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Telemonitoring in Respiratory Diseases: Current Evidence, Clinical Experience, and Future Challenges

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Abstract

This narrative review summarizes current evidence and clinical experience regarding telemonitoring across major respiratory diseases and care settings, including chronic obstructive pulmonary disease (COPD), asthma, interstitial lung diseases, obstructive sleep apnea, as well as non-invasive ventilation and pulmonary rehabilitation programmes. Advances in connectivity, artificial intelligence (AI), and wearable devices are facilitating the early detection of clinical deterioration, personalized interventions, and improved self-management, thereby optimizing the use of healthcare resources. Strong evidence supports the benefits of telemonitoring in COPD, particularly in reducing exacerbations and hospital admissions, whereas results are more heterogeneous in asthma and emerging conditions such as interstitial lung diseases. Telemonitoring systems leverage AI-driven analytical frameworks and interoperable digital platforms to process and interpret large volumes of patient data, enabling both automated responses and targeted human interventions. Key challenges include ensuring patient engagement, addressing digital literacy and inequities in access, safeguarding data privacy, and integrating digital solutions into standard care and reimbursement frameworks. The COVID-19 pandemic accelerated the adoption of telemonitoring, confirming its feasibility and acceptability, but also revealed persistent gaps in long-term cost-effectiveness and implementation strategies. Future directions should focus on integrating telemonitoring with AI-supported, coordinated clinical decision-making, enhancing system interoperability, and above all, prioritizing equitable access to digital care. Telemonitoring is poised to become a central component of respiratory patient management, although its large-scale implementation will require overcoming existing technical, ethical, and organizational barriers to fully realize its clinical potential.
Keywords: Telemedicine, Respiratory Tract Diseases, Artificial Intelligence, Pulmonary Rehabilitation, Continuous Positive Airway Pressure, Chronic Obstructive Pulmonary Disease

Introduction

The digital transformation is fundamentally redefining chronic respiratory diseases (CRDs) management, leveraging advances in connectivity, wearable devices, mobile apps, and artificial intelligence (AI) to shift from episodic, face-to-face care to continuous, patient-centered management supported by health data transmission.[1-4] Predictive algorithms, especially machine learning (ML) models, have shown promise in radiological diagnosis[5] and prognostication of diseases like lung cancer,[6-8] chronic pulmonary obstructive disease (COPD),[9-12] and obstructive sleep apnea (OSA).[13-15] Nonetheless, multiple methodological approaches coexist, and substantial room for improvement remains.[16,17] Within this rapidly evolving landscape, telemonitoring has emerged as a leading digital application, enabling early detection of deterioration, personalized treatment, improved self-management, and optimized resource use.[18]

Strictly speaking, telemonitoring refers only to the collection, transmission, integration and storage of data, while its effectiveness comes from what is done with these data: responses can be automated, especially taking advantage of what AI can offer, or relying on human interventions. Usually these two components are combined, with automated data synthesis and first-line interpretation filtering with AI-mediated counselling, followed when required by human intervention, usually nurse-based initially followed by medical input when required. Initially relying on phone calls, instructions and advice can now be sent through apps, facilitating and accelerating communication while decreasing the burden for the healthcare system. The two main models of care delivery using data collected by telemonitoring are the asynchronous (store-and-forward) and the synchronous (real-time) models.[19] In both cases, challenges relate to patient's acceptability and engagement, data security and privacy, integration in care pathways, minimization of burden for healthcare professionals, and concerns about inequities related to health and digital literacy as well as access to technology and healthcare resources.[20-21]

The COVID-19 pandemic accelerated telemonitoring adoption, providing insights into its feasibility and patient acceptance, though evidence varies across conditions and healthcare systems.[22-25] While several interventions show benefits in controlled settings, questions about their long-term sustainability and cost-effectiveness in real-world practice persist, alongside implementation barriers such as digital literacy and system interoperability.[26-31]

This non-systematic review synthesizes perspectives from international respiratory experts across six conditions or treatments (COPD, asthma, OSA, interstitial lung diseases [ILDs], pulmonary rehabilitation [PR], and non-invasive ventilation [NIV]) highlighting telemonitoring's current landscape, evidence base, and clinical experience (see Figure 1). The contributions reflect telemonitoring's maturation in respiratory medicine and the hurdles to equitable, effective deployment. By integrating telemonitoring with AI-driven analytics, interoperable digital systems, and patient-centered care models, it seems respiratory medicine is moving decisively from a reactive, hospital-based framework toward a proactive, connected, and personalized approach.

This manuscript is an invited and narrative review coordinated by the Editorial Committee of *Archivos de Bronconeumología*, with contributions from international experts in telemonitoring across respiratory medicine. Its aim was not to perform a systematic literature review, but to provide an expert-based overview of current evidence, clinical experience, and future challenges in a rapidly evolving field. Relevant literature was identified by each expert group based on domain-specific expertise, prioritising influential trials, real-world implementation studies, and recent clinically relevant publications. Given the heterogeneity of telemonitoring interventions and healthcare contexts, a formal systematic review methodology was not considered appropriate. The authors acknowledge the inherent limitations of this approach, which was nonetheless deemed suitable for the objectives of this invited review.

