Title: Effectiveness of Sequential Automatic-Manual Home Respiratory Polygraphy Scoring

Running head: A Simplified Sleep Apnea Diagnosis

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ABSTRACT

Introduction: Automatic home respiratory polygraphy (HRP) scoring functions can potentially confirm the diagnosis of sleep apnea-hypopnea syndrome (SAHS) (obviating technician scoring) in a substantial number of patients. The result would have important management and cost implications.

Objectives: To determine the diagnostic cost-effectiveness of a sequential HRP scoring protocol (automatic and then manual for residual cases) as compared to manual HRP scoring, both with in-hospital polysomnography.

Methods: We included suspected SAHS patients in a multicentric study and assigned to home and hospital protocols at random. We constructed Receiver Operating Characteristic (ROC) curves for manual and automatic scorings. Diagnostic agreement for several cut-off points was explored and costs for two equally effective alternatives were calculated.

Results: Of 366 randomized patients, 348 completed the protocol. Manual scoring produced better ROC curves than automatic scoring. There was no sensitive automatic or subsequent manual HRP apnea-hypopnea index (AHI) cut-off point. The specific cut-off points for automatic and subsequent manual HRP scorings (AHI>25 and >20 respectively) had a specificity of 93% for automatic and 94% for manual scorings. The costs of manual protocol were 9% higher than sequential HRP protocol, but 69% and 64%, respectively, of the cost of the polysomnography.

Conclusion: A sequential HRP scoring protocol is a cost-effective alternative to polysomnography, although with limited cost savings compared to HRP manual scoring.
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INTRODUCTION

The prevalence of sleep apnea-hypopnea syndrome (SAHS) is about 2-5% in the adult population\(^1\). Several studies have shown associations with arterial hypertension\(^2,3\), cardiovascular mortality\(^4\) and traffic accidents\(^5,6\).

Demand for SAHS diagnostic studies has increased in recent years, but access to subsequent diagnostic testing has been limited\(^7,8\). Therefore, there has been increasing interest in alternative diagnostic processes\(^9\).

The gold standard for SAHS diagnosis is in-hospital polysomnography (PSG), but it is time-consuming and expensive. Manual scoring of home respiratory polygraphy (HRP) is an accepted\(^10\) and cost-effective\(^11-14\) alternative for SAHS diagnosis in selected patients. Respiratory polygraphy involves a Type 3 portable monitoring device\(^15\), which includes sensors for airflow, respiratory effort measured with bands, and pulse oximetry recordings.

Most HRP devices offer the option of performing automatic scoring. Several studies have assessed the agreement of automatic versus manual scoring\(^16\) or polysomnography\(^17-23\). The studies which assessed the agreement of automatic scoring with PSG found good apnea and hyoponea index (AHI) cut-off points to confirm SAHS diagnosis in a substantial number of patients, but not good ruling out cut-off points\(^17,20\).

Thus, one potential use of automatic scoring is to reduce the need for manual scoring, if automatic scoring is done first\(^18\). If SAHS is not confirmed, a manual HRP scoring should be done in the remaining cases. This sequential approach could save the cost of a scoring technician in an important number of HRP tests, improving the cost-effectiveness of HRP. However, previously published studies did not have large
samples or multicentric approaches, and in particular no overall cost-effectives studies have been carried out.

To shed light on this topic, as well as to obtain more accurate and definitive data to allow us to optimize HRP use, we performed a multicentric, randomized, blinded crossover study to determine, in a large sample, the following objectives: a) different aspects of the agreement of automatic HRP scoring in comparison with manual HRP scoring and both with PSG in the hospital setting; and b) the agreement and cost-effectiveness of a sequential HRP protocol (automatic and then manual scorings) as compared to both manual HRP scoring and PSG in the hospital setting.

Prior studies of diagnostic cost-effectiveness and the therapeutic efficacy of therapeutic decision-making between manual HRP and PSG in this cohort have been published^{11,24}.

METHODS

Subjects

We included patients between 18 and 70 years old, referred to pulmonary clinics at eight hospitals in Spain for suspected SAHS, due to snoring, observed apneas, sleepiness (Epworth sleepiness scale >10) or morning fatigue. Patients with other suspected sleep disorders were not included. We excluded patients with severe heart disease, who were unable to set up the HRP instrument in a trial or who refused to participate in the study. The ethics committees of the eight participating centers approved the study. All patients provided written informed consent.

