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Symptom content analysis of Obstructive Sleep Apnea (OSA) questionnaires: time to identify and improve relevance of diversity of OSA symptoms?

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Abstract (250 mots)

Study Objectives. Obstructive Sleep Apnea (OSA) is a heterogeneous condition covering many clinical phenotypes in terms of the diversity of symptoms. Patient-based OSA screening questionnaires used in routine practice contain significantly varying contents that can impact the reliability and validity of the screening. We investigated to what extent common patient-based OSA screening questionnaires differ or overlap in their item content by conducting a rigorous, methodical, and quantified content overlap analysis.

Methods. We conducted an item content analysis of 11 OSA screening questionnaires validated in adult populations and characterized their overlap using a four-step approach: i) selection of OSA screening questionnaires; ii) item extraction and selection; iii) extraction of symptoms from items; iv) assessment of content overlap with the Jaccard Index (from 0: no overlap to 1: full overlap).

Results. We extracted 72 items that provided 25 distinct symptoms from 11 selected OSA questionnaires. The overlap between them was weak (mean Jaccard Index 0.224, ranging from 0.138 to 0.329). All questionnaires contained symptoms of the “OSA symptom” dimension (e.g., snoring or witnessed apneas). The STOP-BANG (0.329) and the Berlin (0.280) questionnaires exhibited the highest overlap content. Ten symptoms (40%) were investigated in only one questionnaire.

Conclusions. The heterogeneity of content and the low overlap across these questionnaires reflect the challenges of screening OSA. The different OSA questionnaires potentially capture varying aspects of the disorder, with the risk of biased results in studies. Suggestions are made for better OSA screening and refinement of clinical OSA phenotypes.

Keywords: obstructive sleep apnea; sleep disorders; sleep symptoms; questionnaires; content analysis; symptom overlap.

Brief summary (120 words)

Current Knowledge/Study Rational

- Obstructive Sleep Apnea (OSA) is a heterogeneous condition with diverse clinical phenotypes, and existing patient-based OSA screening questionnaires may lack reliability and validity with regard to symptom diversity.
- Several systematic reviews of OSA screening questionnaires have demonstrated variations in contents, but there is still no rigorous, methodical and quantified analysis of the content overlap between them.

Study Impact

- A content overlap analysis of 11 validated OSA screening questionnaires revealed heterogeneity of content and low overlap between them, reflecting how challenging it is to screen OSA.
- This first step towards a broad reappraisal of a set of symptoms and clinical characteristics critical for OSA screening should lead to better OSA screening based on refinement of clinical OSA phenotypes.

Introduction

The prevalence of obstructive sleep apnea (OSA) varies between 9 and 13% in the general population but remains massively underdiagnosed. OSA is characterized by the repetitive occurrence of complete (apneas) or partial (hypopneas) upper airway collapses during sleep, leading to intermittent hypoxia, sleep fragmentation, and swings in intrathoracic pressure¹⁻³. The resulting hypoxic burden, autonomic activation, and sleepiness are the main predictors of poor clinical outcomes and altered quality of life in OSA^{4,5}. OSA is associated with multimorbidity and high mortality rates, in particular owing to an increased risk of cardiometabolic diseases⁶, psychiatric disorders⁷ and motor vehicle accidents^{8,9}. It is now acknowledged that OSA is a heterogeneous condition covering many clinical phenotypes in terms of OSA symptom diversity^{2,10}.

Owing to the high prevalence of OSA and its consequences, several patient-based OSA screening questionnaires have been developed. The STOP-BANG and the Berlin questionnaire are widely used^{11,12} and have the highest sensitivity and specificity, as reported in recent systematic reviews and meta-analyses¹³⁻¹⁷. Three main dimensions can be individualized in OSA questionnaires: specific “OSA symptoms” (e.g., snoring or witnessed apneas), “Sleep-related symptoms” (e.g., sleepiness or insomnia) and “Clinical characteristics” (e.g., age, sex, body mass index or neck circumference)¹¹. Not all three dimensions are present in all OSA questionnaires^{11,13,15-17} and each dimension is assessed by items that vary from one questionnaire to another¹³. In particular, a previous review identifying eight different validated patient-based OSA questionnaires found that the number of items in each questionnaire ranged from 3 to 12 items, with significantly varying contents¹³. Thus, empirical research is needed to refine the symptoms that should be investigated to improve OSA screening and phenotyping at the symptom level, as no consensus has emerged to date regarding the symptoms that should be systematically investigated in questionnaires to screen OSA¹³. As Abrishami et al. noted,

“a standard definition of factors is a prerequisite for standardizing questionnaire components and evaluating their values in different combinations”, and “a lack of standard definition of some factors involved in OSA questionnaire could also result in heterogeneity of the data among the studies”¹³. A rigorous discussion of questionnaires is possible only if the content investigated is well known. However, a rarely tested clinical assumption postulates that questionnaires are interchangeable when evaluating OSA. The lack of standardization and rationale for choosing specific questionnaires in clinical practice and research can potentially impact the reliability and validity of the screening of disorders^{11,13}. Indeed, the item content of a questionnaire can impact the reliability and validity of a questionnaire according to the type of population screened in terms of sex¹⁸, comorbid sleep disorders¹³, or other comorbidities^{7,19–21}. Furthermore, additional symptoms may be required to improve OSA clinical phenotyping^{2,10,22,23}. Thus, more relevant questionnaires are needed to capture the diversity of OSA symptoms. The first step before establishing new OSA questionnaires is to identify and list symptoms in existing OSA screening questionnaires. Such an analysis seems particularly important to understand and visualize the variability in the collection of data concerning OSA screening.

In this line, we need an informative, rigorous, methodical, and quantified approach to item content in existing OSA screening questionnaires. Several systematic reviews of OSA screening questionnaires have been published^{11,13–16,19} but there is still no systematic quantified analysis of the content overlap between them. However, such an approach was developed and validated in 2017 by Fried, who proposed a method for analyzing content overlap based on the Jaccard similarity coefficient to reveal the overlap between widely used patient-based questionnaires²⁴. Such symptom content overlap analysis has since been applied to various disorder questionnaires^{24–32} and we recently used it in sleep medicine by studying patient-based multiple sleep disorder screening questionnaires for adult populations²⁵. Here, we

conducted a systematic quantified analysis comparing item content in widely used adult patient-based OSA screening questionnaires ^{24,25}. We sought to establish to what extent common OSA screening questionnaires differ or overlap in their item content, to identify relevant symptoms that constitute consensual characteristics of OSA, to identify the differences between questionnaires and to pave the way for better evaluations of the diversity of OSA symptoms.

Methods

Our method is based on previous content overlap analysis studies^{25–32}. The reference method of content overlap analysis is Jaccard similarity coefficient calculation. If the overlap of symptom content between the scales is high, the questionnaires are interchangeable. If overlap is low, the challenge to develop and validate questionnaires in the context of clinical phenotyping becomes greater. The Jaccard method has not yet been applied to OSA screening questionnaires.

1.1. Selection of OSA screening questionnaires

We included any standardized validated OSA screening questionnaire with at least specific OSA symptoms (e.g., snoring or witnessed apneas) or sleep-related symptoms (e.g., sleepiness or insomnia), used as self-reported questionnaires, which can be completed by patients or clinicians and can be validated against in-laboratory polysomnography (PSG). Following a recently published systematic review¹³, we included eight adult OSA screening questionnaires validated against in-laboratory PSG: the STOP questionnaire (for Snoring, Tiredness, Observed apnea, and high blood Pressure)^{33,34}, the STOP-BANG questionnaire (STOP and BMI, Age, Beck circumference, Gender)³⁵, the Berlin questionnaire^{36–39}, the checklist of the American Society of Anesthesiologists (ASA)³⁷, the Wisconsin sleep questionnaire^{40,41}, the Sleep Apnea scale of the Sleep Disorders Questionnaire (SA-SDQ)^{42,43}, the Haraldsson questionnaire⁴⁴ and the Apnea Score (AS)⁴⁵.

To ensure exhaustiveness in the compilation of these questionnaires, we carried out a PubMed search with the following search terms: [(“Obstructive Sleep Apnea*” OR “OSA*”) AND (“diagnosis*” OR “scale*” OR “questionnaires*” OR “screen*” OR “psychometric*”). We identified four other OSA questionnaires: the NoSAS (for Neck circumference, obesity,

Snoring, Age, and Sex scores)^{46,47}, the Obstructive Sleep Apnea 50 questionnaire (OSA-50)⁴⁸, the GOAL (for Gender, Obesity, Age, and Loud snoring)⁴⁹, and the No-Apnea scale⁵⁰. The NoSAS, the OSA-50 and the GOAL questionnaires were validated against in-laboratory PSG but the No-Apnea scale was not and was excluded⁴⁹. A total of 11 questionnaires were finally included in the analysis.

1.2. Item extraction and selection

An item was defined as any question to be answered by the patient. A total of 72 items from the 11 OSA questionnaires were extracted (items relating to children in the ASA checklist were excluded), see **Supplementary Material 1**.

1.3. Extraction of symptoms from items

Extraction of symptoms from items involved three consecutive steps (see **Supplementary Material 1**). In agreement with previous similar analyses²⁵⁻³², a “symptom” was defined as any unit of analysis from an item. For example, “Daytime sleepiness” is a symptom. We also considered clinical characteristics such as “neck circumference” in this content analysis.