Chronic pulmonary obstructive disease

At present, TM of COPD patients is widely used and has proven its positive effects in improving medical care and disease management by reducing the frequency of COPD exacerbations and unscheduled visits, increasing physical activity.[32] However, 25 years ago, there was not as much evidence present in favor of the benefits of TM. One of the first, from de Lusignan et al., in a pilot study, proved that continuous home cardiopulmonary monitoring presented satisfactory accuracy and was well accepted by COPD patients.[33] In that study, the authors used a recording of the respiratory rate together with blood pressure, heart rate and body temperature. That monitoring was compared to traditional onsite visits performed by a nurse. Another powerful impetus for new research and better implementation of TM was presented in 2006 by Paré et al., who highlighted financial advantages of the TM for COPD patients, with a net gain of 15% compared to traditional home care. Authors showed that patients who received a telehomecare program compared to those receiving traditional home care had fewer home visits by nurses and a reduced number of hospitalisations. Despite the lower technological development in the early 2000s, cost-minimization showed that with the advantages of wearables and Internet coverage, there would be more improvements in the cost-effectiveness.[34]

Recent research confirmed benefits of TM for COPD patients, demonstrating a significant reduction in COPD exacerbations, hospital admissions, along with an improvement in health-related quality of life (HRQoL). Sánchez et al. proved that daily follow-up of COPD patients using an e-health system and a specific mobile application, performed by pulmonologists, GPs and emergency care, leads to 44.3% reduced cases of COPD AE and 51.58% caused hospitalisations. Moreover, it was associated with improved life quality and reduced symptom burden (COPD Assessment Test).[35] With the greatest confidence, this effect was present among the most vulnerable group, COPD patients who recently experienced multiple hospital readmissions. Iriberri Pascual et al. implemented a telemonitoring program tailored for patients with COPD and high risk of acute exacerbations. The program consisted of symptoms and physical activity assessment together with remote measurements (SaO2, RR, HR, temperature, and physical activity). Researchers found that such intervention reduced the number of admissions in such a vulnerable group by 2.5 times during the first year, and the results sustained even during the second year after intervention. The same positive effect was found in reducing the number of hospitalised days.[36] However, at the same time, some studies have found no effect of TM on hospitalizations for COPD exacerbations or HRQoL. Hyldgaard et al. found no difference in outcomes regardless of implementation of telemonitoring (SaO2, GR, symptoms assessment, etc.) and video consultations into the routine care of COPD patients in Denmark.[37]

An important factor which could influence the effectiveness of TM is its design and components. To enable early prediction of COPD exacerbations, it is necessary to consider various factors that may cause exacerbation, including external factors (pollution, ambience temperature, circulating viruses) and patient-derived information (identification of patients with high risk of exacerbation). Such information can be collected via M-health solutions, wearables, or remote monitoring platforms.[38] Wearables are the most useful tool for automatically evaluating the level of physical activity and vital signs (heart rate, breathing frequency and pattern, cough rate, pulse oximetry, sleep patterns).

It is important not only to collect various data from the patients, but also to effectively and precisely analyze it. The quality of such analysis is based on the level of training of the staff involved in this process. Digital technologies, especially machine learning techniques and AI, can perform a revolution in TM. These technologies can change the way data from patients are analyzed, considering their potential for uncovering relationships and patterns that are not visible to the human eye.[39] Moraza et al. developed a machine learning model that learned to predict the deterioration of symptoms in COPD patients, anticipating exacerbations and revealed that such parameters as SaO2, HR and RR were the most useful parameters in predicting exacerbations.[40] Another study showed that ML algorithms can be tailored to a patient's profile and can learn from their previous experience. ML algorithm developed by Orchard et al. achieved an 40% sensitivity and approximately 60% specificity, which was superior to the best symptom-counting algorithm.[41] However, in another research, implementing a COPD prediction algorithm in addition to TM did not show statistically significant improvement in hospitalizations or QoL.[42] Despite such arguable results, implementing AI and ML predictive algorithms is considered a priority for the future development of TM for COPD, considering its potential. It is also important to present this data in an understandable form for clinicians. Sander et al. presented in their study that clinicians clearly highlighted their needs in a clear visualisation of changes in patients' data and exacerbation notifications together with possible reasons for exacerbation.[43]

Barriers to TM for COPD patients must also be considered, as these patients are usually from the elderly age group and may have poor digital literacy, experience impersonal care delivery, or have concerns regarding data privacy.[44] Considering that some interventions show promising results in narrow clinical trials but are unsuitable for broader implementation in routine clinical care, another challenge that should be addressed is the endorsement of effective implementation strategies for new digital tools. Effective implementation in each clinical context depends on various factors, including stakeholder perspectives, level of digital health literacy, clinician perspective, and regulatory, policy, and socio-economic contexts.[45]

Asthma

As for other diseases, telemonitoring in asthma can be used for diagnosis (e.g., through serial measurements of symptoms and lung function to document variability and its determinants), follow-up and treatment adaptation and provision (e.g., in the field of pulmonary rehabilitation or adherence reinforcement and education).[46] The rationale for using digital technologies in asthma to remotely monitor patients' symptoms, physiology and treatment is reinforced by the fluctuating character of symptoms and airway obstruction, the demonstration of insufficient disease control in treated patients, the known challenges related to treatment use (high rates of poor inhalation technique and/or poor adherence) and the subsequent need to facilitate self-management and timely therapeutic adjustments. Traditional models of care centered on clinic visits may fail to capture early deterioration or inadequate behaviors, while telemonitoring offers the potential for continuous or regular assessment, patient's empowerment and improved patient-clinician communication.[46] Telemonitoring can be of value as a tool to feed predictive analytics to identify patients at risk of poor outcomes, and to provide data to be integrated in multimodal datasets informing precision medicine strategies.