Protocol
All patients underwent PSG and HRP in a random order (Figure 1-A). PSG and HRP scorings were done separately and the technicians and physicians were blinded to any identifying information about patients as well as any previous results. Once the first test was begun, the second test was scheduled for within the next three days.

**HRP**

Our HRP (Breas SC20; Breas Medical AB: Mölnlycke, Sweden) measurements included: oxygen saturation (model 8000 J; Nonin Medical; Plymouth, MN), airflow through a nasal cannula, and thoracic and abdominal movements measured by piezoelectric bands (Pro-Tech reference 1295; Respironics; Pittsburgh, PA), which also measured body position.

All patients were instructed on home use of the HRP device by a technician in the hospital setting before randomization. Trained personnel from CPAP service companies in each hospital area, acting as transport companies, moved the HRP instruments from home to home. No additional assistance was provided by the transport services to help the patients set up the HRP devices. The raw data files were telematically transmitted from the home to the hospital\(^1\).

The same technician in each center scored the raw data, following manual and automatic scoring protocols. In the manual scoring, the total number of apneas and hypopneas was divided by the recording time, excluding “invalid time” (time with a bad signal that prevented scoring). For automatic scoring, the total number of apneas and hypopneas was divided by recorded time with no exclusions.

**PSG in the hospital**
We used the American Academy of Sleep Medicine (AASM) 2007 recommendations regarding configuration, filters and signal sampling rates. The neurological variables were electroencephalogram, electrooculogram and electromyogram. Flow tracing was provided by a nasal cannula and thoracoabdominal motion by piezoelectric bands. Oxygen saturation was measured with a finger-pulse oxymeter. The polysomnographic studies were analyzed manually, according to the Rechtschaffen and Kales and the American Sleep Disorders Association 1992 criteria for sleep periods and arousals and according to the Spanish Sleep Network rule for respiratory scoring (see below).

**Definitions**

A valid PSG or HRP had at least three recorded hours. In addition, a valid HRP had at least three hours of flow or band and oxymetry measurements for scoring. An invalid recording could be repeated up to two times.

For the PSG, an apnea was defined as the absence of airflow (≥90% reduction) for ≥10 seconds and a hypopnea as a discernible airflow or band reduction (≥30% and <90%) of at least 10 seconds duration with a ≥3% drop in oxygen saturation or final arousal. For HRP, apneas and hypopneas were defined in the same way, but without the final arousal criteria for hypopneas. For automatic scoring, we predicted apnea/hypopnea events with both flow reduction and desaturation detection, using a previously published regression equation. The number of apneas and hypopneas was divided by recording time for HRP and sleep time for PSG.

Since our principal objective was cost-effectiveness, we chose the polysomnographic AHI cut-off point (≥5, ≥10 or ≥15) for SAHS diagnosis, which produced the lowest negative
post-test probability and consequently has a better capacity to rule out disease. It was ≥15, based on a recent publication with the same group of patients\textsuperscript{11}.

**Cost analysis**

We carried out a cost analysis for two equally effective alternatives\textsuperscript{28}. It consisted of summing the costs of all tests needed to reach a final diagnosis (SAHS or no SAHS) in both arms of study (PSG and HRP). Figure 1-B contains the procedure for calculating the costs of both alternatives. We estimated costs in the following cost groups:

1. **Test costs for PSG and HRP (manual and sequential protocols)**: hospital costs included the following expenditures: personnel salaries (technicians, physicians and administrative staff), linear five-year depreciation of equipment (taking into account the number of recordings done in this period in each hospital as output), fungible material, and the proportional burden of the sleep laboratory in the general budget of the hospital. The costs of PSG and HRP were divided by the number of patients with a valid recording to obtain the cost per patient.

2. **Patients’ costs for PSG and HRP**: the cost of moving from home to hospital and back, per kilometer. The cost per kilometer was calculated for each hospital. The sum of the patients’ costs was divided by the number of patients with a valid recording to derive the cost per patient.

3. **Total cost**: the sum of test (PSG and HRP) and patient costs.

4. **Costs of HRP and PSG for equal diagnostic efficacy**: For manual and sequential HRP protocols, the costs were the sum of the HRP costs and: a) the costs of PSG in patients with invalid recordings, after repetitions; b) the costs of repeated HRPs due to invalid recordings, in patients with a valid final recording; c) the cost of PSG in
patients with indeterminate results (“grey zone”); and d) the cost of PSG in patients with false negative and positive results. For PSG, we added the initial test costs to the cost of repeated PSGs due to invalid recordings.

