Sleep and Breathing (2019) 23:217–226
https://doi.org/10.1007/s11325-018-1686-7

SLEEP BREATHING PHYSIOLOGY AND DISORDERS • ORIGINAL ARTICLE

A French update on the Self-Efficacy Measure for Sleep Apnea (SEMSA) to assess continuous positive airway pressure (CPAP) use

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Received: 7 November 2017 / Revised: 4 June 2018 / Accepted: 18 June 2018 / Published online: 26 June 2018

Abstract

Purpose The Self-Efficacy Measure for Sleep Apnea (SEMSA) is a 26-item self-questionnaire composed of three factors: risk perception of obstructive sleep apnea syndrome (OSAS), benefit of continuous positive airway pressure (CPAP), and self-efficacy (the confidence to engage in CPAP use). It is used to evaluate health beliefs about OSAS and CPAP in order to optimize CPAP use. The purpose of this study was to design and validate a French version of the SEMSA.

Methods A forward-backward translation of the SEMSA was performed. Subjects with OSAS treated by CPAP and followed by our sleep clinic were invited to complete the questionnaire. The psychometric properties of the French SEMSA version were analyzed in terms of its construct validity (with confirmatory factor analysis, CFA), internal structural validity (Cronbach's alpha coefficient), and external validity (Pearson's correlation between SEMSA score and duration of CPAP use).

Results Two hundred eighty-eight subjects filled in the questionnaire. The mean age was 63.16 ± 12.73 years. The number of years since the beginning of CPAP treatment was 6.58 ± 6.03 years. The mean CPAP use duration was 6.19 ± 2.03 h/night. CFA was unsatisfactory (RMSEA = 0.066 and CFI = 0.88). The exploratory factor analysis revealed a fourth factor named "cardiovascular risk" factor. Cronbach's alpha coefficient was 0.886. The correlation between the "self-efficacy" factor and the duration of CPAP use was significant ($r = 0.26$, $p \leq 0.001$).

Conclusions The French version of the SEMSA is a psychometrically acceptable self-report questionnaire for measuring health beliefs and behavior in French patients with OSAS treated with CPAP. Such translation and validation should lead to the adoption of validated psychosocial methods for improving CPAP use.

Keywords Sleep apnea · Self-efficacy · CPAP adherence · CPAP treatment · Validation

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11325-018-1686-7) contains supplementary material, which is available to authorized users.

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Introduction

Continuous positive airway pressure (CPAP) is the reference treatment for obstructive sleep apnea syndrome (OSAS) [1, 2] and is effective in improving symptoms of OSAS, reducing risk of accidents and improving quality of life [3]. However, CPAP use is less than optimal [4–6]. Recommended use is between 6 and 8 h per night and a common clinical and empiric benchmark has been defined for CPAP use as an average of 4 h per night for 70% of the night [7]. From 5 to 50% of patients discontinue CPAP treatment during the first week and 12 to 25% have stopped after 3 years [8]. Globally, approximately 45% of patients become nonobservant to CPAP treatment [8]. When patients become nonobservant, the treatment has no effect [8] so it is very important to identify the factors that influence CPAP use [7, 9–13].

Biomedical factors, in line with the concept of compliance/tolerance to the treatment [14, 15], have been widely studied but explain only 4 to 25% of the variance in CPAP use [8]. Interestingly, health beliefs/behaviors (about illness, treatments efficacy, and constraints) and "self-efficacy" (the confidence to engage in a treatment) [16, 17], in line with the concept of adherence to the treatment [12, 18], were found to explain more than 30% of the variance in CPAP use [19]. Several clinical instruments can be used to investigate health beliefs/behavior and self-efficacy related to OSAS and CPAP [20]. Indeed, self-reported questionnaires have been developed on the basis of various health psychology theories of behavioral change and health maintenance and have been adapted to the context of CPAP treatment for OSAS [20]. The principal self-reported questionnaires are shown in Table 1.

The SEMSA questionnaire has received the most attention [7, 21–29]. The SEMSA is a 26-item questionnaire consisting of three factors confirmed by factor analysis: risk perception of OSAS, benefit (outcome expectancy) of CPAP, and self-efficacy in the use of CPAP in line with Bandura's social cognitive theory [30]. Each item is rated on a Likert scale from 1 to 4, with higher scores indicating greater risk perception, higher benefit expectancy with treatment, and greater perceived self-efficacy [30]. The principal results of the studies using the SEMSA questionnaire are shown in Table 2.