Monitored variables can be collected by electronic diaries or mobile applications, wearables and sensors (measuring, e.g., vital signs and physical activity, or connected to inhalers) and connected mobile devices measuring lung function (peak expiratory flow rate, spirometry, oscillometry),[20,47] fractional exhaled nitric oxide or other biomarkers and levels of exposures. Some of these tools are readily available with varying degrees of testing and validation, while others are still in development. One can predict that possibilities will continue to expand rapidly with advances in digital technology and AI. One crucial key to success is to elaborate beyond the technological potential build effective and cost-effective organizations to optimize healthcare delivery using telemonitoring, e.g. through efficient telehealth integrated platforms.

Surprisingly, the evidence on telemonitoring in asthma remains rather limited altogether,[46] with only 24 clinical studies on telemonitoring or remote monitoring in asthma identified in the PubMed database as of August 2025, including 16 with a randomized design. As outlined in recent systematic reviews, the quality and characteristics (design, sample size, follow-up duration, training of patients and professionals or outcomes of interest) of studies in this area varied markedly as well as the goals pursued, population's characteristics, setting, telemonitoring technology, feedback method and accompanying interventions.[48-50] Their results are also highly heterogeneous. Many but not all non-randomized studies found beneficial effects, but of limited value given their design. In children, some randomized studies demonstrated improvements in terms of symptoms, lung function, quality of life and adherence,[50,51] while others did not.[52] In adults, a short-term (14-day) randomized study found that patient self-monitoring via a digital platform plus remote clinician feedback maintained high baseline ICS adherence and decreased SABA use.[53] However, long-term benefits in terms of adherence are not homogeneous.[54] Similarly, while some randomized studies of longer duration showed improvements in asthma control,[55,56] other well-conducted studies did not demonstrate any clinical nor economic benefit.[57] The heterogeneity of results likely relates to the variability of interventions and study designs highlighted above. Importantly, telemonitoring tools can prove very useful for research and thus potentially indirectly beneficial for patients. One example is MASK-air, a widely available mHealth app (30 countries, >30,000 users) designed to collect daily symptoms using visual-analogic scales, questionnaire data and treatment use in asthma and allergic rhinitis. This app has allowed the development of two digital biomarkers of asthma control and the assessment of patient's behaviours. Collected data have also been used to identify patients' phenotypes and trajectories, assess the impact of rhinitis and asthma and explore the real-world effectiveness of some treatments, informing the Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines.[58] Whether the use of this app directly contributes to improving asthma control remains to be demonstrated formally.

As for any medical intervention, an essential consideration is financial sustainability. Few studies have focused on this aspect, which may be largely driven by how technology is integrated into care pathways and what the burden of related telehealth platforms is, rather than by the cost of the technology itself. In that respect, the identification of economically viable reimbursement models is a key knowledge gap and research priority, as recently outlined by Chan et al.[59] Of note, in a study published in the early 2010's, mobile technology-based self-monitoring relying on regular recording and transmission of asthma symptoms was not shown to be cost-effective.[57] Limited cost-effectiveness was also found in a prior study of nurse-led peak expiratory flow-based intervention in asthmatics.[60] However, none of these studies are recent, highlighting the need for further research.

To conclude, despite the strong clinical rationale for telemonitoring in asthma, available studies remain heterogeneous in terms of interventions, populations, and outcomes, which has limited the generation of consistent, high-quality evidence.[50,61] Many interventions combine multiple components, such as symptom diaries, peak flow monitoring, inhaler sensors, and educational tools, making it difficult to disentangle the specific contribution of telemonitoring itself.[1,62] In addition, asthma's variable disease course, strong dependence on self-management, and generally lower baseline risk of acute events compared with other chronic respiratory conditions may reduce the observable impact of continuous remote monitoring.[63] Importantly, the frequent need for additional devices or mobile applications to capture clinically meaningful data may increase complexity and limit long-term adherence.[64] Future telemonitoring strategies in asthma may therefore benefit from more targeted, low-burden approaches focused on high-risk subgroups, integration with existing digital inhaler platforms, and clearly defined clinical response pathways.

Obstructive sleep apnea

Telemedicine can be used widely in OSA care, from telediagnosis to OSA treatment follow-up.[65] The main field that has been developed is the use of telemonitoring in the context of continuous positive airway pressure (CPAP) treatment follow-up, as it is very simple to use and does not require any intervention from the patient to transmit device-collected data. Treating physicians, nurses, and home care providers (HCPs) can work together to support the patient with the purpose of obtaining early, adequate compliance and treatment effectiveness. CPAP tracking systems are built with connectivity to allow remote access by way of Global System for Mobile Communication or General Packing Radio System, providing information about daily use, patterns of use, respiratory events (e.g., apnea, hypopnea), type of residual respiratory events (e.g., central, obstructive), mask leaks, CPAP pressure, and sleep schedules. These data are available via a centrally secured data center (cloud) for healthcare professionals and HCPs or, for some devices, via an application, accessed directly by the patient, to stimulate self-management. Somnologists can access algorithms to manage residual apnea-hypopnea index.[66,67] Particular attention should be given to patients with residual central events: detection of incident Cheynes-Stokes respiration is associated with heart failure and cardiac arrhythmias.[68]

When compared with traditional face-to-face OSA management, telemonitoring results in modest compliance improvements, 29 min per night (95% CI: 11.8–46.7).[69] However, the main focus should be on difficult patients and those who have just started CPAP treatment, for example by quickly identifying patients at risk of poor compliance. Generally, patients report good acceptance of and satisfaction with telemonitoring.[70] Nursing time savings associated with telemonitoring remain controversial,[70,71] but telemonitoring is likely to be cost-effective, mainly through avoidance of travel costs and loss of workdays.[72]

Moreover, during the pandemic, TMg enabled a fully remote diagnostic and treatment pathway for patients with OSA, helping to mitigate delays. In a pilot study conducted during the first wave of the pandemic, 300 patients underwent remote diagnosis using home polygraphy and home-based self-education for automatic PAP (APAP) treatment, with telephone support. The authors concluded that this approach was feasible, with 3- and 24-month adherence rates of 41%[73] and 38%[74], respectively. While this success rate was similar to that reported in some literature, reduced adherence could be due to contextual factors such as anxiety or fear of viral transmission. However, it could also be related to a lack of personalised CPAP treatment: all patients had the same APAP settings and used a naso-buccal mask.