1.3.1. Symptom extraction from items in each questionnaire

Two medical students (MP and PAS) and four sleep experts (SB, AR, CG, and JAM) performed the extraction. In the event of disagreement between experts, consensus was sought by referring to two key sleep opinion leaders (PP and JLP). Some of the symptoms were split or lumped²⁵. For instance, in the STOP-BANG, item 2, “Do you often feel tired, fatigued, or sleepy during daytime?”, the following symptoms were extracted “Tired”, “Fatigued” and “Daytime sleepiness”. “Tired and “Fatigued” was lumped into a “Fatigue” symptom. “Daytime sleepiness” and “Fatigue” were split.

According to the terminology used in previous content overlap analysis studies²⁵⁻³², symptoms were categorized as follows: *compound* symptoms, *specific* symptoms, and *idiosyncratic* symptoms:

- A compound symptom is an item constructed on the basis of at least two distinct symptoms. For example, item 2 of the STOP-BANG questionnaire, “Do you often feel tired, fatigued, or sleepy during daytime?” encompasses both “Fatigue” and “Daytime sleepiness” symptoms.
- A specific symptom derives from an item constructed on the basis of a single symptom. For example, item 1 of the STOP-BANG questionnaire, “Do you snore loudly?” refers only to the symptom of “Loud snoring”. When a symptom can represent both a specific and a compound symptom, it was considered specific.
- Finally, an idiosyncratic symptom is a symptom appearing only once in a questionnaire among all the analyzed questionnaires. For example, the symptom “Waist circumference” appears only in the OSA-50 questionnaire (item 1).

1.3.2. *Harmonization of wording of the extracted symptom*

To better harmonize the wording of the extracted symptoms, we used an original conservative approach based on our previous work extracting and harmonizing symptoms in two international classifications of sleep disorders (ICSD-3 and Sleep-Wake disorders section of the Diagnostic and Statistical Manual of mental disorders (DSM-5)^{25,51-54} and on the previous dimensions identified in the literature^{11,13,37}. First, we harmonized symptoms that were considered as worded similarly between questionnaires. For instance, “Snoring loud enough to be heard through closed doors” in the ASA index (item 6) and “I am told I snore loudly or bother others” in the SDA-SDQ (item 1), were harmonized into one symptom: “Loud snoring”

Second, we organized the extracted symptoms into three main dimensions. The main dimension of “OSA symptoms” was defined as the set of specific symptoms related to the underlying pathophysiological mechanism, i.e., repeated upper airway collapses. The “Sleep-related symptoms” dimension was defined as the set of symptoms related to sleep and daytime disturbances induced by OSA. The “Clinical characteristics” dimension was defined as the set of specific characteristics of the patient that can be identified in clinical practice and have been reported as being related to OSA.

1.3.3. Data aggregation

The last step of data preparation was to code the collected symptoms on a three-point rating scale: specific or idiosyncratic symptoms were coded 1; compound symptoms were coded 2. If a symptom was absent from a specific questionnaire, it was coded 0.

1.4. Statistical analysis

1.4.1. Number and frequency of sleep symptoms

Three types of analyses were performed: i) the frequency of symptoms identified in the questionnaires (from the most frequent to the least frequent on all dimensions and regarding the three dimensions: OSA symptoms, Sleep-related symptoms and Clinical characteristics), ii) the distribution of the symptoms found in each questionnaire across the three dimensions, and iii) the identification of the questionnaires with the highest number of symptoms and with the highest number of specific and compound symptoms in each questionnaire (to assess the lack of precision due to items constructed on the basis of at least two distinct symptoms).

1.4.2. Content overlap analysis

The Jaccard Index (or “Jaccard similarity coefficient”) measures the similarity between binary data, with values ranging from 0 (no overlap among questionnaires) to 1 (complete overlap). It is calculated by the following equation: $s/(u1 + u2 + s)$, with s representing the number of symptoms shared by two questionnaires, and $u1$ and $u2$ the number of symptoms that are unique to each one ²⁴. In line with previous studies that used this type of content analysis ^{25–32} and considering the absence of well-cited guidelines on the strengths and weaknesses of the Jaccard similarity coefficient, we used the *Evans’ Straightforward Statistics for the Behavioral Sciences* rule of interpretation for the Jaccard Index ⁵⁵: very weak: (0.00-0.19), weak: (0.20-0.39), moderate: (0.40-0.59), strong: (0.60-0.79), and very strong: (0.80-1).

We conducted three Spearman correlations of the Jaccard Index, one with the total number of symptoms captured by a questionnaire (to investigate whether the length of the questionnaire played a role in the overlap), one with the number of specific symptoms and one with the number of compound symptoms (to investigate whether the presence of specific or compound symptoms played a role in the overlap). Finally, we calculated the Jaccard Index for each dimension to evaluate content overlap on each of the three dimensions of the OSA questionnaires. We also calculated pairwise overlaps to analyze the overlap between each questionnaire.

1.4.3. Data visualization of content overlap

We provide two graphical representations of the distribution across the categories of the symptoms measured in each questionnaire using the Python package *plotly*¹. The first one, plotted in **Figure 4**, is an interactive radar plot that represents the different symptoms identified in each questionnaire. It demonstrates the symptom overlap between questionnaires, each concentric circle representing a questionnaire and each point representing a symptom (when

¹<https://github.com/plotly/plotly.py>

there are several “points” on the same “radius”, this means that there is significant overlap between several OSA questionnaires). The second one, plotted in **Figure 5**, is a sunburst plot, that visualizes the hierarchical arrangement of the symptoms within the three dimensions and proposes subdimensions. This hierarchization of symptoms, subdimensions and dimensions is a purely exploratory proposal for making it easier to visualize symptoms.

1.4.4. Availability and reproducibility of results

Based on a previous sleep overlap study and with a view to openness and sharing, all our data, results, figures, tables, and code are available in a GitHub repository². This repository contains the analysis notebook already executed and saved in html format³. To foster reproducibility of these results, we set up a Binder repository⁴, allowing any interested researcher to reproduce our results fully online.

²<https://github.com/vincentpmartin/OSAS.content.analysis>

³https://raw.githubusercontent.com/vincentpmartin/OSAS.content.analysis/main/jupyter_notebook_OSAS_content_analysis.html

⁴https://mybinder.org/v2/gh/vincentpmartin/OSAS.content.analysis/HEAD?labpath=jupyter_notebook_OSAS_content_analysis.ipynb

Results

1.1. Number and frequency of symptoms and clinical characteristics

The 11 questionnaires were composed of 72 items, representing 25 distinct symptoms from the 74 extracted from all the questionnaires. **Figure 1** shows the frequency of each symptom from the most frequent to the least frequent overall, further classified according to the three dimensions: OSA symptoms, Sleep-related symptoms and Clinical characteristics. The most common symptoms were “Stop breathing observations” (appearing in 9 questionnaires out of 11 – 81.8%), “Loud Snoring” (appearing in 8 questionnaires out of 11 – 72.0%) and “Snoring” (appearing in 6 questionnaires out of 11 – 54.5%), all of them belonging to the “OSA symptom” dimension.