The cost per patient for equal diagnostic efficacy (HRP protocols and PSG) was calculated by dividing this total cost by the number of randomized patients that completed the protocol.

5. **Patient costs for equal diagnostic efficacy**: the patient costs plus the burden due to transportation caused by repetitions.

6. **Total cost for equal diagnostic efficacy**: the sum of test costs (HRP protocols and PSG) and patient costs for equal diagnostic efficacy.

**Statistical analysis**

**Agreement of automatic HRP**

To determine the agreement in AHI measurements between automatic and manual scorings, and the agreement of both with PSG, we created Bland-Altman plots, comparing: a) PSG and manual HRP; b) PSG and automatic HRP; and c) manual and automatic HRP.

To assess the diagnostic agreement of automatic HRP and sequential HRP protocols (first automatic and then manual scoring) with PSG we carried out the following analysis:

a) We constructed Receiver Operating Characteristic (ROC) curves for manual and automatic HRP scoring, assuming a polysomnographic AHI score ≥15 as the criterion for SAHS diagnosis.
b) We determined the exclusive (sensitive) and the confirming (specific) HRP cut-off points for SAHS diagnosis by means of: 1) sensitivity and specificity; 2) negative \((1 - \text{sensitivity/specificity})\) and positive \((\text{sensitivity/1-specificity})\) likelihood ratios (LR) and 3) the post-test probability of having disease (SAHS) when the test was positive or negative, based on the pre-test probability (prevalence) and positive and negative LRs\(^{29}\). These analyses were carried out using the two HRP scoring protocols, manual and sequential. For the latter we first analyzed automatic scoring and then manual scoring in the population undiagnosed by automatic scoring.

To find the optimal exclusionary and confirming HRP cut-off points, we tested the previous parameters each five HRP AHI points, starting with a value of five, in manual and sequential protocols.

Due to the high prevalence (pre-test probability) of SAHS in our study population, it is very probable to be able to identify an effective HRP cut-off point that rules in SAHS in our sample with intermediate and high clinical probabilities of disease. We defined one as follows: a positive LR close to ten and a post-test probability clearly greater than 90%, which means that less than one out of ten patients with positive HRP, did not have the disease.

Since it is improbable to be able to identify an effective HRP cut-off point that rules out SAHS in our patients, we defined one as follows: a negative LR <0.1 and a post-test probability <17%, which means that less than two out of ten patients with negative HRP have the disease\(^{30}\).

Cost-effectiveness analysis
Once the HRP cut-off points to confirm (specific) or rule out (sensitive) SAHS diagnosis were determined for manual and sequential protocols, we imputed the cost for PSG and HRP (manual and sequential protocols) arms with the finality of obtaining a definitive diagnosis using HRP or PSG.

RESULTS

Diagnostic efficacy of HRP

Initially, 377 patients were selected. Eleven were excluded (Figure 1-A). Of the 366 randomized patients, 15 could not produce a valid HRP and PSG (4.9%). Four of these patients (three starting with HRP and one with PSG) did not come to their scheduled appointments. Another rejected the PSG test after a valid HRP and two rejected HRP after a valid PSG.

Of the 359 patients who completed the protocol (both branches of study), PSGs were repeated once in nine patients (2.5%) and the HRP 52 times (once or twice per patient), Of these 52 HRP repetitions, 15 were due to the patients’ failure to toggle the device on or off and 37 to invalid or poor quality time registers. Finally, eight patients could not produce a valid HRP after repetitions.

The clinical and anthropometric characteristics of the 348 patients with valid PSG and HRP results are shown in Table 1 and data from sleep studies in Table 2. AHI from automatic scorings were lower than manual and PSG scorings.

Figure 2 shows Bland-Altman plots for PSG and manual HRP, for PSG and automatic HRP and for manual and automatic HRP. AHI from manual HRP showed better agreement with PSG than automatic HRP, which showed important variability that
could be clinically significant for an individual patient. However, good AHI agreement
was observed between manual and automatic HRP.

Figure 3 shows the SAHS diagnosis (PSG AHI≥15) ROC curves for HRP (manual and
automatic scorings). The area under the curve was better for manual AHI than for
automatic AHI (P<0.001).

