMONAR OBSTRUTIVA CRÔNICA EM PORTUGAL: UM CASO
DE ESTUDO PARA A TELEMONITORIZAÇÃO DE DOENTES
CRÔNICOS EM PORTUGAL **PT**

TELEMONITOREO DE PACIENTES CON ENFERMEDAD
PULMONAR OBSTRUCTIVA CRÓNICA EN PORTUGAL: UN
ESTUDIO DE CASO PARA EL TELEMONITOREO DE PACIENTES
CRÓNICOS EN PORTUGAL **ES**

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ABSTRACT

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable, and treatable disease, defined by persistent respiratory symptoms and airflow limitation. Acute COPD episodes dramatically impact patients' quality of life and are a significant burden on healthcare systems. The remote monitorization of COPD patients enables prompt clinical intervention whenever needed, preventing acute episodes and delaying disease progression. Here we present the results from a tele-monitoring initiative for COPD patients, following a national multi-centre pilot study funded by the Shared Services of Ministry of Health (SPMS, Portugal), with 130 patients enrolled. The remote assessment of these patients allowed for the timely intervention in the management of acute episodes and yielded significant improvements for the number of emergency episodes, hospital admissions, days of hospitalization and costs. Moreover, results from a satisfaction questionnaire conducted in 2019 revealed high satisfaction levels among all users. Data on COPD patients' tele-monitoring effectiveness through the COVID-19 pandemic was also collected. In conclusion, the tele-monitoring system for COPD patients herein reported significantly improved value-based healthcare, representing a valuable tool for other chronic diseases whenever clinically feasible.

Keywords: Telemedicine, tele-monitoring, chronic diseases, COPD, COVID-19

RESUMO

A Doença Pulmonar Obstrutiva Crónica (DPOC) é uma doença comum, evitável e tratável, caracterizada por sintomas respiratórios persistentes e limitação do fluxo aéreo. As agudizações da DPOC têm um impacto dramático na qualidade de vida dos doentes e nos encargos dos sistemas de saúde. A monitorização remota dos doentes com DPOC permite uma rápida intervenção clínica sempre que necessário, evitando agudizações e atrasando a progressão da doença. Neste artigo apresentamos os resultados de uma iniciativa de telemonitorização para doentes com DPOC, na sequência de um estudo piloto nacional multicêntrico financiado pelos Serviços Partilhados do Ministério da Saúde (SPMS, Portugal), com 130 doentes inscritos. A avaliação remota destes doentes permitiu a intervenção atempada na gestão de episódios agudos e gerou melhorias significativas no número de episódios de emergência, internamentos hospitalares, dias de hospitalização e custos. Além disso, os resultados de um inquérito de satisfação conduzido em 2019 revelaram elevados níveis de satisfação entre todos os utilizadores. Foram também recolhidos dados sobre a eficácia da telemonitorização de pacientes com DPOC durante a pandemia por COVID-19. Em suma, o sistema de telemonitorização para doentes com DPOC aqui descrito gerou melhorias significativas nos cuidados de saúde, representando uma ferramenta valiosa para outras doenças crónicas sempre que clinicamente viável.

Palavras-chave: Telemedicina, telemonitorização, doenças crónicas, DPOC, COVID-19

RESUMEN

La Enfermedad Pulmonar Obstrutiva Crónica (EPOC) es una enfermedad común, prevenible y tratable, definida por síntomas respiratorios persistentes y limitación del flujo aéreo. Los episodios agudos de la EPOC tienen un impacto dramático en la calidad de vida de los pacientes y suponen una importante carga para los sistemas de salud. La monitorización remota de la EPOC permite la pronta intervención clínica siempre que sea necesario, evitando los episodios agudos y retrasando la progresión de la enfermedad.

Aquí informamos los resultados de una iniciativa de telemonitoreo para pacientes con EPOC, tras un estudio piloto nacional multicéntrico financiado por los Servicios Compartidos del Ministerio de Sanidad (SPMS, Portugal), con 130 pacientes inscritos. La evaluación precoz de estos pacientes permitió intervenir a tiempo en el manejo de los episodios agudos y ha generado mejoras significativas en el número de episodios de urgencias, ingresos hospitalarios, días de hospitalización y costes. Además, los resultados de una encuesta de satisfacción realizada en 2019 revelaron altos niveles de satisfacción entre todos los usuarios. También se recogieron datos sobre la eficacia del telemonitoreo de los pacientes con EPOC durante la pandemia de COVID-19. En conclusión, el sistema del telemonitoreo para pacientes con EPOC aquí descrito ha generado mejoras significativas en la atención sanitaria, lo que representa una herramienta valiosa para todas las demás enfermedades crónicas, siempre que sea clínicamente viable.