The retrospective studies showed that the factor "self-efficacy" of the SEMSA was related to poor CPAP use [21–23]. The prospective studies showed [7, 24–28] that the factor "self-efficacy" of the SEMSA at baseline was not associated with future CPAP use in any of these studies, except when it was completed after a standardized education program [25]. All these studies, except two [28, 29], provided information or therapeutic training on OSAS or CPAP before treatment began and before evaluation by the SEMSA questionnaire. Nevertheless, it was shown that the factor "self-efficacy" of the SEMSA

Table 1 Self-reported questionnaires that have been developed on the basis of health psychology theories of behavioral change and health maintenance, adapted to the context of CPAP treatment for OSAS. Each study showed the significant effect of health beliefs and behavior evaluated by these instruments on observance to CPAP treatment [20]

Name of scale	Number of items (response modality)	Targeted construct	Health psychology theory	References of studies using scale to investigate CPAP observance
Apnea Belief Scale (ABS)	24 (Likert 1–5)	Belief concerning OSAS and CPAP treatment	Health belief model	[55–57]
Apnea Knowledge Test	15 (multiple choice question)	Knowledge concerning OSAS and CPAP treatment	Health belief model	[55–57]
Cues to CPAP Use Questionnaire (CCUQ)	9 (Likert 0–3)	Cues that act as triggers to CPAP use	Health belief model	[58]
Self-Efficacy Measure for Sleep Apnea (SEMSA)	26 items (Likert 1–4)	Belief concerning OSAS and CPAP treatment + Self-efficacy	Bandura's social cognitive theory	[7, 21–28, 30]
Social Cognitive Theory (SCT) questionnaire	30 items (Likert 1–5)	Belief concerning OSAS and CPAP treatment + Self-efficacy + perceived social support	Bandura's social cognitive theory	[19, 31, 59–62]
Transtheroretical Model (TM) questionnaire	32 items (Likert 1–5)	Stage of change, decisional balance adapted to CPAP context	Prochascka and DiClementes' transtheoretical model of behavior	[19, 62]
Ways of Coping Check List (WCC) questionnaire	66 items (Likert 0–3)	Generic scale on coping strategies with stressful event	Lazarus and Folkman's stress and coping model	[63]
Multidimensional Health Locus of Control (MHLC) questionnaire	18 items (Likert 1–6)	Generic scale on locus of control	Lazarus and Folkman's stress and coping model	[64]

Table 2 Studies using the Self-Efficacy Measure for Sleep Apnea (SEMSA) self-reported questionnaires to evaluate the CPAP observance

Studies	Year	Methods	Number of subjects	Number of days of ownership	Principal results
Wallace et al. [21]	2003	Retrospective	248	512 ± 484	Self-efficacy scores significantly associated with mean daily CPAP use (threshold of 4 h per night)
Wohlgemuth et al. [23]	2015	Retrospective	207	475 ± 459	Self-efficacy scores significantly associated with 3 profiles of patients ("non adheres," "attempters," and "adherers")
Dzierzwski et al. [22]	2016	Retrospective	191	485 ± 457	Self-efficacy scores significantly associated with mean daily CPAP use (threshold of 4 h per night)
Micoulaud-Franchi et al.	Present study	Retrospective	288	2401 ± 2200	Self-efficacy scores significantly associated with mean daily CPAP use (mean use per night)
Olsen et al. [24]	2008	Prospective	77	At 4 months	Outcome expectancy and risk perception scores at baseline significantly associated with mean daily CPAP use
Sawyer et al. [25]	2010	Prospective	98	At 1 week At 1 month	Post-educational program baseline risk perception and self-efficacy scores significantly associated with mean daily CPAP use Self-efficacy scores at 1 week significantly associated with mean daily CPAP use at 1 month
Bakker et al. [29]	2011	Prospective	126	At 4 weeks	SEMSA scores at baseline not significantly associated with mean daily CPAP use (threshold of 4 h per night)
Ye et al. [28]	2012	Prospective	91	At 1 week	SEMSA scores at 1 week (but not at baseline) significantly associated with mean daily CPAP use
Lai et al. [26]	2013	Prospective	100	At 3 months	SEMSA scores at 3 months (but not at baseline) significantly associated with mean daily CPAP use
Wallace et al. [27]	2013	Prospective	65	At 1 week At 1 month	Self-efficacy and outcome expectancy scores at 1 week significantly associated with mean daily CPAP use at 1 month
Sawyer et al. [31]	2014	Prospective	97	At 1 month	Outcome expectancy scores significantly associated with mean daily CPAP use at 1 month