Table 3 shows the diagnostic agreement between manual and sequential HRP protocols.
A manual HRP cut off point ≥5 could effectively rule out a SAHS diagnosis, based on
our previous definition for ruling out SAHS (see statistical analysis). An acceptable
HRP AHI cut-off point for confirming SAHS would be 25, based on our previous
definition for ruling in SAHS (Table 3). The percentage of patients with a positive result
(true or false positives) would be 90% for an HRP AHI≥5 and 51% for an HRP
AHI≥25. Therefore, the indeterminate result range (grey zone) requiring PSG
represented 136 patients (39% of 348).

For the sequential protocol (Table 3) an AHI<5 from automatic HRP could not
effectively rule out SAHS. However, an AHI ≥25 could be a confirmation cut-off for
HRP. Two hundred fourteen patients (61%) would remain undiagnosed and available
for manual HRP scoring.

In the aforementioned 214 patients, a manual HRP AHI<5 could not rule out SAHS.
These values, although close to our definition, do not meet our criteria. An effective
HRP confirmation cut-off point could be ≥20. Therefore, the grey zone requiring PSG
would include 135 patients (39% of 348).

Cost analysis
Table 4 shows the mean cost per patient of PSG and HRP with manual and sequential protocols for the calculated cost groups from the eight hospitals. The cost of manual HRP was six times lower than PSG and sequential HRP was seven times lower than PSG. The cost of the sequential HRP was 1.2 times lower than manual HRP due to reductions in the costs of a scoring technician.

To estimate the cost of manual HRP for diagnostic efficacy equal to PSG using the manual protocol, we chose HRP AHI cut-off points to effectively rule out (<5) and to effectively confirm (≥25) SAHS, with indeterminate scores (cases needing further PSG assessment) in 39% of cases (Table 3). In the case of the sequential protocol, both automatic and subsequent manual scorings did not have effective cut-off points for ruling out SAHS, but both had effective confirmation cut-off points (≥25 for automatic and ≥20 for manual). Finally, 39% of the 348 needed PSG due to indeterminate scores. The cost of achieving a sequential HRP efficacy equal to that of PSG was four times higher than the test cost without equal efficacy, but substantially lower than the cost of PSG.

Considering the total cost of PSG as 100% (Figure 4), the cost of manual HRP was 69% and the cost of sequential HRP was 64%. The savings from sequential HRP in comparison with manual protocols was only 9%, primarily caused by the reduction in the cost of a scoring technician.

**DISCUSSION**

To our knowledge, this study has the largest sample of any published HRP study to date, as well as being the only multicentric study. The principal results in our selected population with intermediate or high SAHS suspicion were: a) manual HRP scoring had
better agreement than automatic HRP scoring; b) the sequential HRP protocol is a cost-effective alternative to PSG; and c) the cost savings of the sequential HRP protocol is low in comparison to the manual HRP protocol.

Automatic scoring is a tool available in most HRP devices. Several studies have tested the agreement with simultaneous PSG in sleep labs. The common finding has been that it underestimates the average AHI, and shows worse AHI agreement with PSG in Bland and Altman plot. In addition, automatic scoring has lower diagnostic agreement than manual scoring. However, most of the cited studies had good confirmation cut-off points for the diagnosis of SAHS but not good cut-off points for ruling out the diagnosis. Only one study has compared automatic HRP and manual HRP scorings with PSG. The AHI agreement for the Bland and Altman plots was better with automatic than with manual scorings. A study comparing automatic versus manual HRP scorings showed good AHI agreement for the Bland and Altman plots and similar diagnostic agreement. In this study, the hypopnea definition included desaturation while only flow reduction was used in the previously mentioned home study comparing automatic and manual scorings with PSG.

Based on the above data, automatic HRP scoring could be useful for confirming a SAHS diagnosis in positive cases with the remaining cases referred for manual HRP scoring. Technician time and subsequent costs could be saved for 39% of patients. If we had used another cut-off point for polysomnographic SAHS diagnosis instead of AHI≥15, the savings in comparison with PSG could be somewhat different. However, the difference in savings between manual and sequential protocols would remain similar, because the difference between both protocols in area under ROC curves for
AHI ≥ 5 and ≥10 were similar to the area under the curve for AHI ≥ 15 (0.06 for ≥5, 0.06 for ≥10 and 0.05 for ≥15).