Palabras clave: Telemedicina, telemonitorización, telemonitoreo, enfermedades crónicas, EPOC, COVID-19

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable, and treatable disease defined by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities. COPD results from a complex interplay of environment and host factors. The environmental factor is the long-term cumulative exposure to noxious gases and particles. Host factors include genetic profile, asthma, airway hyper-responsiveness, poor lung growth during childhood, and a history of severe childhood respiratory infection. The most critical risk factor for COPD is tobacco smoking. Other risk factors are occupational exposure to dust, chemical agents and fumes, indoor and outdoor air pollution. COPD risk is also associated with aging and female sex. In most patients, COPD is associated with other concomitant chronic diseases, increasing its morbidity and mortality (GOLD - Global Initiative for Chronic Obstructive Lung Disease., 2021). COPD may be punctuated by exacerbations mainly triggered by infections and are more frequent in the late stages of the disease, raising the number of hospital emergencies and admissions, significantly impacting patient and family quality of life, social well-being, and healthcare costs (MacLeod et al., 2021; Vogelmeier et al., 2020).

In Portugal, 30% of the population has chronic respiratory diseases, which are responsible for 20% of hospital admissions. COPD is the 5th cause of death in Portugal (2.4% of all-cause deaths) and it is associated to a total of 240 million euros of direct costs per year (ONDR - Observatório Nacional das Doenças Respiratórias, 2017; DGS - Direção Geral de Saúde, 2014; CNTS - Centro Nacional de TeleSaúde, 2019). The disease progression also originates a decreased effort tolerance of the patient, which leads to a progressive decrease of its regular activity, distancing of family and friends, and hence, solitude and depression (Silva et al., 2018).

Patients with COPD should be evaluated on a regular basis depending on the disease severity. Follow-up sessions should determine patients' adhesion to medical regimen, response to therapy, inhaler technique, adverse effects of treatment, and disease progression. The level of dyspnea at rest and with exercise should also be evaluated, as well as the number of exacerbations. Smoking status and exposure should be determined at each appointment, followed by appropriate action. Questionnaires such as the COPD Assessment Test (CAT) can be used to assess symptoms. These can be found in the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines (GOLD - Global Initiative for Chronic Obstructive Lung Disease, 2021).

Previous studies have shown that COPD exacerbations have a negative impact on patient prognosis (Soler-Cataluna et al., 2005) and are responsible for the most significant proportion of the total direct costs attributable to COPD (O'Reilly et al., 2007). Therefore, the development of interventions capable of managing exacerbations at an early stage is urgently needed to reduce morbidity and mortality of the COPD population (Cruz et al., 2014a). One promising approach consists in the use of information and communication technologies (ICT) for the remote monitoring of COPD patients at home, also referred to as home telemonitoring. Home telemonitoring, defined as the use of telecommunication technologies to transmit data on patients' health status (e.g., oxygen saturation, vital signs) from home to a healthcare center, can be used to timely assess an acute exacerbation (Cruz et al., 2014b) empowering patients to manage their disease. Ultimately, this approach could improve patient-professional interactions and prevent unplanned hospital admissions (McKinstry, 2013; Paget et al., 2010). In addition, this kind of remote monitoring service offers an opportunity to enhance the quality of care, reassuring (remote) patients that a dedicated clinical team is continuously following them.

While the interest in telemonitoring interventions to manage patients at home is increasing, the evidence to support its effectiveness is still limited (McKinstry, 2013). Here we report the implementation of a telemonitoring initiative for COPD patients served by the regional hospital of Alto Minho, Portugal, using a full-customized turnkey solution developed by an external company.

The main aim of this initiative was to reduce disease exacerbations and the use of health services by COPD patients, improving their quality of life using a feasible, simple to use, and affordable telemonitoring method. The evaluation of the impact of disease telemonitoring on the healthcare-related costs associated with the management of these patients was set as a secondary goal.