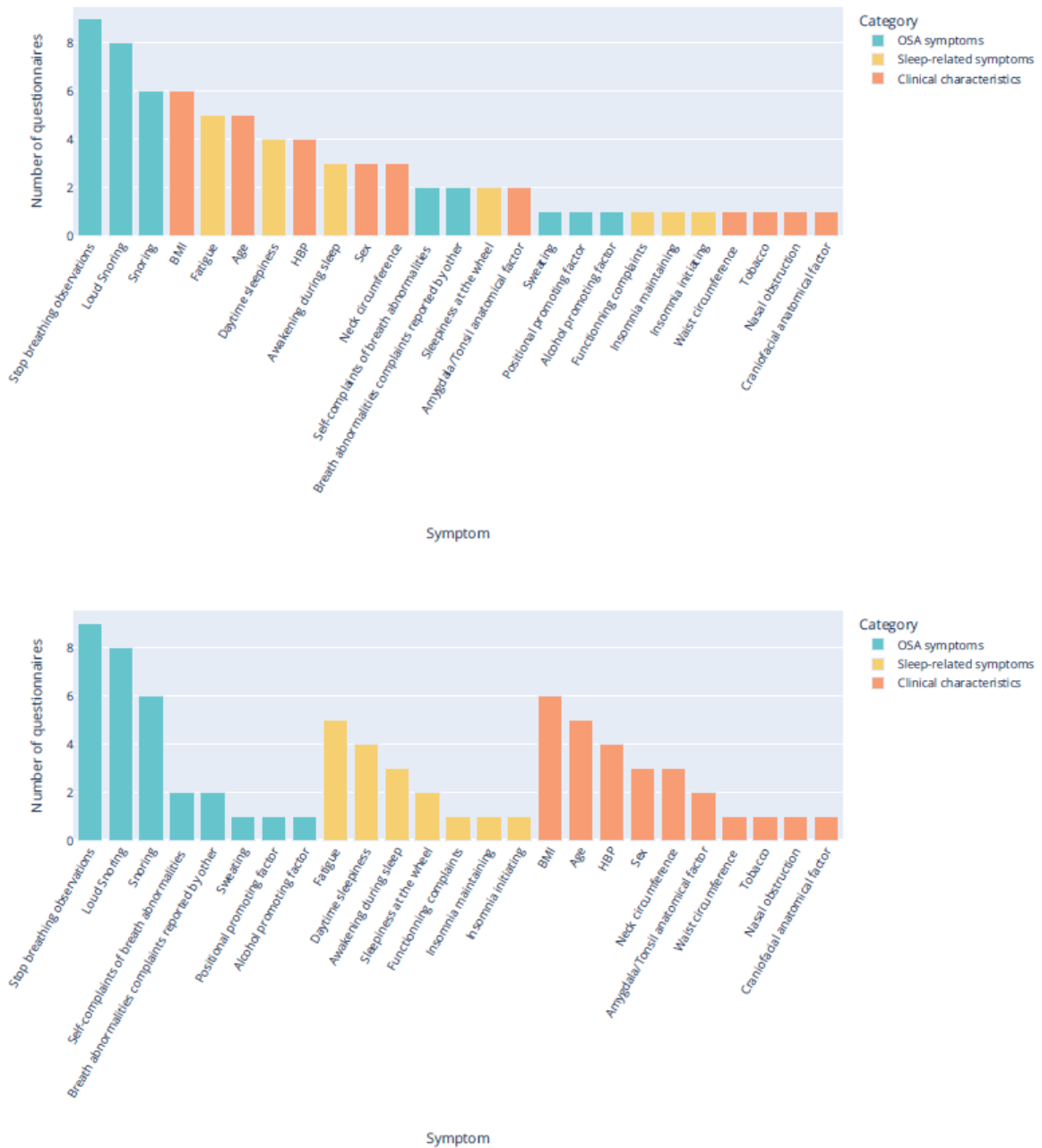


Figure 1—Frequency of symptoms and clinical characteristics identified in the 11 OSA questionnaires. (**Top**) Plot organized from the most frequent to the least frequent for all dimensions. (**Bottom**) Plot organized from the most frequent to the least frequent regarding the three dimensions as identified previously^{53,54,61}.

Figure 2 shows the graphical representation of the distribution of the symptoms and clinical characteristics found in each questionnaire across the three dimensions. Five questionnaires do not contain any symptom from the “Sleep-related symptoms” dimension (NoSAS, GOAL,

OSA-50, AS, Wisconsin questionnaires)^{41,45,46,48,49}; and two questionnaires do not contain any symptom from the “Clinical characteristics” dimension (Haraldsson and Wisconsin questionnaires)^{41,44}. All questionnaires have symptoms of the “OSA symptoms” dimension. The number and the distribution of OSA symptoms across all dimensions for each questionnaire are available in our online analysis notebook⁵.

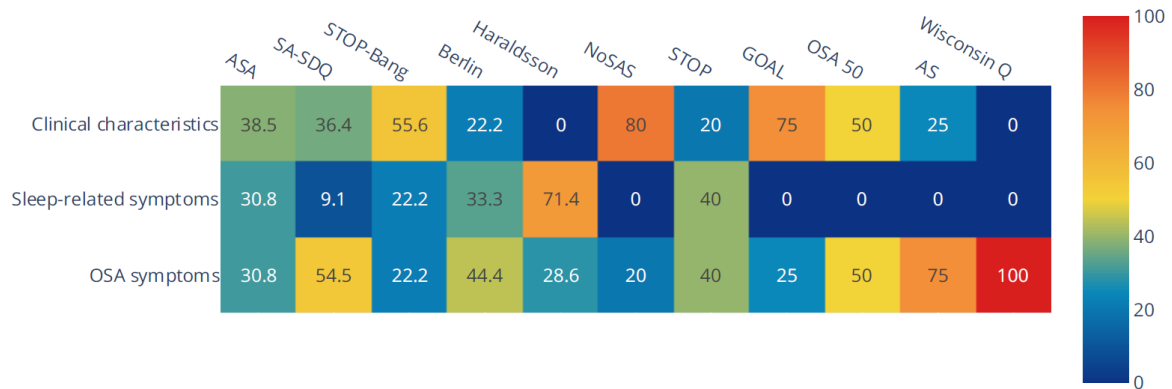


Figure 2–Distribution of the symptoms found in each questionnaire across the three dimensions. The color bar corresponds to the percentages of symptoms per questionnaire according to the three dimensions. ASA: American Society of Anesthesiologists checklist; SA-SDQ: Sleep Apnea scale of the Sleep Disorders Questionnaire; STOP-BANG: Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Beck circumference, Gender); NoSAS: Neck Circumference, Obesity, Snoring, Age, and Sex scores); STOP: Snoring, Tiredness, Observed apnea, high blood Pressure; GOAL: Gender, Obesity, Age, Loud snoring; OSA-50: Obstructive Sleep Apnea 50 questionnaire; AS: Apnea Score.

The questionnaires containing the largest number of symptoms were the ASA (N = 13/25), the SA-SDQ (N = 11/25), and the STOP-BANG and the Berlin questionnaires (N = 9/25) (Table 1). Among the 74 symptoms extracted from the questionnaires, 16 were compound symptoms (21.6%) and 58 were specific symptoms (78.4%). Among the 25 distinct symptoms, 10 symptoms were idiosyncratic (40%), appearing only in one questionnaire. The questionnaires

⁵

https://raw.githubusercontent.com/vincentpmartin/OSAS.content.analysis/main/jupyter_notebook_OSAS_content_analysis.html

with the largest number of compound symptoms were the ASA and the Haraldsson (resp. 4/7 and 4/13), followed by the STOP-BANG (7/9), the STOP (3/5) and the AS (2/4) (**Table 1**).

1.2. Content overlap analysis

Table 1 presents the mean Jaccard Index, the number of items, and the number of specific and compound symptoms per questionnaire. The mean overlap between the questionnaires evaluated with the Jaccard Index was 0.237 (SD = 0.054), indicating a low similarity. The questionnaire with the highest mean Jaccard index was the STOP-BANG (0.329), followed by the Berlin questionnaire (0.280), the ASA checklist (0.257) and the STOP questionnaire (0.267). These four questionnaires are also those with symptoms belonging to the three dimensions. Nevertheless, the correlations between the Jaccard Index and the total number of symptoms or the number of specific symptoms or compound symptoms were not significant (respectively: $\rho = 0.115$, $p = 0.735$, $\rho = 0.0$, $p = 1$, and $\rho = 0.245$, $p = 0.467$), suggesting that neither the length of the questionnaire nor the presence of specific or compound symptoms played a role in the overlap.

Regarding the dimensions, the mean overlap was the highest for the “OSA symptoms” dimension (0.393), followed by the “Sleep-related symptoms” dimension (0.319). The lowest overlap between questionnaires was found for the “Clinical characteristics” dimension (0.213). Lastly, concerning the pairwise analysis, the STOP-BANG and the STOP had a high pairwise overlap (0.556). The Wisconsin and the AS had the highest pairwise overlap (0.750), followed by the GOAL and the NoSAS (0.500) and the GOAL and the STOP-BANG (0.444). (**Figure 3**).

Table 1. Average Jaccard Index, number of items and of specific and compound symptoms in the OSA questionnaires. ASA: American Society of Anesthesiologists checklist; SA-SDQ: Sleep Apnea scale of the Sleep Disorders Questionnaire; STOP-BANG: Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Beck circumference, Gender); NoSAS: Neck Circumference, Obesity, Snoring, Age, and Sex scores); STOP: Snoring, Tiredness, Observed apnea, high blood Pressure; GOAL: Gender, Obesity, Age, Loud snoring; OSA-50: Obstructive Sleep Apnea 50 questionnaire; AS: Apnea Score.

	Average Jaccard Index	Number of items	Specific symptoms	Compound symptoms	Total number of symptoms
ASA	0.257	12	9	4	13
SA-SDQ	0.210	12	10	1	11
STOP-BANG	0.329	8	7	2	9
Berlin	0.280	11	8	1	9
Haraldsson	0.192	5	3	4	7
NoSAS	0.189	6	5	0	5
STOP	0.267	4	3	2	5
GOAL	0.209	4	4	0	4
OSA 50	0.138	4	4	0	4
AS	0.261	3	2	2	4
Wisconsin	0.274	3	3	0	3
MEAN / TOTAL	0.237 (mean)	72 (total)	58 (total)	16 (total)	74 (total)