Telemonitoring is easy to use and there can be a temptation to transfer CPAP follow-up to less qualified healthcare workers (e.g., non-somnologists, general practitioners, HCPs). Indeed, beyond CPAP-collected data, physicians must ensure that PROMs, such as improvement of sleep-related complaints and comorbidities, are addressed before being confident that close management of the patient is no longer mandatory.[75]

Telemonitoring exhibits some technological limitations of which physicians should be aware. These include the fact that the accuracy of CPAP-measured data is heterogeneous among the different devices, for both leaks and residual respiratory events. For example, it is rarely possible to exclude residual apnea-hypopnea index measurement during periods of significant leakage, despite its inaccuracy.[76] Monitoring schemes (e.g., daily, weekly; pro-active or passive use) and duration of telemonitoring (few weeks to 12 months) also remain a matter of debate. It seems obvious to monitor newly CPAP-treated patients, as early compliance is associated with long-term compliance,[77] and efforts should be made at the start of therapy to support and educate patients, and to resolve side effects related to CPAP use. Moreover, most treatment adaptations (e.g., mask changes, pressure adjustments) appear in the first few months of treatment. Over the first 3 months, 43% of patients need a mask change and 35% need humidification adjustment.[78] However, patients experiencing difficulties later during treatment can also benefit from telemonitoring, such as in cases where long-term users become non-compliant, or experience unexpected high residual respiratory events. No data are yet available in this population. Finally, using telemonitoring can put the clinician into the uncomfortable situation of being highly dependent on the device manufacturer and software platform provider for access to patient data.[75] Depersonalization can be another concern.

To conclude, telemonitoring for CPAP-treated patients is feasible, acceptable, and cost-effective. It can even completely replace the face-to-face treatment pathway, when necessary, as was demonstrated during the pandemic. It helps to focus on difficult-to-treat patients, especially during the start-of-treatment period, and slightly increases CPAP compliance. However, physicians should be aware of the limits of CPAP data collection reliability. The effect of telemonitoring on CPAP compliance in different patient groups (e.g., age, sex, ethnicity, comorbidities) as well as different OSA phenotypes and different educational/socioeconomic statuses should be further studied.[70]

Table 1 summarizes ongoing and recent studies on telemonitoring in COPD and OSA. At the time of manuscript preparation, no ongoing interventional telemonitoring trials were identified for asthma in international clinical trial registries.

Interstitial lung diseases

Interstitial lung diseases comprise a heterogeneous group of rare disorders with variable clinical trajectories, a subset of which develop progressive pulmonary fibrosis associated with high morbidity and mortality. To date, most telemonitoring studies in ILDs have focused on idiopathic pulmonary fibrosis (IPF), which predominantly affects older adults and is often managed in specialised referral centres.[79] Patients with IPF frequently experience dyspnoea, cough, fatigue, and impaired exercise tolerance, and many must travel long distances for outpatient follow-up. In this context, telemonitoring has been proposed as a strategy to reduce the burden of hospital visits while maintaining close clinical surveillance.[80]

Telemonitoring approaches evaluated in ILDs include home spirometry, pulse oximetry, mobile applications incorporating electronic patient-reported outcome measures (PROMs), and wearable activity trackers.[80] Among these, home spirometry has been the most extensively studied. Multiple investigations have demonstrated its feasibility and reliability, showing good correlation between home- and hospital-based forced vital capacity (FVC) measurements, relatively low within-patient variability, and acceptable long-term adherence, even in elderly populations.[81-90] These findings suggest that home spirometry may enable earlier detection of disease progression or acute exacerbations and provide more granular longitudinal data than conventional clinic-based assessments, with potential implications for both clinical care and clinical trial design.[82,91]

Nevertheless, experience from large multinational studies has highlighted several challenges. Technical issues, such as connectivity problems and device malfunction, as well as analytical challenges related to variability in measurements, have occasionally limited the interpretability of outcomes.[92-94] Proposed mitigation strategies include structured patient training, access to technical support in native languages, automated reminders to enhance adherence, and real-time alerts to healthcare providers when clinically relevant deterioration is detected.[80,92] These organisational components appear to be at least as important as the technology itself for successful implementation.

Beyond lung function monitoring, additional telemonitoring modalities have been explored in ILDs. Wearable devices and passive monitoring tools generally show higher adherence than active measurements such as spirometry or PROM completion.[95] Online PROMs have been shown to be feasible and reproducible over time in this elderly population and are increasingly used in both clinical trials and routine practice.[96,97] In particular, short and simple visual analogue scales may represent a pragmatic approach for structured longitudinal assessment of symptom burden, although their optimal role in guiding clinical decision-making remains to be established.[98]

The COVID-19 pandemic markedly accelerated the adoption of telemonitoring in ILDs, primarily to ensure continuity of care for this vulnerable group.[99-101] Real-world cohorts evaluated during this period confirmed the feasibility and reliability of remote monitoring and demonstrated high levels of patient satisfaction, with telemonitoring partially replacing in-person visits in selected patients.[101,102] While most patients reported positive experiences and perceived improved communication with care teams, a minority described increased anxiety related to frequent self-measurement, underscoring the importance of individualised implementation and adequate patient support.[103]

Despite encouraging feasibility data, the widespread integration of telemonitoring into routine ILD care remains limited. Key barriers include the absence of robust evidence demonstrating long-term clinical benefit, uncertainties regarding cost-effectiveness, and concerns about organisational impact and clinician workload.[104,105] Importantly, although evidence beyond IPF is still scarce, several ongoing studies now include patients with non-IPF fibrotic ILDs as well, aiming to clarify the value of telemonitoring across the broader ILD spectrum and to inform sustainable implementation strategies.[106-109] Table 2 summarises these studies.