METHODOLOGICAL PROCEDURES

PROJECT DESIGN AND IMPLEMENTATION

The telemonitoring initiative was a challenge proposed by the Telemedicine Working Group (GTT) of the Shared Services of the Ministry of Health (SPMS) in 2013 in Portugal. Five National Public Health Institutions (one for each of the 5 health administrative regions of the mainland) were selected, each of which with 15 patients being included, according to the following criteria: confirmed diagnosis of the disease; follow-up in consultation of at least one year before entering the program; having at least two episodes of emergency or one emergency with a hospital admission in the year before entering the program; minimum necessary clinical and socioeconomic conditions; guarantees of technological and clinical means to fulfill the program.

After positive feedback from a preliminary satisfaction survey promoted by the national health authorities, the one-year pilot project was extended twice. In 2018, the “Unidade Local de Saúde do Alto Minho” (ULSAM) administration board took over the project, incorporating it into the hospital’s routine clinical practice. Here we report the experience and the results obtained at ULSAM from the early pilot phase until the current phase of routine clinical practice of telemonitoring COPD patients.

A nursing team was involved in the project to guarantee the continuous telemonitoring (24 hours/7 days per week) of enrolled COPD patients. The technical team was responsible for the set-up and connection of the communication platform and monitorization devices, training of patients and caregivers, and solving all technical issues.

We have deliberately chosen simple parameters for the telemonitoring of COPD patients (temperature, blood pressure, and O₂ saturation) rather than other more sensitive and sophisticated metrics, such as respiratory frequency, dyspnea scale, and phlegm volume. The rationale for this is that, during the pilot phase of the study, we observed that those simple parameters were sufficient to detect COPD exacerbation with the advantage of not compromising patient compliance or project costs.

The ICT platform was provided by an external company (VitalMobile Health), which developed a full-customized turnkey solution including the proprietary ICT platform, third party biosensor devices, dedicated smartphone, and all communication, cloud storage, and technical services required for the remote monitoring of COPD patients – see Figure 1, panel A. The monitoring devices used in this initiative were: thermometer, oximeter with heart rate, and blood pressure monitor – see Figure 1, panel B. The three monitoring devices communicate automatically and wirelessly with the provided smartphone, enabling the automatic transmission of the biometric data to the ICT platform with minimal

intervention by the patient or caregivers. The clinical team monitored patient data evolution remotely using the platform monitorization console installed on hospital desktop computers, personal tablets, and/or smartphones. Patient case information is uploaded to the patient clinical file at the hospital ICT platform or the central ICT platform of the national health system.

The clinical team, supported by a working group composed of pneumologists, specialized nurses in medical-surgical nursing, specialists in telemedicine, and technicians assigned by the Ministry of Health during the pilot study, has developed and validated customized algorithms for the monitorization of each patient, considering the patient condition, co-morbidities, literacy level, and social context. The algorithm customization included the set-up of a system of alarms and notifications in case patient biometric parameters were not within the expected range (e.g., oximetry levels, temperature, blood pressure, among others). Some alerts prompt immediate action by the nursing team, with backup support from the medical team. In addition, patients and caregivers have direct access to the clinical team either by telephone or video call through the smartphone provided upon enrollment in the telemonitoring initiative.

INCLUSION CRITERIA

Participating COPD patients in the telemonitoring initiative have to meet the following criteria: COPD diagnostics according to GOLD criteria (GOLD - Global Initiative for Chronic Obstructive Lung Disease, 2021); GOLD functional class C and D, and eventually B if very symptomatic; 40 years of age or more; registry of at least two urgency episodes or one hospital admission during the previous year; patient or caregiver with the capacity to understand and follow the instructions of the telemonitoring system in Portuguese; patient receptive to use the telemonitoring system on a daily base; patient with residency in the regional region served by ULSAM; and, given informed consent.

EXCLUSION CRITERIA

Patients with the following characteristics were excluded from the telemonitoring initiative: patients with neurologic, psychiatric, or cognitive disorders impairing the understanding and handling of the telemonitoring system; and patients with a survival prognosis of less than one year.

PATIENT ENROLLMENT

Patients followed by the COPD clinical team of ULSAM were selected for the telemonitoring project according to the above-mentioned inclusion and exclusion criteria. Enrollment was performed once per month, and patients were asked to sign an informed consent. Training was provided at the hospital by the clinical and technical teams to the patient and/or caregiver. Finally, the technical team delivers and tests the monitoring system with the patient at his home.