evaluated 1 week after the initiation of CPAP significantly predicted use at 1 month [25, 27]. Moreover, the factor "self-efficacy" evaluated retrospectively after treatment initiation was associated with CPAP use at the first week [28] and up to the first 3 months of use [26]. At baseline, the factors "outcome expectancy" and "risk perception" of the SEMSA can significantly predict CPAP use during the first month [31] and the first 4 months [24]. The type of education program delivered at baseline can influence the association of these two factors [20]. One week after initiation, the factor "outcome expectancy" was also significantly associated with CPAP use at 1 month [27].

All these studies confirmed that the SEMSA can be used to evaluate health beliefs/behavior and self-efficacy related to OSAS and CPAP in order to optimize CPAP use [7, 13, 30]. However, the original English version has been translated and tested only in Chinese [26]. In Chinese, the translated SEMSA version has proven to be a valid and reliable instrument with good psychometric properties [26]. The Japanese version has not been entirely translated and the validation process lacked rigor [32]. As recommended by Crowford et al. (2014) who encourage "the adaptation of available psychosocial measures for use in the biopsychosocial profiling of patients and research participants" [12], and in order to develop specific strategies for improving CPAP use worldwide, the SEMSA should be available in many languages. A French version is essential for two reasons. First, French is the sixth most widely spoken language with 220 million speakers [33]. Second, CPAP treatment is booming and health-related costs have increased considerably in France. Thus, there is an urgent need to evaluate the factors that influence CPAP use in the French context. Nevertheless, the SEMSA has not previously been translated and validated in French. However, translations of questionnaires may be influenced by cultural factors [34] so before any translated questionnaire can be used, a transcultural validation has to be performed according to specific rules and methods. Thus, the purpose of this study was to design and validate a French version of the SEMSA. In the present cross-sectional study, we analyzed the psychometric properties of the French version in a sample of French patients treated with CPAP.

Methods and materials

Participants and procedure

All the subjects with OSAS treated by CPAP and followed by the sleep clinic at Bordeaux University Hospital and by VitalAire France (a home healthcare provider, activity of Air Liquide HealthCare) were invited to complete the questionnaire. Thus, a cohort of 404 subjects with OSAS diagnosed according to the AASM criteria by polygraphy or polysomnography in the sleep clinic at Bordeaux University Hospital were mailed a letter describing the purpose of the study and inviting them to self-administer a confidential survey. The letter was sent in February 2017. Description of the 404 subjects is shown Table 3.

After providing written informed consent, the patients self-administered a survey and sent it back to the sleep clinic with a postage-paid envelope. The study was conducted in accordance with the Declaration of Helsinki and French Good Clinical Practices. The survey contained a French version of the Self-Efficacy Measure of Sleep Apnea (SEMSA). The following information was collected by the home care team: age, sex, body mass index (BMI), duration of CPAP use in previous month (average number of hours of CPAP run time per night for 1 month), number of years of installation, residual apnea and hypopnea index AHI (calculated by the internal algorithm of the machines), and Epworth Sleepiness Scale (ESS) score. The initial AHI on the polygraphy or polysomnography were collected by the sleep clinic.

French version of SEMSA

Translation of SEMSA

Before carrying out the translation, the agreement of the author of the original English SEMSA was obtained (TW). A forward-backward translation was performed. The original version was translated into French by two French native speakers with a high level of fluency in both English and French and a high competence in sleep medicine and CPAP treatment (JAM & PP). The back-translation into English was undertaken by an English native speaker with a high level of medical expertise and was blinded to the original version (RK). The divergences observed between the back-translation and the original English version were identified and discussed by a committee consisting of the two French translators (JAM & PP), the English native translator (RK), and two French sleep medicine specialists (SB & PJM). For the items where cross-language agreement could not be reached, French sentences were reworded. The translated version of the SEMSA was administered to 10 patients and showed good clarity and cultural acceptability. No further adaptations were required. The final version of the French SEMSA is in Supplementary material 3. The order of presentation of the items in the original version was unchanged.