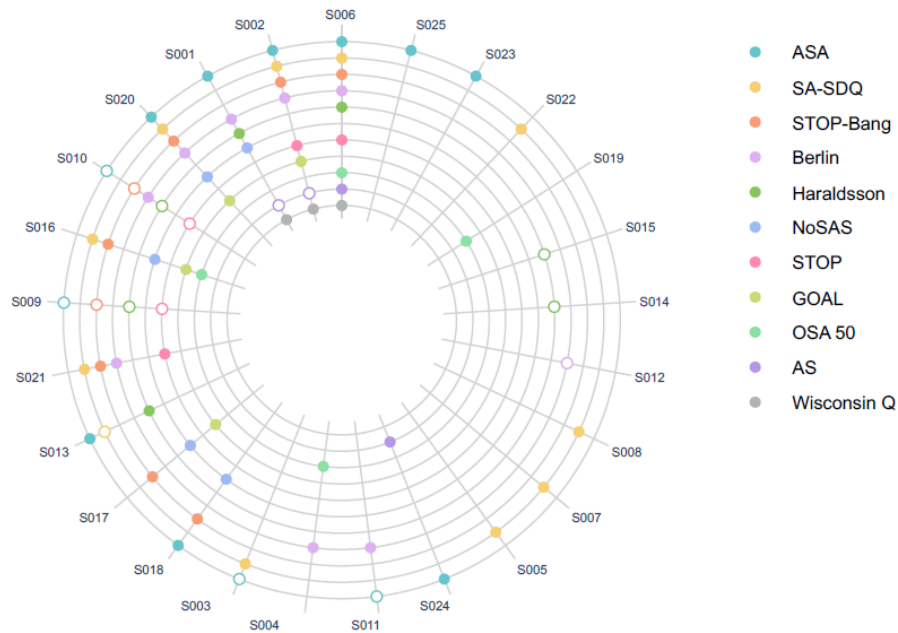
Figure 3–Jaccard Index overlap of item content of the 11 OSA questionnaires for each pair of questionnaires. The numbers from 0 to 1 in the color bar refer to the corresponding percentages. ASA: American Society of Anesthesiologists checklist; SA-SDQ: Sleep Apnea scale of the Sleep Disorders Questionnaire; STOP-BANG: Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Beck circumference, Gender); NoSAS: Neck Circumference, Obesity, Snoring, Age, and Sex scores); STOP: Snoring, Tiredness, Observed apnea, high blood Pressure; GOAL: Gender, Obesity, Age, Loud snoring; OSA-50: Obstructive Sleep Apnea 50 questionnaire; AS: Apnea Score.

1.3. Data visualization of content overlap

Figure 4 shows the analysis of the content overlap of OSA symptoms in the 11 questionnaires (see <https://chart-studio.plotly.com/~vincent.martin/41/#/> for an interactive version online).

A hierarchical arrangement of the symptoms according to the proposed dimensions and subdimensions is given in the sunburst plot in **Figure 5** (see <https://chart->

studio.plotly.com/~vincent.martin/43/#/ for an interactive version online). The proposed subdimensions should not be considered as definitive. These subdimensions illustrate how such visualization helps in grasping the organization and the wording of symptoms with a view to improving the nosology of sleep disorders.



OSA symptoms

S001: Snoring
 S002: Loud snoring
 S003: Self-complaints of breath abnormalities
 S004: Breath abnormalities complaints reported by other
 S005: Sweating
 S006: Stop breathing observations
 S007: Positional promoting factor
 S008: Alcohol promoting factor

Sleep-related symptoms

S009: Daytime sleepiness
 S010: Fatigue
 S011: Sleepiness at the wheel
 S012: Functioning complaints
 S013: Awakening during sleep
 S014: Insomnia maintaining
 S015: Insomnia initiating

Clinical characteristics

S016: Age
 S017: Sex
 S018: Neck circumference
 S019: Waist circumference
 S020: BMI
 S021: HBP
 S022: Tobacco
 S023: Nasal obstruction
 S024: Amygdala/Tonsil anatomical factor
 S025: Craniofacial anatomical factor

Figure 4—Content overlap of the Obstructive Sleep Apnea (OSA) symptoms in the 11 selected OSA questionnaires. The figure illustrates the symptom overlap between questionnaires: each concentric circle represents a questionnaire, and each point represents a symptom. When there are several “points” on the same “radius”, this means that there is significant overlap between several OSA questionnaires. Colored circles for a symptom indicate that this is a specific symptom, while empty circles indicate that this is a compound symptom. See also the interactive version of this Figure online: <https://chart-studio.plotly.com/~vincent.martin/41/#/>. ASA: American Society of Anesthesiologists checklist; SA-SDQ: Sleep Apnea scale of the Sleep Disorders Questionnaire; STOP-BANG: Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Beck circumference, Gender); NoSAS: Neck Circumference, Obesity, Snoring, Age, and Sex scores); STOP: Snoring, Tiredness, Observed apnea, high blood Pressure; GOAL: Gender, Obesity, Age, Loud snoring; OSA-50: Obstructive Sleep Apnea 50 questionnaire; AS: Apnea Score. HBP: High Blood Pressure. BMI: Body Mass Index.

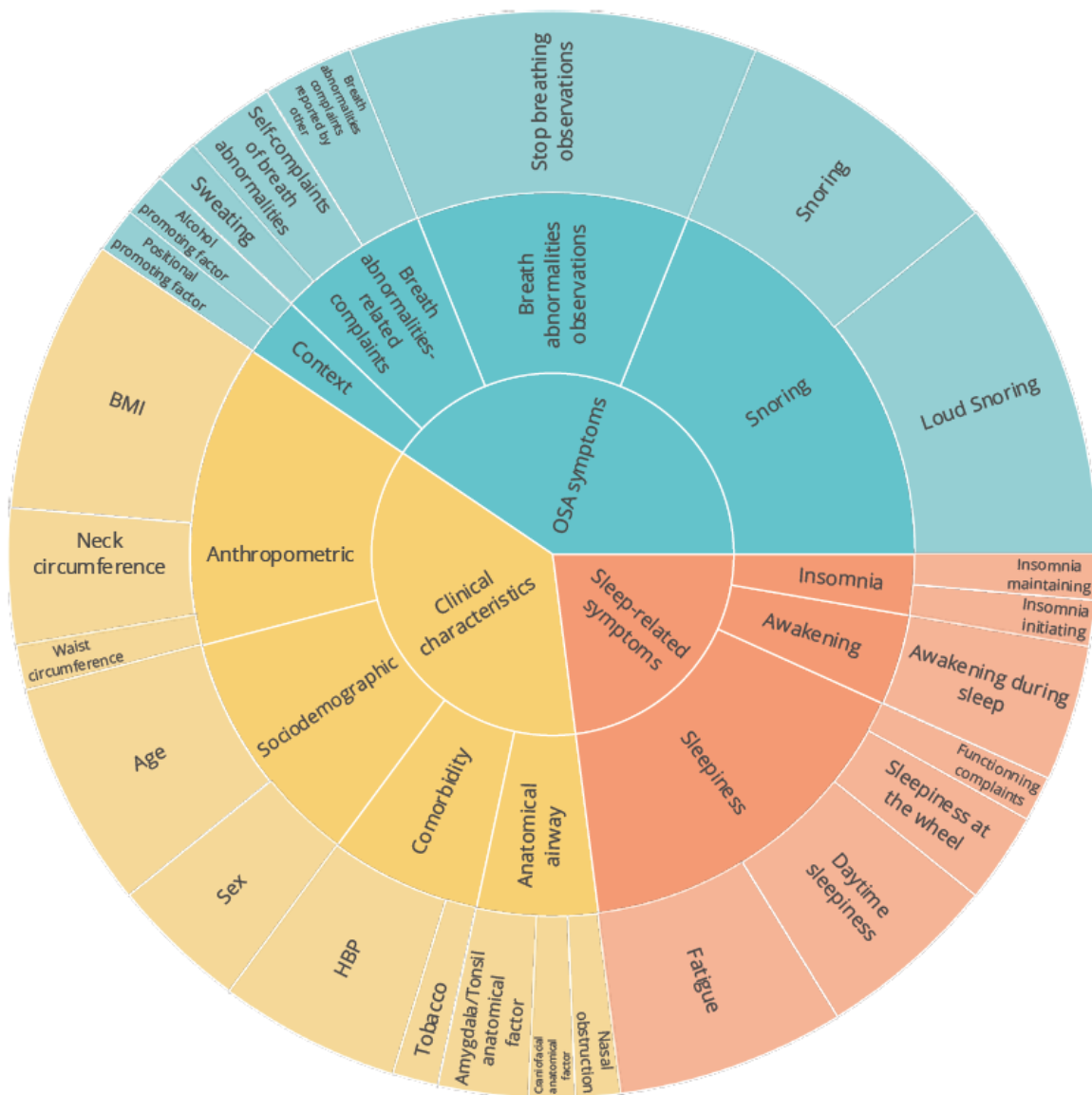


Figure 5—Sunburst plot indicating the hierarchical arrangement of the symptoms according to subdimensions and dimensions. This hierarchization of symptoms, subdimensions and dimensions is a purely exploratory proposal for making it easier to visualize symptoms. Yellow: Clinical characteristic dimension; Red: Sleep-related symptom dimension; Blue: OSA symptom dimension. OSA: Obstructive Sleep Apnea; HBP: High Blood Pressure; BMI: Body Mass Index. Please also see the interactive version of this Figure online: <https://chart-studio.plotly.com/~vincent.martin/43/#/>.

Discussion

This is the first rigorous, methodical and quantified symptom content analysis in widely used patient-based screening OSA questionnaires for adult populations. The “OSA symptoms” dimension (e.g., snoring or witnessed apneas) was found in all questionnaires, confirming their central role in the definition of OSA¹⁻³. The STOP-BANG questionnaire, considered as the most accurate OSA screening questionnaire^{13,14,35,38,38}, was the questionnaire with the highest overlap content analysis, confirming that the choice of items exploring a range of symptoms in the three main dimensions of OSA (“OSA symptoms”, “Sleep-related symptoms” and “Clinical characteristics”) constitute consensual characteristics of OSA^{11,13}.