PATIENT MONITORING

During the first 3 months upon enrollment to the telemonitoring initiative, all clinical parameters were collected twice daily. After this period, the clinical team adjusted the monitoring frequency, usually to once daily during the morning and whenever the patient feels necessary to monitor his/her condition.

OUTCOME MEASURES

The outcome data of the study were: number of emergencies, number of hospital admissions, and number of days at the hospital. For each patient, outcome data were recorded during the year after patient enrollment and retrospectively compared with data from the year before enrollment. Emergency episodes were defined as non-planned visits

to the hospital whenever the patient was unstable for any reason, COPD-related or not. Costs associated with emergency episodes and hospital admissions were calculated using the reference costs per episode/day defined by the hospital administration and used for budget and cost allocation purposes.

SATISFACTION QUESTIONNAIRE

In January 2019, between days 8 – 10, one year after the project was implemented into the routine clinical practice of the ULSAM hospital, a satisfaction questionnaire was performed by phone to all patients enrolled in the project for more than 6 months ($n = 43$). Three out of 43 patients could not be contacted, originating a total of 40 valid questionnaires (93% of the sample).

DATA ANALYSIS

The data presented in this study was collected from a sample of 130 COPD patients (128 GOLD D and 2 GOLD B) during two homologous periods: the year before patients' enrollment in the study and the first year after the inclusion on the telemonitoring program. The average values for each proposed outcome were calculated and compared between the two groups. In this way, we assessed the impact of telemonitoring in the outcome measures on the same group of patients (analyzed before and after their inclusion in the study).

To determine the impact of the COVID-19 pandemics on the effectiveness of telemonitoring in COPD patients, data obtained during the confinement period between March 1 to June 30 2020, was compared with the information registered from the homologous period in 2019.

RESULTS

TELEMONITORING IMPACT ON COPD PATIENT'S CLINICAL OUTCOMES AND HEALTH-RELATED COSTS

The COPD telemonitoring initiative at ULSAM was implemented in 2014 and, as of 1 July 2020, a total of 130 patients had been enrolled, 99 of which were active. Table 1 summarizes the demographic and clinical characteristics of the enrolled patients. Table 2 summarizes the outcome measures, and Table 3 summarizes the results from the satisfaction questionnaire.

Overall, the COPD telemonitoring initiative has originated very positive outcomes, with improvements between 59.1% and 69.1% in all measures: number of emergency episodes (-64.9%), number of hospital admissions (-69.1%), days at the hospital (-59.1%), emergency-related costs (-65%), and hospital stay related costs (-59.1%).

In terms of patient satisfaction, 18 out of the 40 valid questionnaires were replied by patients and 22 by caregivers. As for the global sample, the respondents have low levels of instruction (86% below high school education) and little experience with ICT (50% of respondents reported no experience with informatic devices before enrollment). Nevertheless, high levels of patient satisfaction were recorded, with positive responses above 87.5%, in all dimensions evaluated by the questionnaire: program enrollment and experience (75% considered it excellent), healthcare service level (95% classified the professionalism and competence of the clinical team as excellent), disease-related anxiety (87.5% reported that the program helped them to reduce anxiety levels), and disease management (100% preferred remote telemonitoring over presentational monitoring). Of note, 95% of the respondents felt more confident and better followed after the enrollment in the telemonitoring project, and 87.5% believed that the project has contributed to reduce the number of hospital and primary care visits.

Implementing a telemonitoring system for COPD patients served by the ULSAM hospital has also generated significant improvements in value-based healthcare. We herein report a 59% plus improvement in clinical outcomes (reducing emergency episodes COPD related or not (-64.9%), hospital admissions (-69.1%), and days at hospital (-59.1%). We have also observed a significant reduction of costs: after one year of enrollment, emergency-related costs decreased ca. 28 000€, and hospital stay-related costs decreased ca. 96 000€. The reduction of costs adds up to ca. 124 000€ per year, which largely pays off the investment of 30 000€ made by the national health authorities at the project's onset.