Scoring

The same method of scoring was used as in the original paper validating the SEMSA. The mean of the non-missing item responses was calculated for each of the three factors: perceived risk, outcome expectancies, and treatment self-efficacy. Using this mean-weighted score prevented the distortion of the score from missing responses. Moreover, as done by Weaver et al. (2003) for the original version, the Likert responses were dichotomized into two levels by combining separately the frequencies of responses to the first two choices and the last two choices.

Statistical analyses and hypotheses

Descriptive statistics of the obtained data included frequencies and percentages of categorical variables together with means and standard deviations of continuous variables. For the

Table 3 Description of the population of patients with OSAS who received a letter describing the purpose of the study and inviting them to self-administer a confidential survey ($n = 404$), and description of the population who completed and returned the survey ($n = 288$)

	Initial population ($N = 404$)	Population studied ($N = 288$)
Age (years)	61.59 ± 13.82	63.16 ± 12.73
Sex (% females)	36% ($n = 148$)	31% ($n = 91$)
BMI (kg/m^2)	30.86 ± 6.34	30.39 ± 6.31
ESS	4.50 ± 3.61	4.82 ± 4.01
Duration of CPAP use (h/night)	6.07 ± 2.31	6.19 ± 2.03
Number of years of installation	6.01 ± 5.89	6.58 ± 6.03
AHI before CPAP treatment	29.35 ± 17.95	34.61 ± 20.71
Residual AHI	1.84 ± 2.74	1.93 ± 2.61

BMI body mass index, *ESS* Epworth Sleepiness Scale, *AHI* apnea and hypopnea index, *CPAP* continuous positive airway pressure

validation process, we analyzed the psychometric properties of the French version including construct validity, internal structural validity, and external validity. Data analysis was performed using SPSS software (Version 18 for Mac, PASW Statistics), Stata software (Version 14 for Mac, StataCorp), and WINSTEP Software. For all the tests, the accepted significance level was 5%. The detailed procedure is described in Supplementary material 1.

Construct validity was investigated with a confirmatory factor analysis (CFA) [35]. If the CFA was not satisfactory, a principal component factor analysis (PCA) with varimax rotation was performed to explore the structure of the French version [35–37]. Internal structural validity was investigated by calculating (i) item internal consistency (IIC) [38], (ii) item discriminant validity (IDV) [39], (iii) internal consistency reliability with Cronbach's alpha coefficient [40], (iv) goodness-of-fit statistics (INFIT) using Rasch analysis [41], and (v) floor and ceiling effects. External validity was investigated by exploring the divergent external validity (the relation between SEMSA score and age, BMI, ESS, and the initial AHI investigated with Pearson's coefficients, and the differences in SEMSA scores between men and women investigated by the *t* test), and the convergent external validity (the relation between SEMSA score and duration of CPAP use investigated with Pearson's coefficients).

Results

Sample characteristics

Two hundred eighty-eight subjects returned the questionnaires (71.3% of returns). Two hundred nineteen responded to all the items. The mean number of missing values was 0.84 (range 0–10). Description of the 288 subjects is shown in Table 3. Concerning the number of years since the beginning of CPAP treatment, 20% were below 1 year, 37% below 2 years, 50% below 3 years, 64% below 6 years, and 80% below 8 years. Concerning the mean CPAP use duration, 16% were below 4 h/night, 24% below 5 h/night, 40% below 6 h/night, and 58% below 7 h/night.

Validity

Construct validity

The confirmatory factor analysis revealed that the indicators were unsatisfactory (RMSEA = 0.066 and CFI = 0.88).

The exploratory factor analysis revealed four factors (Supplementary material 2):

- the first factor corresponds to the "perceived risk" factor of the SEMSA but without item 1A "having high blood pressure" and item 3A "having a heart attack,"
- the second factor corresponds to the CPAP "outcome expectancies" factor of the SEMSA but without item 6B "having a heart attack,"
- the third factor corresponds to the CPAP "self-efficacy" factor of the SEMSA but without item 9C "had to pay for some of the cost."
- The fourth factor is a factor that was not described in the original version of the SEMSA and which contained items 1A, 3A, and 6B and can be named "cardiovascular risk" factor.