Nevertheless, our analysis highlights the considerable heterogeneity between the 11 selected OSA questionnaires (i.e., a weak overlap – with a mean Jaccard Index at 0.237). Our analysis found that 40% of symptoms were covered by only one questionnaire. When investigating by dimension, the heterogeneity was the lowest for “OSA symptoms” (with a mean Jaccard Index of 0.393, close to the threshold considered as moderate), but was high for “Sleep-related symptoms” and “Clinical characteristics”. This heterogeneity is due to the presence or absence of items exploring symptoms (**Figure 2**), but also to the choice of the symptoms selected to investigate such a dimension (e.g. “Snoring” or “Loud snoring”) (**Figure 4 and 5**). It is thus important to identify the differences between questionnaires. The STOP-BANG questionnaire and the Berlin questionnaire explore all the main dimensions of OSA, but they do not contain any item probing the symptoms of insomnia, despite its importance for classifying OSA severity and treatment indications⁵⁶, in line with the concept of Comorbid Insomnia and OSA (COMISA)⁵⁷⁻⁶⁰. The Haraldsson questionnaire is composed of seven main symptoms belonging to the “Sleep-related symptoms” dimension, including interestingly insomnia symptoms, but four of these sleep-related symptoms are compound, thus limiting the precision of symptom evaluation⁴⁴. The anatomical airways clinical characteristics subdimension

(amygdala/tonsil and craniofacial anatomical factors, nasal obstruction) was found in only two questionnaire (the ASA³⁷ and the AS⁴⁵). Lastly, except for hypertension, which was found in four questionnaires (the STOP³³, the STOP-BANG³⁵, the Berlin³⁸ and the SA-SDQ^{42,43} questionnaires), the other main cardiometabolic comorbidities of OSA were absent from our content analysis.

This low overlap between the questionnaires underlines the challenge and need to develop and validate new questionnaires that improve clinical screening accuracy while capturing the diversity of OSA symptoms. Indeed, a consensual list and definition of disorder-related symptoms is a prerequisite for standardizing the contents of questionnaires and evaluating their performance in different combinations^{13,61}. Although the objective of this study was not to propose a new questionnaire, the present results are a first step to support research questions about OSA screening so that the diversity of clinical phenotypes may be readily grasped^{2,10}. By making it possible to select more explicitly specific items from dimensions and sub-dimensions found in existing OSA screening questionnaires, the development of specific questionnaires to screen OSA in specific populations will be facilitated, especially with regard to sex¹⁸, comorbid sleep disorders (in particular insomnia and hypersomnolence)¹³, and other comorbidities^{7,19-21}. It will thus be easier to evaluate specific clinical phenotypes. For instance, this overlap analysis can support the search for sex-related phenotypes^{18,62-64} by identifying the most relevant symptoms of certain characteristics in a group, e.g. neck circumference^{65,66}. A putative explanation of the considerable heterogeneity between the 11 questionnaires is that they were not developed to investigate the same construct. In particular, some important symptoms related to the construct defined by the ICSD-3 (i.e., “non-restorative sleep”, called “unrefreshing sleep” in the ICSD-2, and replaced by “impaired sleep-related quality of life” in the ICSD-3-TR), by the ICSD-1-TR (i.e., “morning headaches”, “dry mouth upon awakening”) or by the classical description of the disorder by OSA experts^{1-3,67-69} (i.e., “headache”, “dry

mouth”, “nocturia”, “sexual dysfunction”, “mood alteration”, or “attentional alteration”) do not seem to have played an important role in delineating the construct screened by the questionnaires, as they were not found in any of the 11 questionnaires. We suggest that the questionnaires evaluate two different constructs. Five questionnaires seem to have been developed to screen for OSA as defined by the apnea-hypopnea index (AHI) and exhibit high pairwise overlap (the NoSAS⁴⁷, the GOAL⁴⁹, the OSA-50⁴⁸, the AS⁴⁵ and the Wisconsin⁴¹). Six questionnaires seem to have been developed with a more symptom-based phenotypic approach but exhibit less pairwise overlap (the STOP-BANG³⁵, the STOP³³, the Berlin³⁸, the ASA³⁷, the SA-SDQ^{42,43}, and the Haraldsson⁴⁴). Nevertheless, these 6 questionnaires are of interest in regard to the fact that the consensual AHI metric may not be adequate for predicting OSA outcomes and representing the diversity of pathophysiological mechanisms^{68,70-72}, and that it was recently proposed to combine symptom-based phenotypic approaches with the AHI and other markers of the pathophysiological consequences of OSA such as hypoxic burden and autonomic activation^{10,72,73 10,74}.

Such overlap analysis may thus prove particularly useful for the future refinement of OSA clinical phenotypes in terms of OSA symptom diversity. Several stratification studies have been performed in OSA to define phenotypes in order to predict risk and treatment outcomes and response²². When these studies investigated symptoms in stratification analyses, they generally identified three clinical phenotypes: “disturbed sleep”, “excessive daytime sleepiness” and “minimally symptomatic”^{22,23,68,75-80}. However, the symptoms were investigated neither with common validated OSA screening questionnaires (analyzed in the current study) nor with the same list of questions and symptoms across studies of clinical phenotypes. They were investigated in the Icelandic Sleep Apnea Cohort (ISAC) cohort^{23,81,82} by the Basic Nordic Sleep Questionnaire (BNSQ)⁸³, which is more focused on sleep complaints than on OSA screening⁸³, or by a questionnaire similar to the BNSQ in the Sleep

Heart Health Study (SHHS) cohort ^{77,79} and the Sleep Apnea Global Interdisciplinary Consortium (SAGIC) cohort ⁷⁸. Various OSA symptom questionnaires were used in two different French cohorts ^{84,85} and a Korean cohort ⁸⁶. Such variability highlights the need for a symptom correspondence matrix between cohorts in order to better compare the stratification of clinical phenotypes. Interestingly, in the article by Mazzotti et al. on the SHHS cohort ⁷⁷, the supplementary material provides such a correspondence matrix between the SHHS, ISAC and SAGIC cohorts, but it is not sufficiently meaningful visually to be useful for the community. The results of our content analysis therefore illustrate the need to pursue the search for a consensus regarding the combination of symptoms. Moreover, the proposed visualization of an explicit symptom correspondence matrix would make it possible to compare the relevant clinical phenotypes in the era of stratified medicine for OSA ^{68,75}.

Among the clinical phenotypes proposed in clinical practice, the phenotypic approach of the Baveno classification was designed by the working group of the Sleep-Disordered Breathing Group of the European Respiratory Society and the European Sleep Research Society (ESRS) ^{56,72,87}. It is the first attempt for a consensus clinical phenotype-based approach of OSA based on a two-dimensional scheme divided into four groups. In this consensus, the severity of symptoms (mild or severe) is combined with the presence and severity of comorbidities (minor or major end-organ impact). This classification requires an investigation of sleep-related symptoms (e.g., non-restorative sleep, insomnia, or sleepiness symptoms), and clinical characteristics (e.g. hypertension, cardiovascular disease). In our content analysis, interestingly, daytime sleepiness or sleepiness at the wheel were found in only five questionnaires (the STOP ³³, the STOP-BANG ³⁵, the Berlin ³⁸, the ASA ³⁷ and the Haraldsson ⁴⁴ questionnaires) and insomnia symptoms were found in only one (the Haraldsson questionnaire ⁴⁴), as compound symptoms in both cases. Both symptoms of sleepiness and insomnia in the Baveno classification were found only in the Haraldsson questionnaire⁴⁴. The

combination of sleep-related symptoms and clinical characteristics (in terms of end-organ damages) was found in only three questionnaires (the STOP³³, the STOP-BANG³⁵ and the Berlin³⁸) but was limited to hypertension. Our content analysis highlights the gap between OSA screening questionnaires and symptom-based phenotypic studies^{22,23}, or the Baveno classification⁷², and the value of better evaluating and visualizing OSA symptoms and characteristics by using dedicated OSA questionnaires to establish clinical phenotypes.

Another way of refining the clinical phenotypes of OSA is to take into account precise anatomical (airways characteristics) and physiological traits (inadequate responsiveness of the genioglossus dilating muscle, low respiratory arousal threshold, and instability of the respiratory control system), namely “endotyping” in the era of precision medicine for OSA^{68,76}. Of course, it is more difficult for questionnaires, which are constructed on a symptom-based phenotypic approach, to contribute to the identification of endotypes. These questionnaires were not constructed on the basis of physiological traits but rather on anatomical traits for some of them, as in the ASA³⁷ and the AS⁴⁵. Awakening during sleep was found in three questionnaires (the Haraldsson⁴⁴, the ASA³⁷ and the SA-SDQ^{42,43}), and might be related to one of the physiological traits, i.e., low respiratory arousal threshold, but this needs to be further validated. Nevertheless, the results of our content analysis demonstrate why it is important to better assess the relationships between some symptoms or characteristics and some specific endotypes.