TELEMONITORING OF COPD PATIENTS DURING THE COVID-19 PANDEMIC

Considering the current COVID-19 pandemics, we wondered how it had affected the patients enrolled in the ULSAM COPD telemonitoring project due to the confinement policy. Comparing the confinement period (March 1 to June 30, 2020) with the 2019 homologous period, we observed a decrease of 6.5% in the number of clinical interventions (from 46 in 2019 to 43 in 2020), 42.3% in emergency episodes (from 26 to 15); 25% in hospital admissions (from 4 to 3) and 8.7% in total days at hospital (from 25 to 21). Of note, the confinement period did not affect the healthcare service level provided by the team to the patients to maintain the proper monitoring and prompt clinical intervention whenever needed. Also, no patient has been infected by COVID-19.

DISCUSSION

The telemonitoring initiative herein reported is the first telehealth program to remotely monitor COPD patients in Portugal. The main goal of this initiative was to reduce disease exacerbations and improve COPD patients' quality of life, reducing their use of health services. Moreover, it was sought to determine if telemonitoring could impact the health-related costs associated with the disease management of these patients.

Our data shows that implementing a telemonitoring system for COPD patients served by the ULSAM hospital since 2014 has generated significant improvements in value-based healthcare. We have observed a 59% plus improvement in clinical outcomes (reducing emergency episodes, hospital admissions, and days at the hospital), as well as costs associated with emergency episodes and hospital stays. In addition, we report a satisfaction score from the patients over 84.5% in all dimensions addressed by the satisfaction questionnaire: patient enrolment and experience, healthcare service level, disease-related anxiety, disease literacy, management of symptoms, and quality of family life. These findings are particularly remarkable considering the low level of instruction and informatic literacy of the enrolled patients, which still was not an obstacle to the perceived ease of implementing the home-based telemonitoring system (classified as easy or very easy by all surveyed patients). Altogether, our data suggest that telemonitoring of high-risk COPD patients is an efficient way to engage patients in managing their clinical condition and contribute to patient empowerment and patient centricity principles.

The key success factors of this telemonitoring initiative were the following: dedication and spirit of mission of all project team members (medical doctors, nurses, and technical staff); full endorsement by the administration board of the hospital; set-up of a telemedicine department for chronic diseases with a dedicated team; project implementation by a clinical and technical multi-disciplinary team; rigorous selection of the technologic solution according to the specific requirements for the telemonitoring of COPD patients and an efficient clinical and technical team action model adapted to the ICT platform patient handling methodology, enabling a high level of control over the patient condition and evolution. On the patient's side, the ease of use of the technology and the support and operation models available enabled the participation of older and illiterate patients. Moreover, the telemonitoring system with fully customizable alert algorithms according to patient profiles and the technology/

service available, closely integrated with the clinical and other teams working in the platform, enabled a unique productivity environment. The simplicity of the project design in terms of monitorization devices and the use of wireless technology and automatic transmission of clinical data to the monitoring platform have also facilitated the adaptation to the monitoring procedures by the patient/caregiver monitorization devices with minimal intervention by the patient/caregiver. Altogether, all of these contributed to making the initiative more valuable to the patient and promoting patient empowerment and empathy. Other studies also reported that when properly managed, the remote monitoring of COPD patients at home can be both effective and satisfying, being valued by patients who found it empowering and convenient (Dinesen et al., 2011; Hanley et al., 2018).

Interestingly, the positive impact of COPD telemonitoring on clinical outcomes and quality of life is not consensual in the literature (Cartwright et al., 2013; Gregersen et al., 2016; Ringbaek et al., 2015; Walker et al., 2018). Our interpretation is that in those settings where COPD care bundle and integrated healthcare programs are well established in clinical practice, telemonitoring might not significantly improve clinical outcomes, healthcare costs, or perceived improvement of quality of life. However, there is still a poor integration between primary and hospital care in Portugal, and care bundles and integrated healthcare programs are not consistently implemented in clinical practice. To date, there is still no code regarding the diagnosis and management of COPD in primary health care in Portugal. Indeed, one of the goals of the national health program for respiratory diseases set for 2020 is to double the number of users with a diagnosis of COPD confirmed by spirometry in primary health care (DGS — Direção Geral da Saúde, 2017). Moreover, patient involvement in health care is still relatively weak in Portugal (Laranjo et al., 2017), and this kind of initiative can promote patient engagement with their medical condition. In addition, in the case of this study, the hospital coverage area has remote locations with poor access to hospital care and, in these settings, telemonitoring can make a significant impact.