For each factor, loading was greater than 0.3. There was only one item that loaded less than 0.3: item 9C "had to pay for some of the cost."

Internal structural validity

Item internal consistency (IIC) was satisfactory for the four factors, each item achieving the 0.40 standard threshold value. Item 9C correlated the least with its contributive factor (r = 0.48). Item discriminant validity (IDV) was satisfactory as the correlation between items with their contributive factor was higher than for items with the other factor (Table 4).

Table 4 Factor characteristics of French version of SEMSA

Factor	M ± SD[1]	IIC[2] min-max	IDV[3] min-max	Alpha[4]	INFIT[5] min-max
Perceived risk	2.47 ± 0.69	0.63–0.86	0.06–0.46	0.903	0.77–1.54
Outcome expectancies	3.22 ± 0.61	0.51–0.80	0.14–0.39	0.867	0.62–1.7
Self-efficacy	3.16 ± 0.67	0.48–0.77	0.02–0.38	0.841	0.62–1.61

[1] Mean ± standard deviation

[2] Item internal consistency (item-to-own dimension correlations)

[3] Item discriminant validity (item-to-other dimensions correlations)

[4] Cronbach's alpha

[5] Rasch statistics

Cronbach's alpha coefficient was 0.886 and ranged from 0.879 to 0.889 after items were deleted. The overall internal consistency reliability was satisfactory, except for item 9C, as deleting it increased Cronbach's alpha coefficient.

The overall scalability was satisfactory: only one item in the "perceiving risk" factor (item 8A: "having problem with sexual desire and performance"), two items in "outcome expectancies" (items 2B and 7B), and one item in the "self-efficacy" factor (item 9C: "had to pay for some of cost") showed INFIT statistics above the acceptable range (Rasch analysis). Only three items showed INFIT statistics below the acceptable range: "my job performance will improve" (Item 4B), "be more active" (Item 9B), and "it were a bother" (Item 6C).

Floor and ceiling effects are shown in Supplementary material 3. Concerning "perceiving risk," "falling asleep during day" was the risk the most recognized by patients, with more than 60% of responses to "high" or "very high" risk. The risk the least recognized was "having problem with sexual desire and performance" with fewer than 40% of responses to "high" or "very high" risk. Concerning "outcome expectancies," "improve desire and sexual performance" was the least recognized, with fewer than 60% of responses "somewhat true" or "very true." All the other items of this factor showed well-known linked outcomes to the CPAP. Finally, concerning the "self-efficacy" factor, patients exhibited good ability to deal with obstacles to using CPAP, except for the item "had to pay for some of cost" for which fewer than 60% of patients reported responses "somewhat true" or "very true."

External validity

The correlation between total SEMSA score and age ($r = 0.06$, $p = 0.32$), BMI ($r = -0.06$, $p = 0.38$), ESS ($r = 0.07$, $p = 0.32$), and the initial AHI ($r = 0.07$, $p = 0.37$) were not significant. No significant correlation was found with the scores of each of the three factors. The correlation between duration of CPAP use and total SEMSA score ($r = 0.14$, $p = 0.04$) was significant but low. Concerning the factor of the SEMSA, only the correlation between "self-efficacy" and the duration of CPAP use was significant ($r = 0.26$, $p \leq 0.001$). The correlation between "perceived risk" ($r = -0.02$, $p = 0.76$) and "outcome expectancies" ($r = -0.11$, $p = 0.07$) was not significant. The mean SEMSA score in women was 2.98 (SD = 0.39) and in men was 2.96 (SD = 0.48). No statistical association was related to sex concerning SEMSA scores ($p = 0.74$) (none of the three factors).

Discussion

The original version of the SEMSA [30] has now been translated and validated in French. This is the second translation into another language following the Chinese version [26] and represents one step closer to a global tool for evaluating health beliefs and behavior regarding CPAP use. The French version was designed according to a rigorous standardized linguistic validation process [34]. Backward-forward translation was conducted without any difficulty in the meaning of key terms and the examination of meaning equivalences by the committees was satisfactory. Moreover, the French version showed satisfactory psychometric properties.