This study has some limitations. First, questionnaires focusing on OSA symptoms but not designed specifically for OSA screening (e.g., the BNSQ⁸³) and screening approaches based on probability score calculations were not included, as recommended by Abrishami et al.¹³. Nevertheless, the confluence of probability score calculations with OSA screening questionnaires could be of interest^{14,88,89}, and the content overlap analysis of predictive models should be cross-analyzed with patient-based screening questionnaires in further studies.

Moreover, OSA questionnaires with patient-reported outcomes (PRO) were not analyzed^{74,90}. However, five OSA questionnaires investigate symptoms which can be considered as PRO for sleep disturbances and sleep-related impairments⁹¹ (the STOP-BANG³⁵, the STOP³³, the Berlin³⁸, the ASA³⁷ and the Haraldsson⁴⁴). Following on from the work of Abma et al.⁹⁰ regarding the importance of PRO for developing clinical markers measuring the views of patients on their health and health-related quality-of-life symptoms, a systematic overlap content analysis of OSA PRO questionnaires should be conducted in subsequent research. Secondly, regarding the split and lump procedure, the items were separated or grouped together while remaining as conservative as possible²⁴. This split and lump was constrained by clinical relevance²⁴. Nevertheless, the impact of the granularity of the extraction of the symptoms in terms of precision should be further analyzed (*i.e.*, the split between, “Snoring” and “Loud snoring”, or the split between “Stop breathing observation” and “Breath abnormalities complaints reported by others” for witnessed apneas). Lastly, regarding overlap content analysis, we did not investigate the specific characteristics of the populations that were studied when OSA screening questionnaires were validated. Questionnaires validated in different specific populations (e.g. relative to sex¹⁸, comorbid sleep disorders¹³, or other comorbidities^{7,19–21}) should therefore be compared.

In conclusion, our analysis offers an informative, rigorous, methodical, and quantified approach to item content in existing OSA screening questionnaires. It is a first step towards a broad reappraisal of a set of symptoms and clinical characteristics critical for OSA screening and diagnosis in the era of stratified and precision medicine for OSA. The heterogeneity of content and the low overlap across these questionnaires reflect how challenging it is to screen OSA. Beyond the quest for refining clinical OSA phenotypes in OSA screening, the analysis demonstrates that the current questionnaires potentially capture different aspects of the disorder, with a resulting risk of bias. If the combinations of the contents of OSA questionnaires

could be evaluated more precisely, research findings could be compared more accurately, and bias could be reduced. In this line, further research should better explicit the list of symptoms and clinical characteristics collected in the shift towards stratified and precision medicine for OSA. The principle of prudent conservatism ⁹², whereby a clinical picture of OSA is shared thanks to a consensual core of symptoms that overlap between several questionnaires (e.g. snoring and witness apneas), should be combined with the quest for permanent innovation ⁹², in the view of a personalized symptom-based approach for evaluating OSA.

Abbreviations :

AS: Apnea Score

ASA: American Society of Anesthesiologists checklist

GOAL: Gender, Obesity, Age, Loud snoring

Comorbid association between Insomnia and OSA: COMISA

ESRS: European Sleep Research Society

NoSAS: Neck Circumference, Obesity, Snoring, Age, and Sex scores

OSA: Obstructive Sleep Apnea

PRO: Patient-Reported Outcomes

SA-SDQ: Sleep Apnea scale of the Sleep Disorders Questionnaire

STOP: Snoring, Tiredness, Observed apnea, high blood Pressure

STOP-BANG: Snoring, Tiredness, Observed apnea, high blood Pressure, BMI, Age, Beck circumference, Gender

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Author Contributions

Conceptualization, C.G., V.M., J.C. and J.-A.M.-F.; methodology, C.G., V.M., J.C., S.B. and J.-A.M.-F.; software, C.G., V.M., A.R., M.P., and P.A.S.; validation, J.-A.M.-F., S.B, J.C., A.R. and J.-L.P.; formal analysis, C.G., V.M. and J.-A.M.-F.; writing—original draft preparation, C.G., V.M. and J.-A.M.-F.; writing—review and editing, S.B., R.L., M.P., P.S.A, P.P., J.-L.P. and J.-A.M.-F.; supervision J.-A.M.-F. All authors have read and agreed to the published version of the manuscript.

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Supplementary Materials

Supplementary Material 1: Item extraction and selection for each questionnaire, and symptom extraction and terminology harmonization between questionnaires.

Supplementary Material 2: Online analysis notebook containing all the results and interactive figures, available at:

https://raw.githubusercontent.com/vincentpmartin/OSAS.content.analysis/main/jupyter_notebook_OSA_S_content_analysis.html.

All our code, data, figures and tables and a dedicated repository to reproduce our results online with custom data is available at: <https://github.com/vincentpmartin/generic.content.analysis>.

References

1. Jordan AS, McSharry DG, Malhotra A. Adult obstructive sleep apnoea. *Lancet Lond Engl*. 2014;383(9918):736-747. doi:10.1016/S0140-6736(13)60734-5
2. Lévy P, Kohler M, McNicholas WT, et al. Obstructive sleep apnoea syndrome. *Nat Rev Dis Primer*. 2015;1(1):1-21. doi:10.1038/nrdp.2015.15
3. Veasey SC, Rosen IM. Obstructive Sleep Apnea in Adults. Solomon CG, ed. *N Engl J Med*. 2019;380(15):1442-1449. doi:10.1056/NEJMc1816152
4. Bock J, Covassin N, Somers V. Excessive daytime sleepiness: an emerging marker of cardiovascular risk. *Heart*. 2022;108(22):1761-1766. doi:10.1136/heartjnl-2021-319596
5. Trzepizur W, Blanchard M, Ganem T, et al. Sleep Apnea-Specific Hypoxic Burden, Symptom Subtypes, and Risk of Cardiovascular Events and All-Cause Mortality. *Am J Respir Crit Care Med*. 2022;205(1):108-117. doi:10.1164/rccm.202105-1274OC
6. Pépin JL, Jullian-Desayes I, Sapène M, et al. Multimodal Remote Monitoring of High Cardiovascular Risk Patients With OSA Initiating CPAP: A Randomized Trial. *Chest*. 2019;155(4):730-739. doi:10.1016/j.chest.2018.11.007
7. Gupta MA, Simpson FC. Obstructive sleep apnea and psychiatric disorders: a systematic review. *J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med*. 2015;11(2):165-175. doi:10.5664/jcsm.4466
8. Bioulac S, Micoulaud-Franchi JA, Arnaud M, et al. Risk of Motor Vehicle Accidents Related to Sleepiness at the Wheel: A Systematic Review and Meta-Analysis. *Sleep*. 2017;40(10):zsx134. doi:10.1093/sleep/zsx134
9. Philip P, Bailly S, Benmerad M, et al. Self-reported sleepiness and not the apnoea hypopnoea index is the best predictor of sleepiness-related accidents in obstructive sleep apnoea. *Sci Rep*. 2020;10(1):16267. doi:10.1038/s41598-020-72430-8
10. Pevernagie, Gnidovec-Strazisar B, Grote L, et al. On the rise and fall of the apnea-hypopnea index: A historical review and critical appraisal. *J Sleep Res*. 2020;29(4):e13066. doi:10.1111/jsr.13066
11. Chiu HY, Chen PY, Chuang LP, et al. Diagnostic accuracy of the Berlin questionnaire, STOP-BANG, STOP, and Epworth sleepiness scale in detecting obstructive sleep apnea: A bivariate meta-analysis. *Sleep Med Rev*. 2017;36:57-70. doi:10.1016/j.smr.2016.10.004
12. Senaratna CV, Perret JL, Matheson MC, et al. Validity of the Berlin questionnaire in detecting obstructive sleep apnea: A systematic review and meta-analysis. *Sleep Med Rev*. 2017;36:116-124. doi:10.1016/j.smr.2017.04.001
13. Abrishami A, Khajehdehi A, Chung F. A systematic review of screening questionnaires for obstructive sleep apnea. *Can J Anaesth J Can Anesth*. 2010;57(5):423-438. doi:10.1007/s12630-010-9280-x
14. Bernhardt L, Brady EM, Freeman SC, et al. Diagnostic accuracy of screening questionnaires for obstructive sleep apnoea in adults in different clinical cohorts: a systematic review and meta-analysis. *Sleep Breath*. 2022;26(3):1053-1078. doi:10.1007/s11325-021-02450-9
15. Nagappa M, Liao P, Wong J, et al. Validation of the STOP-Bang Questionnaire as a Screening Tool for Obstructive Sleep Apnea among Different Populations: A Systematic Review and Meta-Analysis. *PLoS One*. 2015;10(12):e0143697. doi:10.1371/journal.pone.0143697
16. Ramachandran SK, Josephs LA. A meta-analysis of clinical screening tests for obstructive sleep apnea. *Anesthesiology*. 2009;110(4):928-939. doi:10.1097/ALN.0b013e31819c47b6
17. Ross SD, Sheinait IA, Harrison KJ, et al. Systematic review and meta-analysis of the literature regarding the diagnosis of sleep apnea. *Sleep*. 2000;23(4):519-532.
18. Bauters FA, Loof S, Hertegonne KB, Chirinos JA, De Buyzere ML, Rietzschel ER. Sex-specific sleep apnea screening questionnaires: closing the performance gap in women. *Sleep Med*. 2020;67:91-98. doi:10.1016/j.sleep.2019.10.023
19. Le Grande MR, Jackson AC, Beauchamp A, Kerr D, Driscoll A. Diagnostic accuracy and suitability of instruments that screen for obstructive sleep apnoea, insomnia and sleep quality in cardiac