Overall, while telemonitoring in ILDs has consistently demonstrated feasibility, patient acceptability, and reliable remote data capture, particularly in IPF, its translation into routine clinical care remains constrained by limited evidence of long-term clinical benefit, cost-effectiveness, and scalability, underscoring the need for pragmatic implementation studies.

Non-invasive ventilation

Of all patients with CRDs, those on long-term NIV can be considered as preferential candidates for telemonitoring solutions because the treatment is itself based on technology with detailed recording (most devices have built-in or connected data transmission capacity) and easy interconnectivity/data incorporation with other devices (such as oxi-capnography). Also, the large prevalence of OSA makes this condition a great drive for research and innovation, and therefore patients on NIV may benefit from technological advances and indirect evidence from OSA trials. Most importantly, conditions leading to long-term NIV are chronic and often progressive diseases that require close monitoring and treatment titration, with individuals that can be severely frail and with impaired care access due to transportation difficulties, and potential treatment dependence.

Telemonitoring facilitates compliance monitoring and can potentiate prompt intervention to address problems and side-effects, which is crucial for improving clinical, physiological and patient reported outcomes.[110,111] Nevertheless, robust evidence on the improved value of telemonitoring in NIV is still scarce.[112]

Trials in the initiation of NIV aided by telemedicine have shown to be non-inferior to inpatient initiation in patients with COPD and restrictive or neuromuscular disorders in terms of safety, efficacy, HRQoL with significant cost reductions.[112-114] Recently published ERS guidelines have made conditional recommendations for telemonitoring in the adaptation to NIV in these patient populations, taken into consideration positive patient preferences and expectations such as fewer hospital visits, lower infection risks, less travelling, better remote communication with their physician, self-monitoring, and real time adjustments of ventilator settings.[112,115] However due to lack of evidence, no recommendation could be made in patients with obesity-hypoventilation syndrome.

Regarding follow-up, evidence is heterogeneous as doubts remain regarding effectiveness, feasibility and generalizability in the long-term. The meta-analysis performed for the ERS guideline showed that both interventions were equally effective for the outcomes analyzed, and there were no telemedicine-related harmful or adverse events, and thus a definite for or against recommendation could not be made.[112] The recent *eVent* trial compared a telemonitoring strategy including automated alerts with usual care. They found similar nighttime transcutaneous capnography measurements but lower daytime partial pressure of carbon dioxide and greater percentage of 'successful NIV', which was defined as NIV with low leaks (<24L/m), good adherence (≥4 hours/day) and low AHI (<10) in the telemonitoring arm.[116] However, sample size was quite small (27 patients in telemonitoring arm) and 7,7 alerts per patient at 6 months were reported, and one can consider the costs and burden of addressing all the alerts in a large real-life program.

Further research is needed to ascertain whether telemonitoring ultimately reduces or increases healthcare utilization, such as consultations, home visits, material consumption and dedicated healthcare workers' time. Also, the challenge remains to determine if follow-up with telemonitoring translates into meaningful clinical benefits for patients such as reduced exacerbations, hospitalizations, improved HRQoL or increased survival and if this strategy is cost effective.[112,117]

One research topic is the potencial of NIV telemonitoring to predict (and potentially prevent) exacerbations in patients with COPD. In 2015, a proof-of-concept study showed that daily variations in respiratory rate and % of triggered breaths were predictors of an exacerbation.[118] Later, a prospective study showed that a respiratory rate (for 2 consecutive days) outside the interquartile limit of the respiratory rate calculated over the 4 preceding days was associated with an increased risk of severe AECOPD of 2.8 and a standard deviation of the daily use of NIV >1.0845 over a 10 days' period was associated with an increased risk of severe AECOPD of 4.[119] Recently, a retrospective study proposed the following biomarkers for AECOPD detection: 7-day mean respiratory rate, abnormal values of daily usage, leaks, and tidal volume.[120] However, real-life studies and with large samples are needed to confirm feasibility, including resource allocation and models for automatic detection and alert delivery to healthcare teams, and impact on patient outcomes and/or healthcare utilization or cost reduction.

Implementation challenges include reliable internet connectivity, technological literacy, costs, resource limitation and fragmented healthcare systems. In earlier studies, patients and caregivers were concerned that they might become overly dependent on the telemedicine system and there was a decrease in self-efficacy in one trial.[117,121] Recent studies have shown that patients describe telemonitoring as a positive experience, and the approach is empowering and effective in promoting patients' well-being.[122]

Research should focus on assessing the optimal monitored parameters needed to obtain meaningful outcomes for patients and healthcare systems (included comparing to outpatient setting), the potential added value of mixed models of monitoring, cost-effectiveness of different strategies and the role of advanced algorithms.[116,122] Table 2 summarizes current evidence and potential research opportunities for future trials in this field.

Pulmonary rehabilitation

Pulmonary rehabilitation is a comprehensive, multidisciplinary, individually-tailored intervention designed to overcome the deconditioning induced by CRDs.[123] Core components include a tailored and graded exercise programme incorporating both endurance training and muscle strengthening in the context of holistic care (including management of common co-morbidities such as anxiety/depression,[124] and nicotine dependence) as well a programme of education supporting disease-specific self-management, lifestyle change and social care.[123] Typical programmes are delivered in regular supervised sessions a week over two to three months.[125]

Evidence of improved exercise capacity and HRQoL is particularly strong for COPD,[126,127] but is emerging for the role of PR in bronchiectasis,[128] ILDs,[129] pulmonary hypertension,[130] and asthma.[131] The challenges are two-fold: improving provision of PR for all people with CRD who could benefit (including those who live in low resource or remote settings), and enhancing uptake and completion of the course of PR. Telerehabilitation, being the supervision of the structured exercise programme and delivery of education by means of remote communication, potentially has a key role in addressing both these barriers to implementation. A Cochrane review in 2021 concluded that telerehabilitation for people with CRDs achieves outcomes similar to those of traditional centre-PR, with no safety concerns.[132] Figure 2 is a Forest plot comparing the effect of telerehabilitation to centre-PR on exercise capacity.

Diverse models of telerehabilitation are described. Most commonly telerehabilitation is delivered directly from a central PR unit to individuals at home via teleconferencing or audio calls,[132] but a ‘hub-and-spoke’ approach has the advantage of enabling professional oversight and group support, whilst reducing travel and not expecting patients to manage unfamiliar technology.[133] Web-based programmes or mobile 'apps' with asynchronous supervision enable flexible access to information and the exercise programme.[134]

Telerehabilitation has the potential to overcome barriers to attending a PR centre, but systematic review evidence of whether this improves completion rates varies. Cox *et al*. showed that telerehabilitation increased the proportion of people who completed a PR programme from 70% in centre-based PR to 93% (95% CI 80 to 96) in remotely-delivered PR.[132] In contrast, in a comparison of Home-PR and Centre-PR, Uzzaman et al. found no evidence that mode of delivery affected completion rates.[133] Current challenges, limitations, and potential avenues for future research in telerehabilitation relate to its acceptability, implementation, health economics, and maintenance of benefits. Most studies describe telerehabilitation as an acceptable alternative to traditional centre-based PR, and it is even preferred by some patients. However, diverse contexts influence the success or failure of implementation,[135] and programmes require adaptation to organisational routines, workforce upskilling, and support for patients in using the technology. Raising awareness among communities, healthcare professionals, service managers, and policymakers is an important strategy to facilitate implementation. Factors considered most favourable for adoption include enhancing patients' motivation and involving high-level leaders,[136] whereas barriers include technical difficulties and a lack of technical skills among stakeholders.[137] Specific challenges relate to avoiding the exacerbation of digital inequities[138] and adapting services to low-resource settings.[139] Health economic evaluations are essential for payors considering the introduction of such services, who need to understand setup costs (though equipment requirements can be minimal)[140] as well as staff workload implications. Although evidence within CRDs is still limited, telerehabilitation has been shown to be cost-effective in other clinical contexts.[141] Maintaining the benefits of PR is another recognised challenge, and several studies have explored the potential of telerehabilitation to provide ongoing motivation and support.[142] In a three-arm study, maintenance rehabilitation delivered via a web-based platform was as effective as continued attendance at a rehabilitation centre in preserving exercise capacity, maintaining quality of life, and reducing hospitalisation risk,[143] suggesting this light-touch home-based approach is efficient and sustainable.

To summarize, PR is an effective intervention that improves health outcomes,[123] but is inaccessible to 98% of the global population with CRDs.[144] Whilst there is still a need for evidence on implementation, telerehabilitation is an approach that could support wider provision.

Cross-cutting challenges and shared implementation considerations

Across respiratory diseases, several common themes emerge when telemonitoring is translated from research settings into routine clinical care. Patient engagement consistently appears as a key determinant of success, influenced by digital literacy, perceived usefulness, and the burden of self-measurement rather than by the underlying disease alone.[145] Across conditions, passive monitoring strategies generally achieve higher adherence than active data entry, while overly intensive monitoring may increase anxiety or disengagement in selected patients, underscoring the need for individualized approaches.[103] Technology acceptance and usability represent another shared challenge. Telemonitoring systems that are intuitive, minimally intrusive, and seamlessly integrated into patients' daily routines are more likely to be sustained over time.[146] In contrast, technical complexity, connectivity problems, and insufficient user support remain recurrent barriers, particularly among older or vulnerable populations, raising concerns about the potential exacerbation of digital health inequities.[147]

From a healthcare system perspective, clinician workload and organisational impact are critical considerations across all disease domains. Although telemonitoring may reduce face-to-face encounters, it can simultaneously generate new demands related to data review, alert management, and patient communication.[148,149] Without clearly defined workflows, task delegation, and decision-support tools, telemonitoring risks shifting rather than reducing workload. Interoperability and data governance challenges also cut across respiratory conditions. Fragmented digital ecosystems and limited integration with electronic health records hinder scalability and continuity of care, while concerns regarding data security, privacy, and regulatory compliance remain central to both patient and clinician acceptance.[150,151]

Finally, uncertainty surrounding cost-effectiveness and reimbursement remains a major barrier to large-scale implementation. Across diseases, economic outcomes appear to depend less on the technology itself than on how telemonitoring is embedded within care pathways and funded within specific healthcare systems, highlighting the need for pragmatic implementation studies that jointly assess clinical, organisational, and economic outcomes.

Conclusions

Digital transformation is a strategic priority of the European Respiratory Society (ERS),[152] reflecting the key role of telemonitoring within contemporary respiratory care, enabling continuous, data-driven, and patient-centered management across a range of chronic respiratory diseases. Although its feasibility and clinical potential have been reasonably demonstrated, its long-term role, cost-effectiveness, and large-scale implementation remain to be fully elucidated and are the focus of the ERS Clinical Research Collaboration CONNECT.[45] Future research should prioritize the integration of telemonitoring with AI, the interoperability of digital systems, and equitable access strategies, to facilitate its transition from a technological innovation to a core element of personalized respiratory medicine.

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Ética de la publicación

1. ¿Su trabajo ha comportado experimentación en animales?:

No

2. ¿En su trabajo intervienen pacientes o sujetos humanos?:

No

3. ¿Su trabajo incluye un ensayo clínico?:

No

4. ¿Todos los datos mostrados en las figuras y tablas incluidas en el manuscrito se recogen en el apartado de resultados y las conclusiones?:

Sí

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Table 1. Ongoing and recent studies on telemonitoring in chronic obstructive pulmonary disease and obstructive sleep apnea.

Study (Identifier)	Study design	Population	Telemonitoring intervention	Main aims	Key endpoints	Expected completion
NCT06331416	Prospective interventional study	Patients with COPD	Home telemonitoring combining symptom reporting and physiological monitoring, integrated into clinical follow-up	To evaluate feasibility and clinical impact of a telemonitoring-supported care model in COPD	COPD exacerbations; healthcare utilisation; patient-reported outcomes; adherence to monitoring	2026-09
NCT07027852	Prospective interventional study	Patients with COPD	Digital health intervention incorporating remote monitoring and clinician-supported telefollow-up	To assess the effectiveness of telemonitoring-supported management compared with standard care	Exacerbation frequency; hospital admissions or unscheduled healthcare contacts; health-related quality of life	2026-06
NCT03043716	Randomized controlled trial	Patients with obstructive sleep apnea treated with CPAP	Telemonitoring-supported CPAP management using remote transmission of device-generated data and clinician feedback	To evaluate whether telemonitoring improves CPAP adherence and treatment management	CPAP adherence and usage patterns; treatment effectiveness; patient-reported outcomes	2025-12
NCT04759456	Prospective interventional study	Patients with obstructive sleep apnea initiating CPAP therapy	Fully remote CPAP setup combined with telemonitoring-based follow-up	To assess feasibility, safety, and patient acceptance of complete remote CPAP initiation	Feasibility of remote setup; CPAP adherence; early treatment effectiveness; patient satisfaction	2026-07

Expected completion dates are reported according to information available in international clinical trial registries at the time of manuscript preparation. Trials listed without associated publications are cited by registry identifier only. COPD: chronic obstructive pulmonary disease; OSA: obstructive sleep apnea; CPAP: continuous positive airway pressure.

Table 2. Ongoing and recent studies on telemonitoring in interstitial lung diseases

Study (Identifier)	Study design	Population	Telemonitoring intervention	Main aims	Key endpoints	Expected completion
NCT04304898 (I-FILE) (109)	Multinational prospective observational registry	Patients with pulmonary fibrosis (IPF and non-IPF fibrotic ILDs)	Patient-led home monitoring including online data capture, home spirometry, and PROMs	To evaluate feasibility of a multinational home-monitoring registry and characterise long-term disease trajectories	Changes in FVC; adherence to home-based measurements; PROMs on health status and symptoms; correlation between home and hospital spirometry	2026-07
NCT06883448 (SUITS)	Multicentre randomized controlled trial	Patients with pulmonary fibrosis	Partial replacement of hospital visits with home monitoring and video consultations	To evaluate the impact of home monitoring on patient self-management and healthcare outcomes	Patient activation; healthcare utilisation; PROMs; lung function parameters; cost-effectiveness	2026-09
NCT06732674 (RMD-mILDer)	Multinational randomized controlled trial	Patients with rheumatic disease–associated ILD	Home monitoring of FVC and PROMs compared with usual care	To assess the value of home monitoring in detecting disease progression	Time to disease progression; lung function decline; PROMs on health status and symptoms	2028-02
NCT05662124 (REMOTE-ILD) (107)	Multicentre prospective interventional study	Patients with fibrotic ILD	Remote monitoring using home spirometry and pulse oximetry	To evaluate safety, feasibility, and effectiveness of home monitoring in routine care	Detection of disease progression or acute exacerbations; healthcare use; adherence and acceptability	2025-04
DRKS00028968 (eurILDreg ASA-ILD) (108)	Multicentre prospective observational study (Germany)	Patients with ILD	Digital home monitoring incorporating lung function measures and patient-reported outcomes	To assess feasibility and clinical utility of telemonitoring in ILD care	Adherence; correlation with hospital-based assessments; PROMs; healthcare utilisation	2028-02
IRRID: DERR1-10.2196/65339 (106)	Prospective observational study (protocol / registered report)	Patients with interstitial lung diseases	Home monitoring program incorporating digital data capture, lung function measurements, and patient-reported outcomes	To evaluate the safety, feasibility, acceptability, and clinical utility of home monitoring in routine ILD care	Detection of disease progression or acute exacerbations; healthcare utilisation; adherence and patient acceptability	2025-12

Expected completion dates are reported according to information available in clinical trial registries at the time of manuscript preparation. Trials listed without associated publications are cited by registry identifier only. RRID: International Registered Report Identifier. ILD: interstitial lung disease; IPF: idiopathic pulmonary fibrosis; FVC: forced vital capacity; PROMs: patient-reported outcome measures

Table 3. Current evidence and future research opportunities for telemonitoring in non-invasive ventilation