As in the original and Chinese versions, the present study found that approximately half of patients perceived OSAS as carrying a low risk. Risk perception was the highest for excessive daytime sleepiness, as in the original version [30]. This could be because sleepiness-related traffic accidents have been largely studied in France and public campaigns have targeted the risk due to excessive daytime sleepiness [42]. However, in contrast with the findings of Weaver et al. (2003), perception of the risk of high blood pressure was relatively low in our population, suggesting that the well-documented association between cardiovascular morbidities and OSAS is not sufficiently explained to French patients [43].

As in the original English version, we found a low rate of patients who associated problems with sexual desire and performance and risk of being depressed with OSAS, and we found a similar low rate of association between CPAP outcome and improving sexual desire and performance [30]. This could be due to a lack of knowledge about these risks, even though they are well known in literature [44, 45]. For sexual desire and performance, we found a similar rate of patients who were unwilling to answer questions on sexual aspects (around 8%) to that in the Chinese version. Some patients may consider such a question as private. Moreover, the mean age of our population was high, so sexual desire and performance may not have been their major concern regarding the consequences of OSAS. The hypothesis that they did not consider sexual desire and performance as consequences on the same plane as other consequences is reinforced by the goodness-of-fit statistics showing an INFIT mean square above the acceptable range for this item.

A CFA was conducted to confirm the three-factor structure of the SEMSA, but it showed a suboptimal RMSEA and CFI values. However, each factor had high internal reliability (Cronbach's alpha > 0.70 for all), suggesting that items under the same factor were more associated than those under different dimensions. The IIC and IDV were very satisfactory as the correlation between items and their hypothesized factor was higher than the correlation with their competing factors. Only the removal of item 9C ("had to pay for some of the cost") increased Cronbach's alpha coefficient. Moreover, item 9C had a low IIC of 0.5. These results suggest that this item is not closely interrelated to "self-efficacy."

As the CFA showed that the three-factor structure of the original version was suboptimal, we conducted an exploratory factor analysis to identify the optimal factor structure of the

French version. Item 9C showed very low loading (< 0.3) for each of the factors and a four-factor solution was found.

Firstly, the very low load on item 9C is in line with the INFIT mean square above the acceptable range. The results for this item may be due to the fact that CPAP treatment is entirely reimbursed by French national health care so patients have nothing to pay for it [46]. Indeed, France is known for the quality and generosity of its health care system [47]. Public health insurance covers the entire population and all fees for CPAP. Furthermore, sleep medicine doctors are free to choose the type of machine and type of mask best suited to their patients [46]. Indeed, it may be hypothesized that paying for health care is not a belief of the French concerning their health and how they should behave with regard to it. Thus, item 9C probably did not represent the same concept than the other items of the SEMSA in a French population.

Secondly, three of the four factors in the French version are similar to those in the original one. However, a fourth unexpected factor was found containing an item related to cardiovascular risk (Item 1A: "having high blood pressure," Items 3A and 6B: "having a heart attack"). Although these items exhibited a load > 0.3 compared to the factor they were hypothesized to represent, they also exhibited a higher load than the fourth factor that we propose to call "cardiovascular risk" factor. This means that perception of cardiovascular risk is not entirely part of the same factor as perception of the other risks related to OSAS. This could be because French patients with OSAS are insufficiently informed about cardiovascular risk in comparison with other risks [48–50]. Another explanation is that only patients with a cardiovascular risk are informed about it [51, 52]. Further studies are needed to explore the different profiles of risk perception with regard to the clinical comorbidities of OSAS patients.

Lastly, the exploratory factor analysis and the goodness-of-fit statistics for the item "will not snore" and "my partner will sleep better" of the "outcome expectancies" factor revealed a relatively low loading factor and an INFIT mean square above the acceptable range. While Rash analysis was not reported in the original SEMSA study [30], the factor load of these two items was already lower in it. This might indicate that these items did not measure the same concept, perhaps because they are related to nighttime outcome expectancies, whereas other items are daytime outcome expectancies. In contrast, two items of daytime outcome expectancies "My job performance will improve" and "Be more active" revealed an INFIT mean square below the acceptable range suggesting that they may be redundant. Thus, further studies should investigate the difference between the night and daytime outcome expectancies of CPAP treatment in order to better equilibrate the evaluation of these two important dimensions.