- patients: a meta-analysis. *Sleep Med.* 2021;86:135-160. doi:10.1016/j.sleep.2021.02.021
20. Liamsombut S, Tantrakul V. Sleep Disturbance in Pregnancy. *Sleep Med Clin.* 2022;17(1):11-23. doi:10.1016/j.jsmc.2021.10.002
 21. Sedov ID, Cameron EE, Madigan S, Tomfohr-Madsen LM. Sleep quality during pregnancy: A meta-analysis. *Sleep Med Rev.* 2018;38:168-176. doi:10.1016/j.smrv.2017.06.005
 22. Zinchuk A, Yaggi HK. Phenotypic Subtypes of OSA: A Challenge and Opportunity for Precision Medicine. *Chest.* 2020;157(2):403-420. doi:10.1016/j.chest.2019.09.002
 23. Ye L, Pien GW, Ratcliffe SJ, et al. The different clinical faces of obstructive sleep apnoea: a cluster analysis. *Eur Respir J.* 2014;44(6):1600-1607. doi:10.1183/09031936.00032314
 24. Fried EI. The 52 symptoms of major depression: Lack of content overlap among seven common depression scales. *J Affect Disord.* 2017;208:191-197. doi:10.1016/j.jad.2016.10.019
 25. Gauld C, Martin VP, Richaud A, et al. Systematic Item Content and Overlap Analysis of Self-Reported Multiple Sleep Disorder Screening Questionnaires in Adults. *J Clin Med.* 2023;12(3):852. doi:10.3390/jcm12030852
 26. Charvet C, Boutron I, Morvan Y, et al. How to measure mental pain: a systematic review assessing measures of mental pain. *Evid Based Ment Health.* 2022;25(4):e4. doi:10.1136/ebmental-2021-300350
 27. Chrobak AA, Siwek M, Dudek D, Rybakowski JK. Content overlap analysis of 64 (hypo)mania symptoms among seven common rating scales. *Int J Methods Psychiatr Res.* 2018;27(3):e1737. doi:10.1002/mpr.1737
 28. Fried EI, Flake JK, Robinaugh DJ. Revisiting the theoretical and methodological foundations of depression measurement. *Nat Rev Psychol.* 2022;1(6):358-368. doi:10.1038/s44159-022-00050-2
 29. Visontay R, Sunderland M, Grisham J, Slade T. Content overlap between youth OCD scales: Heterogeneity among symptoms probed and implications. *J Obsessive-Compuls Relat Disord.* 2019;21:6-12. doi:10.1016/j.jocrd.2018.10.005
 30. Karstoft KI, Armour C. What we talk about when we talk about trauma: Content overlap and heterogeneity in the assessment of trauma exposure. *J Trauma Stress.* September 2022. doi:10.1002/jts.22880
 31. Wall A, Lee E. *What Do Anxiety Scales Really Measure? An Item Content Analysis of Self-Report Measures of Anxiety.*; 2021. doi:10.31234/osf.io/t7gpx
 32. Chrobak AA, Krupa A, Dudek D, Siwek M. How soft are neurological soft signs? Content overlap analysis of 71 symptoms among seven most commonly used neurological soft signs scales. *J Psychiatr Res.* 2021;138:404-412. doi:10.1016/j.jpsychires.2021.04.020
 33. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. *Anesthesiology.* 2008;108(5):812-821. doi:10.1097/ALN.0b013e31816d83e4
 34. Patel D, Tsang J, Saripella A, et al. Validation of the STOP questionnaire as a screening tool for OSA among different populations: a systematic review and meta-regression analysis. *J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med.* 2022;18(5):1441-1453. doi:10.5664/jcsm.9820
 35. Chung F, Abdullah HR, Liao P. STOP-Bang Questionnaire: A Practical Approach to Screen for Obstructive Sleep Apnea. *Chest.* 2016;149(3):631-638. doi:10.1378/chest.15-0903
 36. Ahmadi N, Chung SA, Gibbs A, Shapiro CM. The Berlin questionnaire for sleep apnea in a sleep clinic population: relationship to polysomnographic measurement of respiratory disturbance. *Sleep Breath Schlaf Atm.* 2008;12(1):39-45. doi:10.1007/s11325-007-0125-y
 37. Chung F, Yegneswaran B, Liao P, et al. Validation of the Berlin questionnaire and American Society of Anesthesiologists checklist as screening tools for obstructive sleep apnea in surgical patients. *Anesthesiology.* 2008;108(5):822-830. doi:10.1097/ALN.0b013e31816d91b5
 38. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med.* 1999;131(7):485-491. doi:10.7326/0003-4819-131-7-199910050-00002
 39. Sharma SK, Vasudev C, Sinha S, Banga A, Pandey RM, Handa KK. Validation of the modified

- Berlin questionnaire to identify patients at risk for the obstructive sleep apnoea syndrome. *Indian J Med Res.* 2006;124(3):281-290.
40. Sharma SK, Kumpawat S, Banga A, Goel A. Prevalence and risk factors of obstructive sleep apnea syndrome in a population of Delhi, India. *Chest.* 2006;130(1):149-156. doi:10.1378/chest.130.1.149
 41. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med.* 1993;328(17):1230-1235. doi:10.1056/NEJM199304293281704
 42. Douglass AB, Bornstein R, Nino-Murcia G, et al. The Sleep Disorders Questionnaire. I: Creation and multivariate structure of SDQ. *Sleep.* 1994;17(2):160-167. doi:10.1093/sleep/17.2.160
 43. Weatherwax KJ, Lin X, Marzec ML, Malow BA. Obstructive sleep apnea in epilepsy patients: the Sleep Apnea scale of the Sleep Disorders Questionnaire (SA-SDQ) is a useful screening instrument for obstructive sleep apnea in a disease-specific population. *Sleep Med.* 2003;4(6):517-521. doi:10.1016/j.sleep.2003.07.004
 44. Haraldsson PO, Carefelt C, Tingvall C. Sleep apnea syndrome symptoms and automobile driving in a general population. *J Clin Epidemiol.* 1992;45(8):821-825. doi:10.1016/0895-4356(92)90064-t
 45. Kapuniai LE, Andrew DJ, Crowell DH, Pearce JW. Identifying sleep apnea from self-reports. *Sleep.* 1988;11(5):430-436. doi:10.1093/sleep/11.5.430
 46. Coutinho Costa J, Rebelo-Marques A, Machado JN, et al. Validation of NoSAS (Neck, Obesity, Snoring, Age, Sex) score as a screening tool for obstructive sleep apnea: Analysis in a sleep clinic. *Pulmonology.* 2019;25(5):263-270. doi:10.1016/j.pulmoe.2019.04.004
 47. Marti-Soler H, Hirotsu C, Marques-Vidal P, et al. The NoSAS score for screening of sleep-disordered breathing: a derivation and validation study. *Lancet Respir Med.* 2016;4(9):742-748. doi:10.1016/S2213-2600(16)30075-3
 48. Chai-Coetzer CL, Antic NA, Rowland LS, et al. A simplified model of screening questionnaire and home monitoring for obstructive sleep apnoea in primary care. *Thorax.* 2011;66(3):213-219. doi:10.1136/thx.2010.152801
 49. Duarte, Magalhães-da-Silveira FJ, Oliveira-E-Sá TS, Silva JA, Mello FC, Gozal D. Obstructive Sleep Apnea Screening with a 4-Item Instrument, Named GOAL Questionnaire: Development, Validation and Comparative Study with No-Apnea, STOP-Bang, and NoSAS. *Nat Sci Sleep.* 2020;12:57-67. doi:10.2147/NSS.S238255
 50. Duarte, Rabahi, Magalhães da SFJ, de O e STS, Mello FCQ, Gozal D. Simplifying the Screening of Obstructive Sleep Apnea With a 2-Item Model, No-Apnea: A Cross-Sectional Study. *J Clin Sleep Med.* 2018;14(07):1097-1107. doi:10.5664/jcsm.7202
 51. American Academy of Sleep Medicine. *International Classification of Sleep Disorders, Third Edition.*; 2014.
 52. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition.*; 2013.
 53. Gauld C, Lopez R, Morin C, et al. Symptom network analysis of the sleep disorders diagnostic criteria based on the clinical text of the ICSD-3. *J Sleep Res.* July 2021. doi:10.1111/jsr.13435
 54. Gauld C, Lopez R, Morin CM, et al. Why do sleep disorders belong to mental disorder classifications? A network analysis of the “Sleep-Wake Disorders” section of the DSM-5. *J Psychiatr Res.* 2021;142:153-159. doi:10.1016/j.jpsychires.2021.07.050
 55. Evans JD. *Straightforward Statistics for the Behavioral Sciences.* Belmont, CA, US: Thomson Brooks/Cole Publishing Co; 1996:xxii, 600.
 56. Randerath, Herkenrath S, Treml M, et al. Evaluation of a multicomponent grading system for obstructive sleep apnoea: the Baveno classification. *ERJ Open Res.* 2021;7(1). doi:10.1183/23120541.00928-2020
 57. Sweetman A, Lack L, McEvoy RD, et al. Bi-directional relationships between co-morbid insomnia and sleep apnea (COMISA). *Sleep Med Rev.* 2021;60:101519. doi:10.1016/j.smrv.2021.101519
 58. Lechat B, Loffler KA, Wallace DM, et al. All-Cause Mortality in People with Co-Occurring