	What do we know?	What do we need to know?
Initiation of NIV with telemonitoring	- Non-inferior to inpatient in COPD and restrictive/neuromuscular diseases with cost reductions	- Data on remaining populations such as OHS - Comparison with outpatient adaptation - Comparison with using automatic modes without titration period - Cost-effectiveness - Caregiver burden
Follow up of NIV with telemonitoring	- Equally effective comparing to standard of care - Potential to detect early exacerbations	- Added value of telemonitoring in meaningful clinical benefits for patients such as reduced exacerbations, hospitalizations, improved quality of life or increased survival - Impact on healthcare utilization - Optimal parameters and timing to monitor - Added value of mixed models (telemonitoring + in-person) - Impact of advanced data processing algorithms - Cost-effectiveness - Generalizability in the long term - Caregiver burden

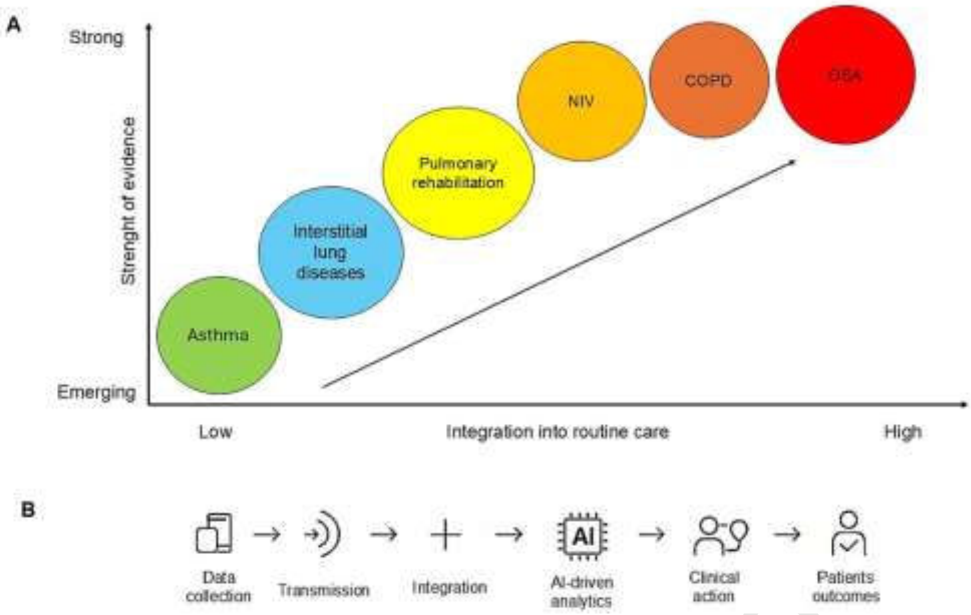

Figure 1. Telemonitoring across respiratory diseases: evidence maturity and integration into routine care. Panel A presents the conceptual overview showing the relative strength of evidence (Y-axis) and degree of integration into clinical practice (X-axis) for telemonitoring across respiratory diseases. Axes represent a qualitative, expert-based assessment of evidence strength and degree of integration into routine clinical practice, and are intended as a conceptual rather than quantitative representation. Panel B summarizes the telemonitoring pathway from data collection to patient outcomes, emphasizing the growing role of AI-driven analytics.

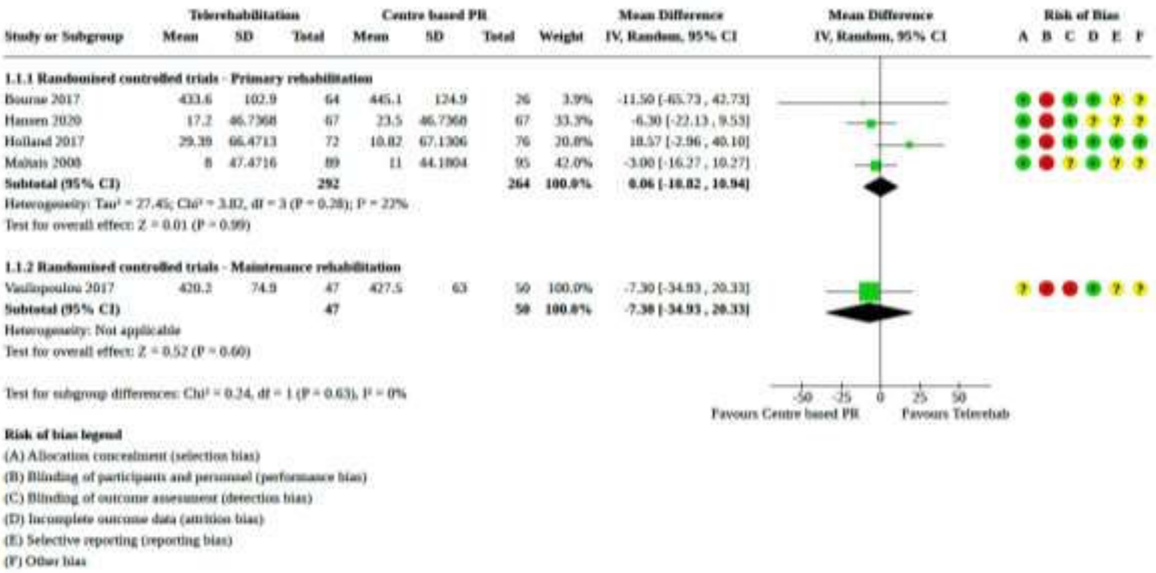

Figure 2. Comparison of telerehabilitation vs centre-based pulmonary rehabilitation on exercise capacity (6-minute walk test) at the end of the intervention. (Reproduced with permission from Cox et al.(132))