The relationship between CPAP use and SEMSA scores was investigated to explore the external validity of the questionnaire. Among the three factors of the SEMSA, only the "self-efficacy" factor was significantly correlated to CPAP use, which is in line with previous cross-sectional studies using the SEMSA [21–23]. Risk perception and outcome expectancies are important factors when initiating the treatment, and self-efficacy is a major factor in maintaining CPAP use in the long term [7, 12]. No significant relationship was found with age, sex, BMI, ESS, or the initial AHI, which indicates that data obtained with the SEMSA are not related to socio-demographical variables or OSAS severity.

This study has some limitations. Firstly, the population studied could be not representative of the general population of patient treated with CPAP. Indeed, in comparison to previous studies (Table 2), we found a very low rate of CPAP use below 4 h/night and a high number of years of ownership. The high rate of CPAP use could be explained by the CPAP initiation, education, and follow-up procedure. A certified sleep respiratory technologist from the Vitalaire home healthcare provider began CPAP treatment at home. The technologist spent a standardized 1-h session to install the CPAP unit, to adjust the mask, and to give information on OSAS, CPAP treatment, the medical consequences of OSAS, and the side-effects of CPAP. The technologist returned to the participant's home after 1 month, then annually. Patients were encouraged to contact the technologist if they encountered ongoing difficulties, and the technologist visited the patient when necessary to optimize their care. Three to six months after treatment initiation, patients were followed up by a consultation with a sleep medicine physician at the sleep clinic, then annually. If intercurrent problems occurred during treatment (nasal obstruction, upper airway infection, concomitant sleep disorders…), patients were seen at the sleep clinic to evaluate the impact on CPAP tolerance. Thus, the impact of the type of CPAP initiation, education, and follow-up procedure on SEMSA responses should be investigated in further studies. Secondly, test-retest reliability and responsiveness to change were not evaluated so further studies are needed to measure the intra-class correlation coefficient between two points of evaluation and to measure the degrees of responsiveness between a baseline evaluation and after a CPAP education program. The relationship with the improvement in CPAP use should also be studied. Thirdly, the impact of education level and comorbidities was not studied. Such factors could impact responses on the SEMSA, but also the correlation between SEMSA score and duration of CPAP use, so further studies are needed to explore the results of the SEMSA in different patient profiles. This is important because a recent study showed a high degree of biomedical phenotype heterogeneity in OSAS patients [53, 54]. Further studies should investigate the relationship between these biomedical phenotypes and possible psychological profiles based on health beliefs and behavior [12]. As highlighted by Crowford et al. 2014 in their research agenda, this will necessitate "the adoption of sophisticated statistical approaches to explore the interactive effects of biomedical, psychological and social variables" [12]. Fourthly,

this study was cross sectional and not prospective so no causal inference can be made between SEMSA scores and CPAP use. Future studies with longitudinal approaches are needed.

Despite these limitations, the French version of the SEMSA is a psychometrically acceptable self-report questionnaire for measuring health beliefs and behavior in French OSAS patients treated with CPAP. Thus, we contend that the SEMSA in its French, Chinese, and original versions provides clear insights into CPAP use. Better evaluation of beliefs and behavior towards OSA and CPAP treatment could help in developing tailor-made strategies to improve CPAP use, such as early CPAP educational programs to help patients to deal with the side-effects and obstacles of CPAP use and to make them aware of the benefits of CPAP use.

Acknowledgments Special thanks to VitalAire France, home healthcare provider, activity of Air Liquide HealthCare, and Muriel Bacarisse for collecting and monitoring data and for administrative, technical, and logistic support.

Many thanks to Ray Cooke for translation of the SEMSA items and copy-editing the paper.

Compliance with ethical standards

The study was conducted in accordance with the Declaration of Helsinki and French Good Clinical Practices.

Conflict of interest Dr. Weaver is Principal Investigator for the University of Illinois at Chicago site for the Jazz Pharmaceuticals 110 pharmaceutical clinical trial. She also receives royalty fees from the following companies for use of the Functional Outcomes of Sleep Questionnaire: Philips Respironics, Nyxoah, ResMed, Jazz Pharmaceuticals, NightBalance, and Inspire, Inc. The other authors report no conflicts of interest.

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