- Insomnia Symptoms and Sleep Apnea: Analysis of the Wisconsin Sleep Cohort. *Nat Sci Sleep*. 2022;14:1817-1828. doi:10.2147/NSS.S379252
59. Lechat B, Appleton S, Melaku YA, et al. Comorbid insomnia and sleep apnoea is associated with all-cause mortality. *Eur Respir J*. 2022;60(1). doi:10.1183/13993003.01958-2021
 60. Lechat B, Appleton S, Melaku YA, et al. The association of co-morbid insomnia and sleep apnea with prevalent cardiovascular disease and incident cardiovascular events. *J Sleep Res*. 2022;31(5):e13563. doi:10.1111/jsr.13563
 61. Gauld C, Lopez R, Geoffroy PA, et al. A systematic analysis of ICSD-3 diagnostic criteria and proposal for further structured iteration. *Sleep Med Rev*. 2021;58:101439. doi:10.1016/j.smrv.2021.101439
 62. Wimms A, Woehrle H, Ketheeswaran S, Ramanan D, Armitstead J. Obstructive Sleep Apnea in Women: Specific Issues and Interventions. *BioMed Res Int*. 2016;2016:1764837. doi:10.1155/2016/1764837
 63. Arnardottir ES, Islind AS, Óskarsdóttir M. The Future of Sleep Measurements: A Review and Perspective. *Sleep Med Clin*. 2021;16(3):447-464. doi:10.1016/j.jsmc.2021.05.004
 64. Martínez-García MÁ, Sierra-Párraga JM, Garcia-Ortega A A. Obstructive sleep apnea in women: We can do more and better. *Sleep Med Rev*. 2022;64:101645. doi:10.1016/j.smrv.2022.101645
 65. Dancy DR, Hanly PJ, Soong C, Lee B, Shepard J, Hoffstein V. Gender Differences in Sleep Apnea: The Role of Neck Circumference. *Chest*. 2003;123(5):1544-1550. doi:10.1378/chest.123.5.1544
 66. Cizza G, de Jonge L, Piaggi P, et al. Neck Circumference Is a Predictor of Metabolic Syndrome and Obstructive Sleep Apnea in Short-Sleeping Obese Men and Women. *Metab Syndr Relat Disord*. 2014;12(4):231-241. doi:10.1089/met.2013.0093
 67. Malhotra A, White DP. Obstructive sleep apnoea. *Lancet Lond Engl*. 2002;360(9328):237-245. doi:10.1016/S0140-6736(02)09464-3
 68. Pépin JL, Eastwood P, Eckert DJ. Novel avenues to approach non-CPAP therapy and implement comprehensive obstructive sleep apnoea care. *Eur Respir J*. 2022;59(6). doi:10.1183/13993003.01788-2021
 69. Stradling JR, Davies RJO. Sleep. 1: Obstructive sleep apnoea/hypopnoea syndrome: definitions, epidemiology, and natural history. *Thorax*. 2004;59(1):73-78. doi:10.1136/thx.2003.007161
 70. American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep*. 1999;22(5):667-689.
 71. Malhotra A, Ayappa I, Ayas N, et al. Metrics of sleep apnea severity: beyond the apnea-hypopnea index. *Sleep*. 2021;44(7):zsab030. doi:10.1093/sleep/zsab030
 72. Randerath, Bassetti CL, Bonsignore MR, et al. Challenges and Perspectives in Obstructive Sleep Apnoea: Report by an ad hoc working group of the Sleep Disordered Breathing Group of the European Respiratory Society and the European Sleep Research Society. *Eur Respir J*. January 2018. doi:10.1183/13993003.02616-2017
 73. McNicholas WT, Pevernagie D. Obstructive sleep apnea: transition from pathophysiology to an integrative disease model. *J Sleep Res*. 2022;31(4):e13616. doi:10.1111/jsr.13616
 74. Pevernagie, Bauters FA, Hertegonne K. The Role of Patient-Reported Outcomes in Sleep Measurements. *Sleep Med Clin*. 2021;16(4):595-606. doi:10.1016/j.jsmc.2021.07.001
 75. Zinchuk AV, Gentry MJ, Concato J, Yaggi HK. Phenotypes in obstructive sleep apnea: A definition, examples and evolution of approaches. *Sleep Med Rev*. 2017;35:113-123. doi:10.1016/j.smrv.2016.10.002
 76. Eckert DJ. Phenotypic approaches to obstructive sleep apnoea - New pathways for targeted therapy. *Sleep Med Rev*. 2018;37:45-59. doi:10.1016/j.smrv.2016.12.003
 77. Mazzotti DR, Keenan BT, Lim DC, Gottlieb DJ, Kim J, Pack AI. Symptom Subtypes of Obstructive Sleep Apnea Predict Incidence of Cardiovascular Outcomes. *Am J Respir Crit Care Med*. 2019;200(4):493-506. doi:10.1164/rccm.201808-1509OC
 78. Keenan BT, Kim J, Singh B, et al. Recognizable clinical subtypes of obstructive sleep apnea

- across international sleep centers: a cluster analysis. *Sleep*. 2018;41(3):zsx214. doi:10.1093/sleep/zsx214
79. Redline S, Yenokyan G, Gottlieb DJ, et al. Obstructive sleep apnea-hypopnea and incident stroke: the sleep heart health study. *Am J Respir Crit Care Med*. 2010;182(2):269-277. doi:10.1164/rccm.200911-1746OC
80. Pien GW, Ye L, Keenan BT, et al. Changing Faces of Obstructive Sleep Apnea: Treatment Effects by Cluster Designation in the Icelandic Sleep Apnea Cohort. *Sleep*. 2018;41(3):zsx201. doi:10.1093/sleep/zsx201
81. Arnardottir ES, Maislin G, Schwab RJ, et al. The interaction of obstructive sleep apnea and obesity on the inflammatory markers C-reactive protein and interleukin-6: the Icelandic Sleep Apnea Cohort. *Sleep*. 2012;35(7):921-932. doi:10.5665/sleep.1952
82. Arnardottir E, Janson C, Bjornsdottir E, et al. Nocturnal sweating - A common symptom of obstructive sleep apnoea: The Icelandic sleep apnoea cohort. *BMJ Open*. 2013;3. doi:10.1136/bmjopen-2013-002795
83. Partinen M, Gislason T. Basic Nordic Sleep Questionnaire (BNSQ): a quantitated measure of subjective sleep complaints. *J Sleep Res*. 1995;4(s1):150-155. doi:10.1111/j.1365-2869.1995.tb00205.x
84. Bailly S, Destors M, Grillet Y, et al. Obstructive Sleep Apnea: A Cluster Analysis at Time of Diagnosis. *PLOS ONE*. 2016;11(6):e0157318. doi:10.1371/journal.pone.0157318
85. Gagnadoux F, Le Vaillant M, Paris A, et al. Relationship Between OSA Clinical Phenotypes and CPAP Treatment Outcomes. *Chest*. 2016;149(1):288-290. doi:10.1016/j.chest.2015.09.032
86. Kim J, Keenan BT, Lim DC, Lee SK, Pack AI, Shin C. Symptom-Based Subgroups of Koreans With Obstructive Sleep Apnea. *J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med*. 2018;14(3):437-443. doi:10.5664/jcsm.6994
87. Randerath, Lange J de, Hedner J, et al. Current and novel treatment options for obstructive sleep apnoea. *ERJ Open Res*. 2022;8(2). doi:10.1183/23120541.00126-2022
88. Nigro CA, Borsini E, Dibur E, et al. Indication of CPAP without a sleep study in patients with high pretest probability of obstructive sleep apnea. *Sleep Breath Schlaf Atm*. 2020;24(3):1043-1050. doi:10.1007/s11325-019-01949-6
89. Rowley JA, Aboussouan LS, Badr MS. The Use of Clinical Prediction Formulas in the Evaluation of Obstructive Sleep Apnea. *Sleep*. 2000;23(7):929-938. doi:10.1093/sleep/23.7.929
90. Abma IL, van der Wees PJ, Veer V, Westert GP, Rovers M. Measurement properties of patient-reported outcome measures (PROMs) in adults with obstructive sleep apnea (OSA): A systematic review. *Sleep Med Rev*. 2016;28:18-31. doi:10.1016/j.smrv.2015.07.006
91. Buysse DJ, Yu L, Moul DE, et al. Development and validation of patient-reported outcome measures for sleep disturbance and sleep-related impairments. *Sleep*. 2010;33(6):781-792. doi:10.1093/sleep/33.6.781
92. Demazeux S, Singy P. *The DSM-5 in Perspective: Philosophical Reflections on the Psychiatric Babel*. Springer. SAM Fischer; 2017.