As mentioned, a constant in previously published studies and the present study is the underestimation of AHI by automatic scoring in comparison with manual scorings\textsuperscript{17,18,20,21}, which can make it difficult to identify a cut-off point that rules out SAHS. This happens primarily with the hypopnea number, indicating deficient algorithms for automatically identifying hypopneas. Therefore, future improvements in software may produce better automatic scoring.

Several studies have calculated the costs of HRP in comparison with PSG based on simulated hypothetical cohorts of patients, including diagnosis and treatment\textsuperscript{31-34}, with contradictory results. Our study had more adequate patient inclusion, since it was performed on a large cohort of real patients, but our cost estimation was limited to diagnosis. Although the diagnostic method seems to be the most important factor for finding cost differences in these hypothetical cohort studies, cost-effectiveness studies including diagnosis and CPAP treatment based on real patients needing SAHS diagnosis (intermediate and high clinical probability) are necessary.

The fact that manual and sequential scoring protocols had lower difference in cost-effectiveness could result in limited interest in the sequential protocol on the part of specialized sleep centers. However, the eventual usefulness of our results could be in an integrated network of tertiary and non-tertiary hospitals. Generally, the tertiary hospitals have complete sleep laboratories (PSG and HRP) and very specialized physicians and technicians. In contrast, in non-tertiary hospitals the frequent scenario is no complete sleep laboratory (PSG unavailable; option to get a HRP device), no highly
specialized physicians (i.e. pulmonologists with general training) and no specialized technicians. These physicians receive patients from general practitioners and they can select patients to be screened with HRP based on guidelines, similar to the procedure in tertiary hospitals. Instead of referring patients to tertiary centers for diagnosis, HRP with automatic analysis could be done instead. Patients susceptible to an accurate diagnosis could be diagnosed and be recommended for CPAP or not based on the guidelines. The recordings from the remaining patients could be telematically transmitted to a tertiary hospital for manual scoring, providing a diagnosis for an additional number of patients. Finally, patients without a diagnosis would need to be moved to a tertiary hospital for a PSG. Regarding the cost, the main saving from applying this model would be decreasing the patient’s direct cost by eliminating patient travel to the tertiary hospital and the intangible cost from the inconvenience of moving. Nevertheless, specific studies to validate these potential results seem necessary.

In summary, sequential HRP scoring is a significantly lower cost alternative to PSG for the diagnosis of patients with suspected SAHS. However, the low cost savings of sequential versus manual scoring protocols could not suppose an interesting alternative to manual scoring until more refined software for automatic scoring becomes available.
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REFERENCES:


CAPTIONS

Figure 1. Figure 1-A: General flow chart of patients in the study; 359 patients completed both branches of the study. Figure 1-B: More detailed study flow chart to calculate the costs for the two alternatives. Decision nodes refer to alternatives by protocol, random nodes include alternatives determined at random and terminal nodes mark the end of the branch and additional costs.

In the HRP branch five patients were lost without adding costs. Patients with invalid recordings underwent one or two new HRPs with two options: a) patients with repeated invalid recordings reached the terminal node of the HRP arm; the costs of the consequent full PSG and that of HRP repetitions were added to the final cost; b) patients with a valid recording. In the latter group of patients, manual and automatic scorings were performed with two potential alternatives: diagnosis established or no diagnosis. Patients with manual or automatic HRP diagnosis (true positive or negative) reached the terminal node of the HRP branch and the burden of HRP (without a technician reading the raw-data in automatic scoring) and repetitions were included. Patients without a manual HRP diagnosis (grey zone and false positives and negatives) reached the terminal node and both HRP and PSG costs were included. In patients without an automatic HRP diagnosis, manual scoring was carried out with two possible options: diagnosis established or no diagnosis. Patients with a diagnosis reached the terminal node and the costs of HRP and repetitions were included. Patients without a diagnosis also reached the terminal node and both HRP and PSG costs were included. Patients with an initial valid HRP followed the same procedure as patients with a valid HRP after repetitions. In the PSG branch, two patients were lost to follow-up without additional costs. In patients with an invalid PSG, the test was repeated and they reached
the terminal node of this arm, with the cost of two PSGs added to the total PSG costs. Patients with a valid PSG contributed the cost of one PSG. HRP = home respiratory polygraphy; PSG = polysomnography; and SAHS = sleep apnea and hypopnea syndrome.

