# Telemedicine Applications in Sleep Disordered Breathing
## Thinking Out of the Box

Johan Verbraecken, MD, PhD

**KEYWORDS**

• Telemedicine • Sleep disordered breathing • Technology • Monitoring

**KEY POINTS**

- Telemedicine encompasses the use of information and communication technology (telephone, video, Internet, satellite, cloud) to deliver health care at a distance.
- Diagnostic telemedicine applications include telemonitored polysomnography, long-term polygraphic monitoring, and remote continuous positive airway pressure (CPAP) titration.
- Telemedicine allows clinicians to remotely monitor CPAP adherence and compliance and fine-tune CPAP settings.
- Patient counseling, as well as therapy reinforcement by combining and integrating psychoeducational interventions and telemonitoring, is feasible.
- Barriers like patient's and physician's cooperation, privacy concerns, financial barriers, technological barriers, and quality concerns have to be overcome.

## INTRODUCTION

The popularity of technology is increasing in nearly every field, and sleep medicine is no exception. Telemedicine as a means of remote patient-physician interaction is growing and virtual consultations with sleep specialists are feasible.[1] The potential benefits of telemedicine include improved access to health care, reduced waiting time for appointments, and increased adherence to chronic illness treatment plans.[2] Because many sleep disorders, particularly sleep apnea, are chronic conditions, and require a continuous treatment and monitoring of therapy success, telematic communications and new information technologies could be useful to establish diagnostic and therapeutic strategies. It is important to install cost-efficient technologies for an initial simple diagnosis, rapid treatment initiation, and for long-term monitoring of treatment adherence and compliance, providing the possibility for patients to avoid traveling.[3] A substantial proportion of patients are willing to consider telemedicine as an option for their care. In such settings, in case of insufficient adherence or compliance, device dysfunction, or subjective problems, alerts can be generated and sent to the health professional, who can react rapidly and focus on the patient's needs.

In this article, telemedicine solutions in sleep disordered breathing are reviewed, with emphasis on adherence and compliance monitoring:

- Diagnostic telemedicine applications: telemonitored polysomnography, long-term polygraphic monitoring.
- Remote continuous positive airway pressure (CPAP) titration.

Department of Pulmonary Medicine, Multidisciplinary Sleep Disorders Centre, Antwerp University Hospital, University of Antwerp, Wilrijkstraat 10, Edegem, Antwerp 2650, Belgium
*E-mail address:* johan.verbraecken@uza.be

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- Monitoring of CPAP adherence and compliance:
  - Standard care
  - Remote monitoring and fine-tuning therapy
- Patient counseling and therapy reinforcement by combining and integrating the most promising elements of both psychoeducational interventions and technological innovations.
- Barriers in the implementation of telemedicine are also highlighted.

## DIAGNOSTIC TELEMEDICINE APPLICATIONS

### *Telemonitored Polysomnography*

Telemonitored polysomnography (PSG) is designed to overcome the disadvantages of home recordings and could provide an organizational solution to the overloading of specialized sleep centers. Dedicated technicians regularly verify, at a distance, the quality of the PSG recordings by means of periodic access to the PSG monitoring device. From a telemonitoring control panel, they are able to insert comments in the recording; adjust transducer gain; and, in the event of an artifact or an undesirable accident, inform the patient by telephone.[4] However, evidence on the efficacy of telemonitored PSG is weak. Gagnadoux and colleagues[5] reported that PSG performed in a local hospital and telemonitored by a sleep laboratory was clearly superior to unattended home PSG. Kristo and colleagues[6] proposed a telemedicine protocol for the online transfer of PSG data from a remote site to a centralized sleep laboratory, which provided a cost-saving approach for the diagnosis of obstructive sleep apnea (OSA). Their system was based on the transmission of data using an Internet file transfer protocol (FTP), which is the conventional system for file transfer. Kayyali and colleagues[7] presented a new compact telemetry-based sleep monitor, consisting of a 14-channel wearable wireless monitor and a cell phone–based gateway to transfer data, including video, in real time from the patient's home to a remote sleep center. The monitor can easily be worn and transported, and it offers reliable recordings. The receiver is a separate unit connected with the back of the display. Internal Bluetooth receivers, usually included in laptops, can also be used instead of a dedicated external Bluetooth receiver. A major problem encountered with home sleep studies is the potential loss of data in about 4.7% to 20% of the cases, which results in lower than expected cost savings.[8] Using Sleepbox technology (Medatec, Brussels, Belgium), a wireless system able to communicate with the polysomnograph and with Internet through a WiFi/3G interface, and communicating via Skype, the investigators were able to deliver recordings with excellent quality in 90% of the cases.[9] This finding suggests an interesting way to decrease the failure rate of home sleep studies, although it is still problematic, and some technical aspects need to be improved. Pelletier-Fleury and colleagues[10] comparatively evaluated the cost and effectiveness of PSG telemonitoring and PSG by conventional unsupervised home monitoring, and showed that remote telemonitoring made the procedure clearly superior from a technical point of view and was preferred by the patients. The cost of PSG telemonitoring was US$244, whereas the cost of PSG with conventional unsupervised home monitoring was US$153. The health care infrastructure savings have to be taken into account as well. For example, by adding up the working days that the patients did not lose and the round-trip travel costs they avoided, it can be estimated that the real cost would be similar or lower than that of conventional PSG.[3] Masa and colleagues[11] compared the costs made between device transportation and telematic transmission of data, with comparable results. Having devices moved by a transportation company or sent telematically as raw data proved cost-effective and equally beneficial. This finding opens the possibility of application among patients who live a long way from the hospital or those with limited mobility. Fields and colleagues[12] showed the feasibility of a comprehensive, telemedicine-based OSA evaluation and management pathway compared with a more traditional, in-person care model. They combined video consultation for intake with home sleep testing using a type 3 portable monitor with remote download, and automatic CPAP (autoCPAP) titration with wireless modem technology. Patient satisfaction, CPAP adherence and compliance, and improvement in quality of life were similar in both groups.

### *Long-Term Polygraphic Monitoring*

In clinical practice, the use of PSG is a standard procedure to assess sleep disordered breathing. However, PSG is not suitable for chronic monitoring in the home environment. New telemedicine applications have become available using a home appliance as a precautionary measure for monitoring snoring and OSA. Seo and colleagues[13] developed a nonintrusive health-monitoring home system to monitor patients' electrocardiogram (ECG) results, weight, motor activity, and snoring. Choi and colleagues[14] proposed a ubiquitous health-monitoring system in a bedroom, which monitors the ECG, body movements, and