Despite this, other studies have reported similar outcomes as the ones herein described. In a controlled trial involving 60 patients monitored for 7 months, Calvo and co-workers have reported a significant reduction in the number of emergency visits, hospitalizations, and length of hospital stay when comparing patients followed at conventional care facilities with the ones monitored through a home telehealth system (Segrelles Calvo et al., 2014). Moreover, they reported an increase from 77 to 141 days on the appearance of acute exacerbations in COPD patients followed in conventional care versus the telemonitored patients (Segrelles Calvo et al., 2014). Similar satisfaction levels as the ones reported in this study were also observed. A systematic review comparing data from randomized controlled trials published from 1990 to 2020 on the effectiveness of telemedicine in reducing adverse clinical outcomes in COPD patients also reported that telemonitoring could reduce emergency room visits and exacerbation-related readmissions, as well as acute exacerbation-related hospital stays and mortality (Lu et al., 2021). Along with our data, this set of results highlights that the implementation of telemonitoring is therefore a potential protective therapeutic strategy that could facilitate the long-term management of COPD patients.

Challenges faced in the implementation of this telemonitoring project were mainly related to patient illiteracy and the inter-operationality of ICT systems. Patient illiteracy about COPD and ICT systems resulted in some difficulty and resistance to participate in telemonitoring initiatives and to adapt to the monitoring procedures. Furthermore, the lack of inter-operationality of ICT systems between primary care institutions and the hospital resulted in some difficulties that affected the articulation of care by the clinical professionals, one of the project's objectives. In the future, the application of standard guidelines to fulfill the interoperability standards, quality, security, scalability, reliability, and timeliness in data

storage could be adopted to better manage these issues (Jardim, 2013).

In terms of strategic vision, we believe that a telemonitoring system, like the one described in this study, is a pivotal tool to integrate the healthcare of COPD patients between primary and hospital care. This integration is essential for the management of patients at higher risk (such as GOLD class C and D patients) and to promote disease awareness, early diagnosis, prevention of acute episodes, and delay of disease progression. For instance, for lower-risk patients (GOLD class A and B), routine spirometry and follow-up can be done at primary care, complemented when needed with a video call with the clinical team at the hospital. Moreover, the rationale of this telemonitoring initiative can be applied to other chronic diseases, such as chronic heart failure.

The COVID-19 pandemic had a special impact on COPD patients and stressed the importance of studies about telemonitoring (Desai & Diamond, 2021). Due to the high infection rates of COVID-19, chronic and vulnerable patients were not able to attend regular clinical assessments. Here we show that during the confinement period of March to June 2020, there was a decrease in the number of clinical interventions, emergency episodes, hospital admissions, and total days at the hospital compared to the homologous period in 2019. These results may reflect these patients' fear of getting out of their homes, as seen in other social-economic dimensions nationwide and, consequently, better compliance to the telemonitoring regimen, which promoted a significant improvement in the clinical outcomes. It is worth noting that, in the current times of COVID-19 pandemics, COPD patients are at a higher risk for severe SARS-COV2 infection. Indeed, the GOLD initiative recognizes a need for developing new approaches to remotely interact with COPD patients and that remote consultations are superb tools to minimize the risk of transmitting coronavirus (GOLD - Global Initiative for Chronic Obstructive Lung Disease., 2020). Indeed, no COPD patients telemonitored on this program have been infected by COVID-19. The fact that these patients were being telemonitored and that the medical team had access to their oximetry and temperature data also made it possible to alert patients in case of a suspected SARS-CoV-2 infection. This is particularly important in this set of patients, who are more vulnerable to respiratory infections, as it enables prompt clinical responses to avoid worsening their health status.



Total number of patients enrolled			130
Age			
Range			48 - 89
Average			71.8
Instruction level			
No school	10		7.7%
Primary school	102		78.5%
Secondary school	17		13.1%
Higher education	1		0.7%
GOLD Class			
B	2		1.5%
C	0		0.0%
D	128		98.5%

TABLE 1. PATIENT DEMOGRAPHIC AND CLINICAL CHARACTERIZATION.

	1 year prior enrolment	1 year to after enrolment	Variation (%)
# of emergency episodes	305	107	-64.9%
# of hospital admissions	97	30	-69.1%
Total # of days at hospital	744	304	-59.1%
Emergency related costs	€ 43 177	€ 15 125	-65.0%
Hospital stays related costs	€ 162 720	€ 66 487	-59.1%

TABLE 2. OUTCOMES MEASURES.

Question	Patient/caregiver answer (n=40)		
How do you classify the COPD telemonitoring project promoted by ULSAM?	not good	good	excellent
	0	10 (25%)	30 (75%)
How do you classify the general concept of remote telemonitoring your health condition?	not good	good	excellent
	0	9 (22.5%)	31 (77.5%)
Before enrollement on the COPD telemonitoring project, how often had you used a computer, tablet or other informatic device?	never	good	excellent
	20 (50%)	8 (20%)	12 (30%)
How easy was to use the telemonitoring devices and the smatphone mode available for the project?	difficult	easy	very easy
	0	25 (62.5%)	15 (37.5%)
How you classify the service level and the information provided by the clinical and technical teams?	not good	good	excellent
	0	6 (15%)	33 (82.5%)
How you classify the professionalism and competence of the clinical team?	not good	good	excellent
	0	1 (2.5%)	38 (95%)
How do you classify the profissionalism and competence of the technical team	not good	good	excellent
	0	40 (100%)	0
Do you feel more confident and better followed with the telemonitoring project?	no	yes	DK/NR
	2 (5%)	38 (95%)	0
Do you prefer remote telemonitoring of your health condition to the previous presential monitoring?	no	yes	DK/NR
	0	40 (100%)	0
Do you agree that the COPD telemonitoring service should be offered to more patients?	no	yes	DK/NR
	0	40 (100%)	0
Has the telemonitoring project helped you to better control or symptoms and understand your disease	no	yes	DK/NR
	0	40 (100%)	0
Has the telemonitoring project helped you to reduce the anxiety levels and, as such, to decrease the number of visits to the hospital and/or primary care facilities?	no	yes	DK/NR
	4 (10%)	35 (87.5%)	1
Do you consider that your family has also benefited from the COPD telemonitoring service?	no	yes	DK/NR
	1 (2.5%)	39 (97.5%)	1

TABLE 3. SATISFACTION QUESTIONNAIRE.

ABBREVIATIONS: DK/NR – DOESN'T KNOW/NO REPLY

A



B



FIGURE 1. TELEMONITORING SYSTEM DEVELOPED BY VITALMOBILE HEALTH USED IN THE ULSAM COPD TELEMONITORING INITIATIVE.

Note. Panel A - The full-customized turnkey solution provided includes the proprietary ICT platform, third-party biosensor devices, dedicated smartphone and all communication, cloud storage, and technical services required for the remote monitoring of COPD patients. Panel B - Self-monitorization devices used in the ULSAM COPD telemonitoring initiative: 1 – blood pressure monitor; 2 – oximeter; 3 – thermometer; 4 - smartphone

CONCLUSIONS

The telemonitoring initiative described in this report significantly enhanced chronic COPD patients' quality of life. Significant reductions were observed in the number of emergency episodes, hospital admissions, and days of hospitalization. High levels of satisfaction have also been recorded by the telemonitoring system end-users, with most respondents considering it excellent. Moreover, the added value of improved patient quality of life went hand in hand with reducing healthcare-related costs, as significant cost savings related to emergency episodes and hospitalizations among high-risk COPD patients were obtained.

As an additional benefit, during this study it was found that the effectiveness of COPD patients' telemonitoring persisted through the COVID-19 pandemic. Our data show that the confinement period experienced during the pandemic did not affect the monitoring of patients or their communication with the clinical team. On the contrary, a significant decrease in the number of clinical interventions, emergency episodes, and hospital admissions was observed within this period, confirming the value of telemonitoring systems in situations where face-to-face monitoring is not advised or possible.

In sum, this report highlights the use of telemonitoring as a key tool for managing chronic diseases, contributing to the integration of healthcare systems and patient empowerment. Furthermore, its use may originate better clinical outcomes and significant cost savings and, thus, contribute to the value-based healthcare agenda.

CONFLICTS OF INTEREST

R. Nêveda and J. Silva declare collaborating and receiving fees from Novartis and other pharmaceutical companies through participation in advisory board or consultancy, congress symposia, clinical trial conduct, investigator-initiated trials, or grants. J. Belo, F. Silva, and C. Balinha work for VitalMobile Health, the supplier of the telemonitoring system developed and used in this study, and want to declare a potential conflict of interest. Novartis Portugal had no role in the preparation of the manuscript or in the decision to submit the manuscript for publication.

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