Figure 2: Mean AHI versus the difference in AHI between PSG and automatic SRP and HRP scorings, and between manual and automatic SRP and HRP scorings (Bland-Altman plots). Central lines represent mean values and upper and lower lines represent agreement limits (two standard deviations). Abbreviations: PSG = polysomnography; AHI = apnea-hypopnea index; SRP = simultaneous respiratory polygraphy and HRP = home respiratory polygraphy.

Figure 3: Receiver Operating Characteristics (ROC) curves for the automatic and manual HRP scorings based on an AHI ≥15 polysomnographic cut-off point for sleep apnea and hypopnea syndrome diagnosis. PSG = polysomnography, AUC = area under the curve, HRP: home respiratory polygraphy, AHI = apnea-hypopnea index and CI = confidence interval.

Figure 4

Percentages of total HRP (manual and sequential approaches) costs and their distribution in three groups (test cost, patients’ cost and cost for equal efficacy) compared to polysomnography costs, which were considered to be 100%. HRP = home respiratory polygraphy; PSG = polysomnography.
### Table 1: Characteristics of the studied population.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>N=348 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, %</td>
<td>75.6</td>
</tr>
<tr>
<td>Age, years</td>
<td>48.7 (11.8)</td>
</tr>
<tr>
<td>Snoring, %</td>
<td>95</td>
</tr>
<tr>
<td>Observed apneas, %</td>
<td>75</td>
</tr>
<tr>
<td>Body mass index</td>
<td>31.0 (6.6)</td>
</tr>
<tr>
<td>Obesity, %</td>
<td>48.3</td>
</tr>
<tr>
<td>Subjective sleep time/day, hours</td>
<td>6.9 (1.4)</td>
</tr>
<tr>
<td>Subjective nap time, hours</td>
<td>0.5 (0.6)</td>
</tr>
<tr>
<td>Epworth sleepiness scale</td>
<td>11.6 (5.0)</td>
</tr>
<tr>
<td>Morning fatigue, %</td>
<td>86</td>
</tr>
<tr>
<td>Alcohol, gr.</td>
<td>8.9 (22.3)</td>
</tr>
<tr>
<td>Smokers, %</td>
<td>23.9</td>
</tr>
<tr>
<td>Depression/anxiety %</td>
<td>23.3</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>30.7</td>
</tr>
<tr>
<td>Cardiovascular events, %</td>
<td>5.6</td>
</tr>
<tr>
<td>Systolic pressure, mmHg</td>
<td>130.5 (17.2)</td>
</tr>
<tr>
<td>Diastolic pressure, mmHg</td>
<td>76.0 (12.1)</td>
</tr>
<tr>
<td>Starting home, %</td>
<td>47.7%</td>
</tr>
</tbody>
</table>

Abbreviation: SD = standard deviation
Table 2: Sleep studies

<table>
<thead>
<tr>
<th></th>
<th>PSG Mean (SD)</th>
<th>Manual HRP Mean (SD)</th>
<th>Automatic HRP Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recording time, min.</td>
<td>443 (43)</td>
<td>428 (82)</td>
<td>428 (82)</td>
</tr>
<tr>
<td>Sleep time or valid time, min.</td>
<td>372 (64)</td>
<td>404 (71)</td>
<td>--</td>
</tr>
<tr>
<td>NREM stages 1 and 2, %</td>
<td>64 (22)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>NREM stages 3 and 4, %</td>
<td>17 (12)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>REM stage, %</td>
<td>17 (13)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Arousal index</td>
<td>39 (25)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>AHI</td>
<td>38 (29)</td>
<td>31 (24)</td>
<td>25 (22)</td>
</tr>
<tr>
<td>AHI≥5, %</td>
<td>90</td>
<td>90</td>
<td>84</td>
</tr>
<tr>
<td>AHI≥10, %</td>
<td>83</td>
<td>80</td>
<td>68</td>
</tr>
<tr>
<td>AHI ≥15, %</td>
<td>75</td>
<td>70</td>
<td>58</td>
</tr>
<tr>
<td>SaO2&lt;90% of sleep or recording time</td>
<td>9.9 (19)</td>
<td>6.5 (14)</td>
<td>6.4 (13)</td>
</tr>
<tr>
<td>Desaturation index</td>
<td>27 (29)</td>
<td>29 (24)</td>
<td>28 (24)</td>
</tr>
</tbody>
</table>

Abbreviation: PSG: polysomnography; SD = standard deviation; Min: minutes; AHI = apnea-hypopnea index; HRP = home respiratory polygraphy
Table 3. AHI HRP cut-off points to rule out or confirm SAHS diagnosis, for manual and sequential protocols.

<table>
<thead>
<tr>
<th></th>
<th>Se</th>
<th>Sp</th>
<th>LR + (95% CI)</th>
<th>Post-test probability + (95% CI)</th>
<th>LR – (95% CI)</th>
<th>Post-test probability – (95% CI)</th>
<th>HRP +/-, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual scoring for the total sample (N= 348; pretest probability 75%)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥5</td>
<td>98</td>
<td>31</td>
<td>1.42 (1.23-1.64)</td>
<td>81 (79-83)</td>
<td>0.06 (0.03-0.16)</td>
<td>15 (8-32)</td>
<td>90/10</td>
</tr>
<tr>
<td>≥25</td>
<td>67</td>
<td>92</td>
<td>8.36 (4.09-17)</td>
<td>96 (92-98)</td>
<td>0.36 (0.30-0.44)</td>
<td>52 (47-57)</td>
<td>51/49</td>
</tr>
<tr>
<td>Sequential protocol</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Automatic scoring for the total sample (N= 348; pretest probability 75%)</td>
<td></td>
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<tr>
<td>≥5</td>
<td>93</td>
<td>41</td>
<td>1.58 (1.32-1.89)</td>
<td>83 (80-85)</td>
<td>0.18 (0.11-0.29)</td>
<td>35 (25-47)</td>
<td>84/16</td>
</tr>
<tr>
<td>≥25</td>
<td>49</td>
<td>93</td>
<td>7.11 (3.25-16)</td>
<td>96 (91-98)</td>
<td>0.55 (0.48-0.62)</td>
<td>62 (59-65)</td>
<td>39/61</td>
</tr>
<tr>
<td>Manual scoring for a sub-sample (N= 214; pretest probability 62%)</td>
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<tr>
<td>≥5</td>
<td>95</td>
<td>33</td>
<td>1.43 (1.22-1.68)</td>
<td>70 (67-73)</td>
<td>0.14 (0.06-0.31)</td>
<td>19 (9-34)</td>
<td>85/15</td>
</tr>
<tr>
<td>≥20</td>
<td>56</td>
<td>94</td>
<td>9.01 (3.80-21)</td>
<td>94 (86-97)</td>
<td>0.47 (0.39-0.58)</td>
<td>44 (39-49)</td>
<td>37/63</td>
</tr>
</tbody>
</table>

Abbreviations: AHI = apnea-hypopnea index; HRP = home respiratory polygraphy; Se = sensitivity; Sp = specificity; LR = likelihood ratio; CI = confidential interval; Post-test probability + = the post-test probability of having disease (SAHS) when the test (HRP) was positive; Post-test probability – = the post-test probability of having disease (SAHS) when the test (HRP) was negative; and HRP +/-, % = percentage of patients with a positive/negative diagnosis based on HRP.
Table 4. Cost per patient of PSG and HRP (manual and sequential protocols), for the different cost groups in the eight hospitals*

<table>
<thead>
<tr>
<th></th>
<th>PSG</th>
<th>Manual HRP</th>
<th>Sequential HRP</th>
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<tbody>
<tr>
<td>Test costs, mean (SD)</td>
<td>540.60</td>
<td>91.35</td>
<td>76.95</td>
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<tr>
<td>Patient costs, mean (SD)</td>
<td>22.21</td>
<td>44.42</td>
<td>44.42</td>
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<tr>
<td>Total costs, mean (SD)</td>
<td>562.81</td>
<td>135.77</td>
<td>121.37</td>
</tr>
<tr>
<td>Cost for equal diagnostic efficacy, mean (SD)</td>
<td>554.08</td>
<td>348.37</td>
<td>320.87</td>
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<tr>
<td>Patient costs for equal diagnostic efficacy, mean (SD)</td>
<td>23.13</td>
<td>49.98</td>
<td>49.98</td>
</tr>
<tr>
<td>Total cost for equal diagnostic efficacy, mean (SD)</td>
<td>577.21</td>
<td>398.35</td>
<td>370.85</td>
</tr>
</tbody>
</table>

Abbreviations: PSG = polysomnography; HRP = home respiratory polygraphy; and SD = standard deviation.
* = Cost in 2009 Euros
Figure 1:

Figure 1-A: