

The Canadian Thoracic Society/Canadian Sleep Society Guideline on the diagnosis of obstructive sleep apnea in children

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RATIONALE: Access to polysomnography, the recommended standard for the diagnosis of obstructive sleep apnea (OSA) in children, is limited in many jurisdictions. Many children undergo treatment for OSA without confirmatory testing, are denied treatment in the absence of testing, or have a delay in treatment of other sleep disorders until OSA can be ruled out.

METHODS: An expert panel conducted a systematic review and meta-analysis examining alternative testing to polysomnography. Recommendations formulation followed a process of proposal, discussion, revisions and voting, considering the evidence, panel members' judgment, as well as patient and family preferences.

RESULTS: A total of 250 articles across five types of clinical assessment were included. Most articles excluded children with comorbidities or did not report exclusions (62% and 26%, respectively). Only 13% of articles included children under 2-years of age. Limited data were appropriate for meta-analysis.

CONCLUSIONS: The panel upholds polysomnography as the recommended standard for the diagnosis of OSA in children given the absence of an alternative test that could be considered a replacement. Level 3/Home Sleep Apnea Testing is recommended as an alternative option to diagnose OSA in otherwise healthy children over 5-years of age for whom access to polysomnography is effectively absent. While the Pediatric Sleep Questionnaire and overnight oximetry add information to the clinical assessment, we suggest that these should not be used to diagnose OSA in children. Given patient and family preferences for testing at home, further investment is needed in developing accurate and accessible home-based testing options to diagnose OSA in children. CHEST 2026; ■(■):■-■

KEYWORDS: Child; clinical assessment; physical examination; physiological assessment; polysomnography

ABBREVIATIONS: AGREE = Appraisal of Guidelines, Research and Evaluation; AHI = apnea hypopnea index; AASM = American Academy of Sleep Medicine; AUC = area under the curve; BMI = body mass index; BPAP = bilevel positive airway pressure; L3/HSAT = level 3 polysomnography/home sleep apnea testing; CDA/AMC = Canada's Drug Agency/L'Agence des médicaments du Canada; CPAP = continuous positive airway pressure; CRGC = Canadian Respiratory Guidelines Committee; CSS = Canadian Sleep Society; CTS = Canadian Thoracic Society; IQR = interquartile range; MeSH = medical subject heading; MOS = McGill oximetry score; OAH = obstructive apnea hypopnea index; OMAHI = obstructive-mixed apnea hypopnea index; ODI = oxygen desaturation index; OLS = online supplement; OSA = obstructive sleep

apnea; PICO = population (P), intervention (I), comparison (C) and outcome (O); PRISMA = Preferred Reporting Items for Systematic Review and Meta-Analyses; PSG = polysomnography; PSQ = Pediatric Sleep Questionnaire; QUADAS = Quality Assessment of Diagnostic Accuracy Studies; SpO₂ = pulse oxygen saturation; sROC = summary received operator curve; YPAG = Young Person Advisory Council

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Introduction

OSA is a common condition affecting 1-5% of children.¹ Multiple factors contribute to the risk of OSA in children with differences in the presentation by age and specific risk factors.²⁻⁴ While the primary contributors to OSA risk in children are likely adenotonsillar hypertrophy and obesity, children with a broad range of medical conditions affecting craniofacial structures, upper airway motor control and respiratory control present with symptoms of OSA that need investigation.⁵ The consequences of untreated OSA and the resulting sleep and other physiologic disruptions in children are equally broad and result in impairments in physical health, neurocognition and day-time function.⁶⁻⁹ Airway obstruction causing repetitive oxygen desaturation and sleep disruption result in: (a) impairments in psychosocial and neurocognitive function, including impairments in learning and memory, affect regulation, behavior, and mood;¹⁰⁻¹⁴ (b)

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disruption in metabolic regulation that increases risk for dyslipidemia, insulin resistance, and early onset type 2 diabetes;¹⁵⁻¹⁸ and (c) stimulation of the sympathetic nervous system, leading to hypertension, impaired heart rate response, dry mouth, impaired bronchodilation, and impaired gastric motility.^{19,20} The assessment of children with suspected OSA can be challenging because of a wide spectrum of risk factors, presentations, and consequences. Clinical history alone, including symptoms of snoring and mouth breathing, are insufficient to rule in or rule out OSA, highlighting the need for additional testing.²¹

Polysomnography (PSG), an observed overnight multiparameter sleep study (also referred to as type 1 PSG), is the recommended standard for establishing the diagnosis of OSA in children.¹ Unlike in adults, the American Academy of Sleep Medicine does not recommend Home Sleep Apnea Testing (HSAT) in children due to insufficient validation of the devices in children and the lack of signals for CO₂ and arousal monitoring in most devices currently used for this purpose.²² Access to PSG testing is complicated by variability across jurisdictions in timely access to PSG and pediatric sleep specialists, in addition to significant knowledge gaps among pediatric healthcare providers with respect to the diagnosis and treatment of OSA.^{23,24} Starting from the first year of life, otherwise healthy children who are subsequently diagnosed with OSA have higher healthcare usage including a 215-226% greater healthcare costs in the year preceding OSA diagnosis compared to children matched for age, sex, primary care physician and geographical location.^{25,26} This supports the need for early diagnosis and intervention for children with OSA to improve overall health and reduce comorbidities associated with OSA. Inappropriate or lack of appropriate assessment leading to overdiagnosis of OSA may result in unnecessary treatment. In a Canadian study of children 0-10 years of age, only 12.8% of children had PSG prior to adenotonsillectomy for treatment of OSA.²⁷ In a retrospective study from a center where PSGs are not part of the assessment of otherwise healthy children, the authors estimated that routine use of polygraphy (PSG without EEG monitoring) could reduce adenotonsillectomies by 44%.¹⁰ As PSG results predict post-operative respiratory complications,^{11,12} lack of testing prior to surgical treatment of OSA may increase unexpected complications post-operatively. Given these challenges, timely and accurate diagnostic testing strategies for OSA in children are greatly needed.

This clinical practice guideline is informed by a systematic review and meta-analysis of the data relevant to identifying alternatives to PSG for the diagnosis of OSA in children. This guideline represents the first CTS/CSS guideline for the diagnosis of OSA in children. It brings together a broad range of organizational stakeholders who nominated members to participate in the guideline development panel. The guideline development panel evaluated the quality of the evidence, and incorporated considerations of potential benefits and harms as well as equitable access to testing, to formulate evidence-informed recommendations. The overall goal was to offer practical guidance to all clinical practitioners involved in providing healthcare to children with suspected OSA in order to improve the care and clinical outcomes of these children.

Objectives

The overall objective of this CTS/CSS guideline is to help clinicians to choose appropriate testing to identify OSA in children. The specific objective is to provide clinical guidance through evidence-based recommendations based on systematic review, meta-analysis and expert consideration of other relevant clinical and healthcare issues including considering children and family preferences. This guideline does not address OSA treatment. The Canadian context of pediatric OSA is like many other jurisdictions where access to PSG is limited or absent. Although diagnostic testing for OSA would ideally help to inform individualized treatment plans, any treatment plans must start from an accurate diagnosis of OSA.

Clinical question

The key clinical question was developed using the PICO model. Given the challenge with accessing PSG, our key clinical questions focused on evaluating alternative tests to diagnose OSA in children. This included a broad range of alternative measures with the key question of: "Should alternative measure be used to diagnose OSA in children?" This PICO question was selected by panel members because:

- (i) PSG is the current standard for diagnosing OSA in children;
- (ii) the constraints on access to PSG mean that most children with suspected OSA do not undergo PSG prior to treatment, whereby access to testing is the most pressing issue in the field of pediatric OSA; and (iii) there had not been a systematic review examining the accuracy of alternative diagnostic tests to PSG for diagnosis of OSA in children.

Target population and users

This guideline applies to all children (<18 years of age) with suspected OSA. This guideline is targeted to healthcare practitioners who evaluate children with suspected OSA and have the appropriate training to make diagnostic decisions about OSA. This may include, but is not limited to, general practitioners, general pediatricians, pediatric subspecialists, otolaryngologists, child psychiatrists, child psychologists and nurse practitioners. In addition, this document provides guidance to healthcare decision makers (ie, local, provincial, and national policy makers and funders), patient advocates, patients and their families, healthcare researchers and knowledge translation specialists.

Methodology

This guideline was developed in accordance with the CTS guideline development process,¹³ including use of GRADE methodology¹⁴ and the AGREE II checklist.¹⁵

Guideline development panel composition

The Diagnosis of Obstructive Sleep Apnea in Children panel included 14 voting panel members who voted on recommendations. Panel members were invited by email to participate based on their interest in being part of the panel and ensuring that the panel was balanced in geographic representation across Canada and expertise of the panel members. The CSS, Canadian Pediatric Society, and the College of Family Physicians of Canada each identified a representative to participate in the panel. The Canadian Society of Otolaryngology – Head & Neck Surgery identified two members to participate in the panel. The panel included 3 pediatric respiratory and sleep medicine physicians, 1 pediatric respiratory physician, 1 pediatric sleep medicine physician, 1 pediatric neurologist and sleep medicine physician, 2 otolaryngologists, 1 pediatrician, 1 family medicine physician and 4 sleep medicine fellows. The project was supported by a methodologist, a knowledge mobilization specialist and a project manager.

There were no children or parents with lived experience of OSA participating in the guideline panel. A consultation to consider preferences around medical testing including sleep studies was completed with the KidsCan YPRAG. KidsCan YPRAG is a national initiative that aims to increase the engagement of patients in all phases of the research process by offering consultations with youth patients aged 13-19

years across Canada. KidsCan youth participated in a 60-minute consultation which included a review of materials as well as open-ended questions facilitated by the Chair of the guideline development group (JEM). A summary of the discussion was provided to the Chair by KidsCAN YPRAG. This information was presented to the panel as part of the considerations when formulating recommendations.

Information sources, search and article screening

The systematic review and meta-analysis were conducted following the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy¹⁶ and adhered to the PRISMA.¹⁷ The protocol was registered in the PROSPERO database for international prospective reviews (CRD42020157842).¹⁸ The search strategy used Medical Subject Headings and free-text terms for “OSA”, “diagnostic tool” and “diagnosis.” It was developed for MEDLINE (Ovid) and translated to other databases by an academic librarian. Articles from 1990 onward were identified through Ovid MEDLINE, Embase (Ovid), CINAHL (Ebsco), Cochrane Library (Wiley; Inception to Present) and PubMed (see OLS, eTable 1). The search was initially run on 27 November 2018 with the most recent update on 5 March 2025.

Articles were eligible for inclusion if they included children (aged 0-17 years), used in-laboratory PSG as the reference standard for the diagnosis of OSA, and compared this to an alternative test for OSA (index test). No restrictions were placed on year of publication or study design. All articles with an English language abstract were included in the initial search with language limited to English, French, Italian, and Spanish for the full text retrieval. Independent review for inclusion was completed at both the title and abstract stages by two reviewers (JEM, AA). Disagreements were resolved by consensus. Additional details of the information sources, search, study selection, and data collection are included in OLS, eAppendix 1. The PRISMA diagram (Figure 1) shows the search results, reasons for exclusions, and numbers of studies included in the qualitative and quantitative synthesis.

Risk of bias and synthesis of results

The QUADAS-2 tool was used for the assessment of the quality of the included studies.¹⁹ The QUADAS-2 tool is designed to assess risk of bias and applicability of primary diagnostic accuracy studies.¹⁶ Ratings were tailored to this study (see OLS, eTable 2). The summary

results for risk of bias and applicability are shown in the OLS, eAppendix 3.

To summarize the data, all comparisons between PSG and index tests were grouped according to five types of clinical assessments (clinical history, physical examination, physiological assessment, biomarkers and combined factors), with subgrouping where appropriate, for a total of 13 clinical assessments subgroups (see OLS, eTable 3). Some subgroups included individual tests (eg, Pediatric Sleep Questionnaire) while others combined similar tests where there was limited data for each individual test (eg, individual clinical history items). For a comparison between PSG and a specific clinical assessment to be included in further quantitative synthesis (ie, meta-analysis and sROC) the article needed to include the true positive, false positive, true negative and false negative data or provide sufficient data for these to be back calculated. As a result of identifying 90 distinct criteria for the PSG diagnosis of OSA (see OLS, eTable 4), the criteria for PSG diagnosis of OSA to be included in the quantitative analysis were limited to the two most common PSG variables used to define OSA: the AHI (65%) and the OAHl (24%). This resulted in inclusion of 85% of the data. The data that were excluded defined OSA based on other single variables (3%), multiple parameters (10%) or did not include a PSG definition of OSA (2%). Sensitivity, specificity and AUC were the metrics for diagnostic test accuracy. Additional information about the data synthesis is available in the OLS, eAppendix 1.

Grading of the quality of the evidence

Grading of evidence was performed by a Methodologist using the GRADE process.²⁰ The components of GRADE system such as, study design, risk of bias, inconsistency, indirectness, imprecision and other considerations, such as publication bias and magnitude of the effect, were considered in evaluating the certainty of the outcome. Additional details of the GRADE process and the GRADE evidence tables are provided (see OLS, eAppendix 3).

Review of the evidence and formulation of the recommendations

The Guideline Development process was conducted virtually via teleconference over four sessions. For each index test subgroup, the Guideline Development Panel was asked to consider whether the index test(s) should be used to diagnose OSA in children. The panel was

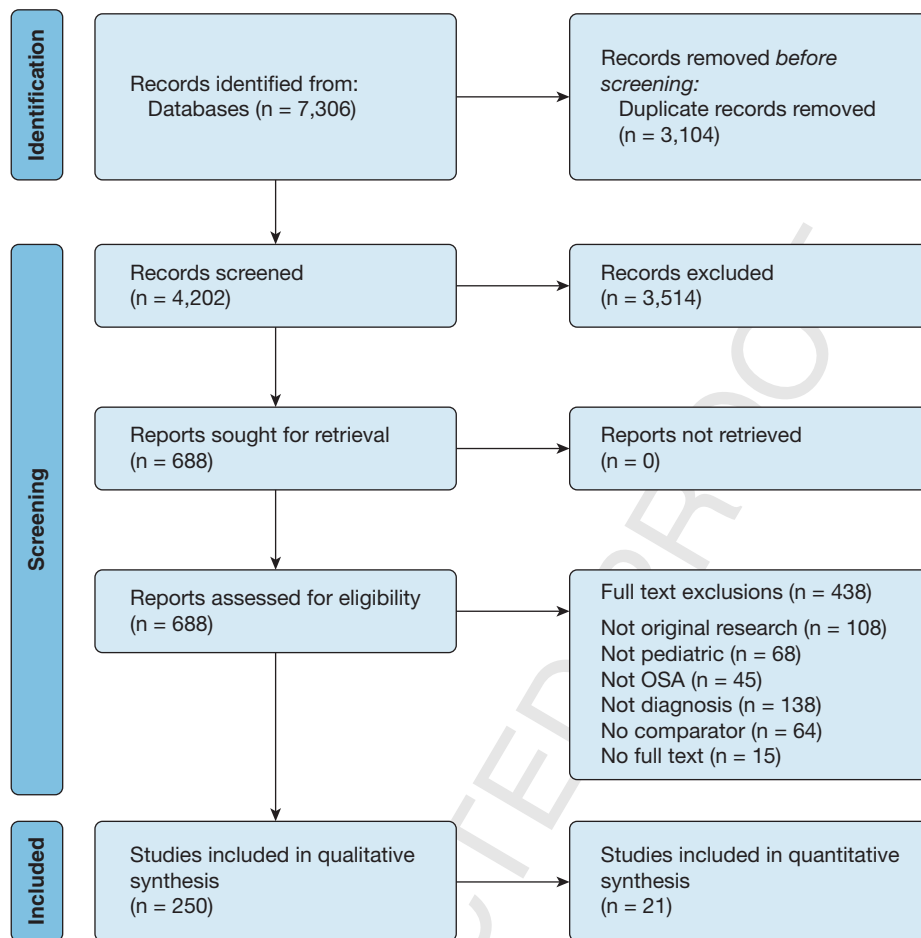


Figure 1 – Flow diagram outlining the study selection process for the systematic review, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

presented with the GRADE summary of the evidence (see OLS, [Appendix 3](#)). In establishing the recommendations and their strength, panel members considered the quality of the evidence, the balance of desirable and undesirable effects, child and family preferences and values, resource use, health equity and acceptability and feasibility of implementation including access to testing. A draft recommendation was discussed, revised and then a request for voting was made. The voting included five options: (1) wholeheartedly agree; (2) agree; (3) can support; (4) reservations—would like more discussion; and (5) serious concerns—needs more discussion. If 80% of panel members voted 1, 2 or 3 then the recommendation was accepted without further discussion. If the 80% threshold was not met, the cycle of discussion, recommendation revision and voting was repeated with voting options revised to: (1) agree; (2) can support; and (3) cannot support—block it. This cycle was repeated until 80% of panel members voted 1 or 2

using the revised voting options. Because not all panel members were able to attend each teleconference, an on-line poll was circulated for voting after all recommendations were drafted to confirm the threshold was met and the distribution of the level of agreement for each recommendation.

Review and approval process

The draft guideline was reviewed and revised by the CTS CRGC executive members (Chair and Past Chair) and the executive of the CSS. The CTS also independently invited formal review of the guideline by four external (non-CTS/ CSS members) and two internal (CTS/CSS members) content experts. One of the internal reviewers performed an AGREE assessment of the guideline. The lead author responded to the comments and revised the manuscript. These reviews and the AGREE II scoresheet were provided to the CTS CRGC for review. After revisions were completed, the CRGC recommended approval of the guideline to the

CTS Executive committee for final approval. All reviews and author responses are posted on the CTS website.

Living guideline/future updates

The guideline will be reviewed every three years or sooner to determine the need for and nature of any updates, in accordance with CTS Living Guideline Model. The CTS Sleep Assembly Steering Committee members will also use the continuous updated McMaster Plus database, whereby they will receive alerts when new articles pertaining to this PICO question are published (starting from the last date of the literature search conducted for this guideline). This will serve to prompt members to consider the need for timely guideline updates with evolving evidence.

Summary of the current standards for the diagnosis of OSA in children

Type 1 PSG, as described by the AASM,²⁸ is an observed, overnight, multi-parameter sleep study carried out in a sleep laboratory that collects data from 10 separate signal types.²⁹ In children, PSG has strong face and content validity, moderately strong convergent validity, and moderate-to-strong test-retest validity with limited data to support discriminant validity for characterizing breathing during sleep.³⁰ Test-retest reliability is good to excellent for respiratory parameters.

Type 1 PSG, is the recommended^{1,28,31} or preferred test³² for four of nine organizations across the world that have published recommendations (eg, guidelines, statements, task force) on diagnosing OSA in children. One additional organization recommends that children with high-risk comorbidities (eg, obesity, Down syndrome, sickle cell disease, craniofacial disease, neuromuscular disease) undergo PSG prior to tonsillectomy and that there should be advocacy for PSG prior to tonsillectomy for other children.³³ For two organizations, PSG or polygraphy (typically does not include EEG monitoring) is indicated for children at high-risk of OSA, to investigate persistent symptoms of OSA post-adenotonsillectomy, prior to the use of oral appliances or CPAP/BPAP.³⁴⁻³⁸ The organizations with the two most recently published guideline or consensus documents suggest PSG for children without comorbidities only when results of recommended sleep questionnaires is inconsistent with clinical features or a higher degree of diagnostic certainty is needed,³⁹ or in the absence of lymphoid tissue hypertrophy or moderate tonsil hypertrophy.⁴⁰

PSG has important limitations that must be acknowledged. This multi-parameter study is carried out in a sleep laboratory and requires trained PSG technicians to complete the testing and sub-specialty trained pediatric sleep physicians for accurate interpretation. This makes it expensive which has undoubtedly contributed to challenges with accessing PSG in many jurisdictions across Canada and around the world.^{23,24,41,42} The complex data obtained during PSG requires pediatric sleep specialist expertise for interpretation. With a paucity of pediatric sleep specialist, the interpretation of a PSG report may be based on a single metric, most commonly the AHI or the OAHl. This means that much of the data collected during PSG, including metrics of sleep disruption, oxygen desaturation, changes in heart rate, and carbon dioxide parameters, are not used to inform the diagnosis of OSA and may not be used to inform treatment decisions. While single metrics such as AHI and OAHl, eliminate the need to understand the rest of the PSG report, there is also no consensus on the PSG definition of OSA using these single metrics. Indeed, we identified 18 different PSG definitions of OSA using the AHI and 13 different definitions using the OAHl in the included articles (see OLS, eTable 4). In addition, the AHI does not accurately predict OSA-related morbidity or outcomes in adults or children.^{43,44} Despite its limitation, PSG is the recommended standard for the diagnosis of OSA in children.

Summary of the evidence-based recommendations

Strengths and limitations of the overall evidence

The systematic review identified a large body of evidence on a broad range of alternative tests to diagnose OSA in children. Two main factors limited our ability to combine data across studies for meta-analysis: (1) lack of a consistent definition of OSA by PSG, the current recommended standard to diagnose OSA in children; and (2) limited, if any, replication studies for most alternative tests. Our search included children aged 0-17 years but only 12% of articles included children <2 years of age and only 3 studies focused on this age group. We did not place a limit on the medical complexity of the children in our search; however, 58% of the articles excluded children with comorbidities and an additional 17% did not list exclusion criteria. All recommendations ultimately

received 100% support (ie, all panel members voting 1, 2 or 3) with some recommendations requiring additional discussion and a second round of voting.

Recommendations for the diagnosis of OSA in children

A summary of the evidence-informed recommendations and corresponding evidence tables/figures is presented in Table 1.

1. We recommend Level 3/Home Sleep Apnea Testing (L3/HSAT) as an alternative (2nd line) option to diagnose OSA in otherwise healthy children over 5-years of age for whom access to polysomnography is effectively absent. (Quality of evidence: Low to Moderate; Strength of recommendation: Strong)

This recommendation diverges from the AASM 2017 recommendation that recommends L3/HSAT should not be used in children.²² The AASM position paper on HSAT for the diagnosis of OSA in children concluded that the available evidence did not support L3/HSAT use because of lack of validation in the home, and the lack of CO₂ and arousal monitoring (viewed as critical in pediatric populations) in most L3/HSAT devices available at that time. All five studies identified in the systematic review used to inform the AASM position paper were identified in our search with two studies excluded from our analysis because they did not use AHI or OAH in their PSG criteria to define OSA. In addition, our search added twelve studies for a total of 17 studies included in our analysis and an increase in the quality of the evidence of the relationship between L3/HSAT compared to PSG for the diagnosis of OSA in children.

The analysis of the studies was grouped by the L3/HSAT OSA definitions (AHI > 1 event/h, AHI > 5 events/h) and PSG OSA definitions (AHI > 1 or > 1.5 events/h, AHI > 5 or > 5 events/h). Combining only studies with similar L3/HSAT and PSG definitions of OSA is a more stringent approach than has been applied in a previous meta-analysis.⁴⁵ The results show that, compared to PSG with an AHI > 1 event/h, L3/HSAT has high sensitivity and moderate specificity for 'mild OSA' (AHI > 1 event/h) with an increase in sensitivity and specificity for detecting 'moderate OSA' (AHI > 5 or > 5 events/h; Table 2). With a PSG with an AHI > 5 event/h and an L3/HSAT cutoff to AHI > 5 events/h, the sensitivity decreases, and the specificity increases (Table 2). Using sROC, which account for both sensitivity and specificity, AUC varied from 0.88 to

0.92 to 0.89 (Figure 2) where an AUC of 0 would mean that none of the L3/HSAT predictions are correct and an AUC of 1.0 would mean 100% of the L3/HSAT predictions are correct. Together, these data show that L3/HSAT has a high level of agreement with OSA identified by PSG.

However, there are important limitations in the available evidence that prevented the panel from making a universal recommendation for L3/HSAT as an alternative to PSG. Most studies (67%) excluded children with comorbidities.⁴⁶⁻⁵⁴ Only one L3/HSAT study was conducted in a population of children with comorbidities (Down syndrome).⁵⁵ While age for inclusion ranged from 0 to 22 years, only one study included children <2 years of age, with a lower limit of age ranging from 0 to 16 years, and with 35% of studies including children under 5 years of age. The median age across studies was 10.7 years of age. The participant numbers were also relatively low (median 38 [IQR 45], range 12-100) and there was high heterogeneity for some summary statistics suggesting variability in the results across studies. The technology used to conduct L3/HSAT studies also varied between studies.

The panel recognized L3/HSAT could be used to increase access to diagnostic testing for OSA for children where PSG is limited or unavailable. There were insufficient data to compare results between sub-groups (eg, age groups, comorbidities groups). The validity of L3/HSAT in infants and pre-school aged children, and children with higher levels of medical complexity is unknown. Potential safety risks of unmonitored testing are also important to consider with case reports of accidental strangulation with an apnea monitor,⁵⁶ as well as entanglement with intravenous tubing and enteral feeding delivery sets.⁵⁷⁻⁵⁹ Access to L3/HSAT testing addresses patient and family preferences for testing that can be performed at home, limits costs of travel and time away from school or work for children and their families, and may reduce costs to the healthcare system.

The panel recognized that the definition of 'effectively absent' may vary across jurisdictions and will be impacted by provincial/territorial regulatory frameworks, and whether PSG testing is available in the province/territory. In addition, wait times to access PSG testing, as well as travel times and cost for families to access testing may result in PSG testing being

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TABLE 1] Summary of recommendations for alternatives to polysomnography for the diagnosis of obstructive sleep apnea in children and the supporting evidence summaries

Recommendation	Quality / Certainty of the evidence	Strength of the recommendations	Evidence tables/ figures in the OLS
1. We recommend L3/HSAT as an alternative (2nd line) option to diagnose OSA in otherwise healthy children over 5-years of age for whom access to polysomnography is effectively absent. <i>Clinical remarks:</i> The available evidence for L3/HSAT is limited to select children such that these results may not be generalized to all children. Most studies exclude children with comorbidities. Only one study included children under 2-years of age, 50% of studies excluded children under 5-years of age, and the median/mean age was 10 years of age. Safety risks of unmonitored testing, such as accidental strangulation, must be considered. The use of Level 3/HSAT is likely to improve access to testing in areas where polysomnography is effectively absent.	Moderate (TP, FN) to Low (TN, FP)	Strong	OLS, eFigure 2a-c eAppendix 3
2. We suggest that the following tests be considered as adjunct tools in the clinical assessment of children with suspected OSA but should NOT be used in isolation to diagnose OSA in children: • PSQ • Overnight oximetry, including the MOS <i>Clinical remarks:</i> Of the questionnaires available to identify OSA in children, the PSQ shows the highest level of agreement with a polysomnography diagnosis of OSA. The PSQ provides a standardized way to assess OSA symptoms. It is important to note that the PSQ may have a lower level of agreement with polysomnography in infants and children with comorbidities. Overnight oximetry, either using the standard report data or applying the MOS, is commonly used in the assessment of children with suspected OSA. While neither is a diagnostic test for OSA nor a replacement for polysomnography, these tests are often used in clinical practice as initial screening or for triaging of polysomnography, to determine post-operative surgical risks, or to add information to the clinical assessment to support or refute a diagnosis of OSA.	PSQ vs AHI > 1 and >5 (Low), PSQ vs OAH1 >5 (Moderate) Low	Weak Weak	Figure 3a-b OLS, eAppendix 3 OLS, eAppendix 3
3. We suggest that the following tests should NOT be used to diagnose OSA in children: • Single clinical history items or other questionnaires aimed at diagnosing OSA, including the OSA-18 questionnaire • BMI • Descriptors of airway anatomy, that include tonsillar size, adenoid size, high arched palate, mid face hypoplasia • Physiological measures of airway function analyzed with machine learning algorithms • Physiological measures of autonomic function, including HRV and PTT	Very low Very low Very low Very low Very low	Weak Weak Weak Weak Weak	OLS, eAppendix 3 OLS, eAppendix 3 OLS, eAppendix 3 OLS, eAppendix 3 OLS, eAppendix 3

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TABLE 1] (Continued)

Recommendation	Quality / Certainty of the evidence	Strength of the recommendations	Evidence tables/ figures in the OLS
- Other continuous physiological measures, including partial-night polysomnography, CO₂ responses, scoring of video recordings during sleep, and automated analysis of mandibular movements - Biomarkers, including individual and composite markers - Combined measures including actigraphy and overnight oximetry, anatomical and historical models, upper airway narrowing and mouth breathing, and models that include multiple factors <i>Clinical remarks:</i> A broad range of tests have been compared against polysomnography as potential replacements for polysomnography or additions to clinical assessments. Some appear promising but there are no replication studies. Some of these comparisons have been conducted to investigate underlying mechanisms or comorbidities associated with OSA rather than for diagnosis. While some of these tests may add information, they cannot be considered diagnostic tests or as replacements for polysomnography.	Very low Very low Very low	Weak Weak Weak	OLS, eAppendix 3 OLS, eAppendix 3 OLS, eAppendix 3

Abbreviations: OLS, Online Supplement; L3/HSAT, Level 3/Home Sleep Apnea Testing; TP, true positive; FP, false positive; TN, true negative; FN, false negative; OSA, obstructive sleep apnea; PSQ, Pediatric Sleep Questionnaire; MOS, McGill oximetry score; HRV, heart rate variability; PTT, pulse transit time; BMI, body mass index; CO₂, carbon dioxide.

practically unavailable and, therefore, effectively absent for some children. A report published by CDA/AMC on federal, provincial and territorial coverage of diagnostic sleep studies highlights differences in coverage for L3/HSAT testing across Canada, though did not include information specific to pediatric diagnostic sleep testing, with L3/HSAT costs covered by some provinces.⁶⁰ The panel recognized that translation of this recommendation into clinical practice will require the development of standards for L3/HSAT testing and reporting in children, potential updates to provincial/territorial regulatory and funding approvals and education and training for providers.

2. We suggest that the following tests may be considered as adjunct tools in the assessment of children with suspected OSA but should NOT be used in isolation to diagnose OSA in children: the Pediatric Sleep Questionnaire,^{61,62} and overnight oximetry, including the McGill oximetry score.^{63,64} (Quality of evidence: Low to Moderate; Strength of recommendation: Weak)

The panel recognized that these tests are commonly used by practitioners in the assessment of children with suspected OSA. The PSQ was the only questionnaire where there was sufficient data for meta-analysis and sROC analysis. Overnight oximetry was the most common test studied in comparison to PSG. The panel identified these tests as ones where additional discussion and consideration was warranted.

The Pediatric Sleep Questionnaire (PSQ): The PSQ^{61,62} is a 22-item questionnaire that was developed to investigate sleep-related breathing disorders in children in clinical research.⁶¹ A positive test result, designed to be indicative of OSA, is a test score of 0.33 (33% of 22 items scored as “yes”) or greater. The validity and reliability of the PSQ was originally assessed in children 2-18 years of age, excluding children with severe medical or mental impairment but not milder levels of impairment to ensure this test could be applied broadly. The PSQ was found to have the highest level of agreement with PSG, compared to other pediatric OSA related questionnaires, in both our analysis as well as two previous studies.^{65,66} Despite variation in study inclusion criteria, all three analyses showed similar results for the PSQ, which had moderate sensitivity and low specificity for the diagnosis of OSA compared to a PSG definition of “mild OSA” (AHI $\geq$ 1 event/h; Table 2, Figure 3). Across these analyses,

TABLE 2] Summary of receiver operator curve (sROC) characteristics for the comparisons of an index tests against polysomnography for the diagnosis of obstructive sleep apnea in children

Summary statistics (mean, [95% confidence intervals])								
Index test [definition]	Polysomnography criteria (events/h)	#studies	#participants	Sensitivity	Specificity	LR+	LR-	Diagnostic odds ratio
HSAT/L3 [AHI > 1 event/h]	AHI > 1 or ≥ 1 or >1.5	10	466	0.89 (0.85–0.92) $I^2 = 72.5\%$	0.57 (0.47–0.67) $I^2 = 77.9\%^{\text{y}}$	2.02 (1.18–3.48) $I^2 = 84.9\%^{\text{y}}$	0.23 (0.17–0.31) $I^2 = 0.0\%$	14.18 (7.15–28.12) $I^2 = 0.0\%$
HSAT/L3 [AHI > 1 event/h]	AHI > 5 or ≥ 5	3	94	0.96 (0.80–1.0) $I^2 = 0.0\%$	0.62 (0.50–0.74) $I^2 = 97.1\%^{\text{y}}$	10.78 (0.007–15562.6) $I^2 = 97.1\%^{\text{y}}$	0.13 (0.041–0.44) $I^2 = 0.0\%$	62.66 (1.43–2737) $I^2 = 61.1\%$
HSAT/L3 [AHI > 5 event/h]	AHI > 5 or ≥ 5	10	485	0.73 (0.66–0.79) $I^2 = 87.3\%^{\text{y}}$	0.76 (0.71–0.81) $I^2 = 92.4\%^{\text{y}}$	5.04 (1.58–16.01) $I^2 = 97.1\%^{\text{y}}$	0.25 (0.13–0.50) $I^2 = 79.5\%^{\text{y}}$	24.08 (7.89–73.48) $I^2 = 59.4\%$
PSQ [≥ 0.33]	AHI > 1 or ≥ 1 or >1.5	5	352	0.69 (0.63–0.75) $I^2 = 81.5\%^{\text{y}}$	0.49 (0.39–0.59) $I^2 = 42.5\%$	1.23 (0.97–1.55) $I^2 = 29.1\%$	0.69 (0.51–0.94) $I^2 = 8.4\%$	1.96 (1.17–3.30) $I^2 = 0.0\%$
PSQ [≥ 0.33]	AHI > 5 or ≥ 5	7	468	0.67 (0.59–0.73) $I^2 = 73.6\%^{\text{**}}$	0.55 (0.49–0.61) $I^2 = 93.3\%^{\text{y}}$	1.38 (0.95–2.0) $I^2 = 75.5\%^{\text{y}}$	0.60 (0.46–0.79) $I^2 = 26.8\%$	2.69 (1.22–5.93) $I^2 = 56.4\%^{\text{*}}$

Inconsistency was high for sensitivity or specificity for all comparison so results must be interpreted with caution.

Abbreviations: AHI, apnea hypopnea index; HSAT/L3, Home Sleep Apnea Testing/Level 3 polysomnography; I^2 , Inconsistency statistic; LR+, positive likelihood ratio; LR-, negative likelihood ratio; PSQ, Pediatric Sleep Questionnaire.

* $p < .05$; ** $p < .01$; *** $p < .001$.

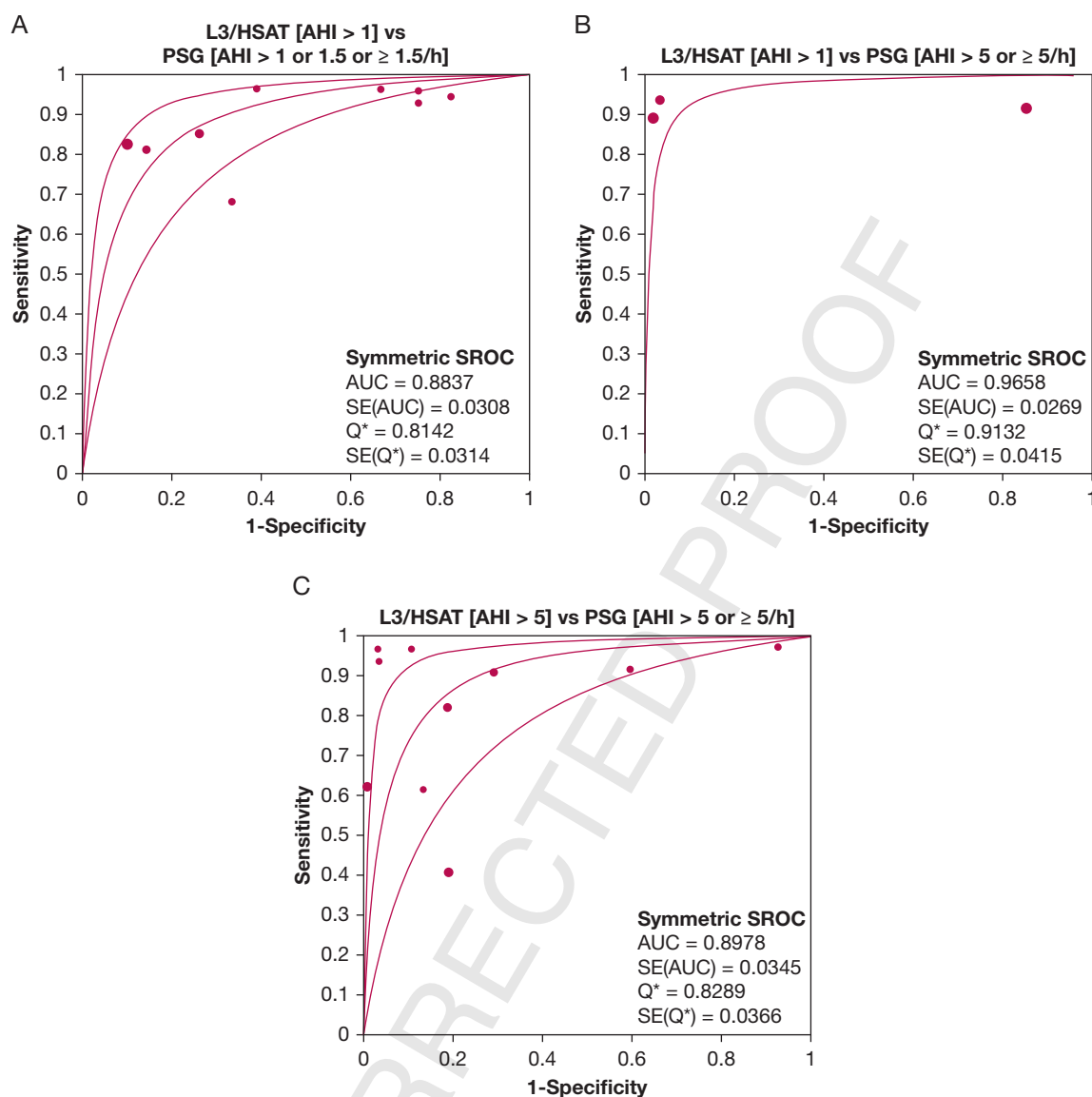


Figure 2 – Summary receive operation characteristics (sROC) curve summarizing studies comparing home sleep apnea test/level 3 polysomnography for the diagnosis of obstructive sleep apnea in children. Panel A: L3/HSAT [AHI > 1] compared to polysomnography [AHI > 1 or ≥ 1.5 events/h]; Panel B: L3/HSAT [AHI > 1] compared to polysomnography [AHI > 5 or ≥ 5]; Panel C: L3/HSAT [AHI > 5] compared to polysomnography [AHI > 5 or ≥ 5]. The dots represent individual study data with the size of the dots representing the number of participants in the study. The curves in each figure show the mean (middle) and 95% confidence intervals (outer curves).

neither sensitivity nor specificity was improved using a PSG OSA definition of AHI ≥ 5 event/h. These results preclude the PSQ as a replacement for PSG.

The PSQ has been translated in several languages and undergone cross-cultural adaptation with similar results for performance as above for translation to French,⁶⁷ Spanish,⁶⁸ Portuguese,⁶⁹ Brazilian Portuguese,⁷⁰ Hindi,⁷¹ Thai,⁷² Arabic,⁷³ Chinese⁷⁴ and Hebrew.⁷⁵ Translations and cross-cultural validations are available for Malay,⁷⁶ Danish⁷⁷ and Turkish,⁷⁸ although without reporting of the performance of the translated test. The PSQ has been assessed in several groups with

comorbidities, including children with asthma, Chiari malformation, cleft lip and/or palate, sickle cell anemia, Down syndrome, juvenile rheumatoid arthritis and adolescents undergoing bariatric surgery, with few or no replication studies. The results show variable performance. There is limited data to support use of the PSQ in children <2 years of age.

The panel acknowledged that, while the PSQ could not be recommended as a diagnostic test, it may add information to the assessment of a child with suspected OSA and can provide a standardized way to track symptoms of OSA.

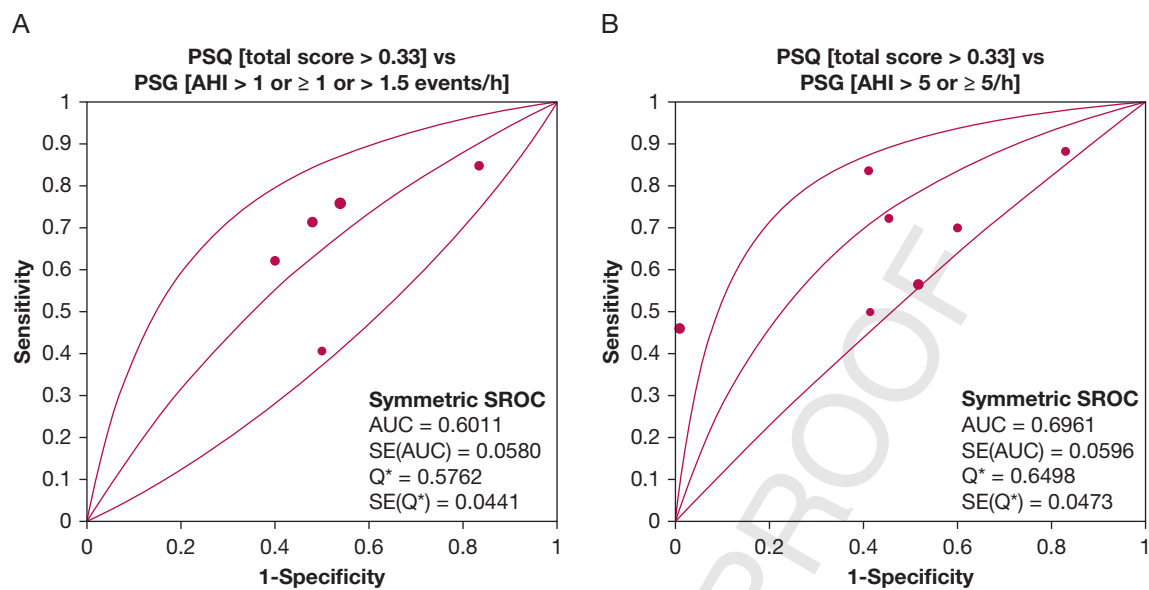


Figure 3 – Summary receiver operation characteristics (sROC) curve summarizing studies comparing Pediatric Sleep Questionnaire (PSQ) for the diagnosis of obstructive sleep apnea in children. Panel A: PSQ [total score > 0.33] compared to polysomnography [AHI > 1 or ≥ 1 or > 1.5 events/h]; Panel B: PSQ [total score > 0.33] compared to polysomnography [AHI > 5 or ≥ 5/h]. The dots represent individual study data with the size of the dots representing the number of participants in the study. The curves in each figure show the mean (middle) and 95% confidence intervals (outer curves).

Overnight oximetry and the McGill Oximetry Score (MOS): An overnight oximetry test is a continuous measure of S_pO_2 recorded overnight. Some practitioners refer to this as a “sleep study” or level 4 PSG but it measures only S_pO_2 and pulse rate with no measure of sleep. It is a common test used in the assessment of children with suspected OSA where PSG access is limited or unavailable. It is used as initial screening, for triaging access to PSG in children without comorbidities, to determine post-operative surgical risks, or to add information to the clinical assessment to support or refute OSA. Oximetry is one of the many signals included in PSG but is different from an overnight oximetry study as the additional data collected during PSG allows more accurate removal of artifact or poor signal data during PSG review and scoring.

The clinical assessment sub-group of overnight oximetry had the most studies of any sub-group, with 32 studies included in the qualitative synthesis. While the overnight oximetry data collected across studies was similar, there was variability in how the data was analyzed. Three main options used to determine a positive test result for overnight oximetry included: (1) the ODI cutoff where the ODI is the number of oxygen desaturation events (drop in S_pO_2 from baseline of 3% or 4%) per hour of the recording with reported cutoffs ranging from ODI > 1 to 25 events/h; (2) analysis using machine learning algorithms; and (3) the

MOS where review of the oximetry data, after removal of artifact and poor signal data, is used to classify the recordings using a 4-point scale as inconclusive (denoted as 1) or abnormal (with increasing levels of severity from 2 to (4) based on the absence or presence of clustered oxygen desaturation events.^{63,79} A cluster of oxygen desaturation is defined as ≥5 events within a 10–30 min period of sleep.⁸⁰ Because of the variability in the ODI cutoff and PSG OSA definitions across the studies using ODI to identify OSA, there were insufficient data for meta-analysis with no clear pattern in the results across individual studies. The studies using machine learning algorithms tested a range of different algorithms across the same dataset so the data across studies were not independent and could not be combined. The results of combining two studies that used a MOS > 2 and PSG OSA definition of OAH1 > 2 showed a broad range in sensitivity (0.57, 0.91) and specificity (0.27, 0.88). Together, this means that, in a child with suspected OSA, the evidence is insufficient to use overnight oximetry to rule in or rule out OSA. The panel acknowledged that overnight oximetry is a common metric used in the assessment of children with suspected OSA. While overnight oximetry, including using the MOS, should not be used as a diagnostic test for OSA, overnight oximetry can add to the assessment of children with suspected OSA.

3. We suggest that the following tests should NOT be used to diagnose OSA in children

- Single clinical history items (eg, individual symptoms of OSA [eg, snoring], demographics [eg, age, sex, obesity], and consequences of OSA [eg, concerns with attention]; OLS, [eAppendix 3](#));
- Other questionnaires to assess OSA in children (eg, the Brouillette score modified STOP-BANG for teens; OLS, [eAppendix 3](#));
- The OSA-18 questionnaire⁸¹ (OLS, [eAppendix 3](#));
- BMI (OLS, [eAppendix 3](#));
- Descriptors of airway anatomy (eg, size of tonsils/adenoids/mandible/maxilla, shape of the palate, OLS, [eAppendix 3](#));
- Physiological measures of airway function (derived from airflow measurement using machine learning algorithms, OLS, [eAppendix 3](#));
- Physiological measures of autonomic function (eg, measures of heart rate variability, cardiopulmonary coupling, and pulse transit, OLS, [eAppendix 3](#));
- Other continuous physiological measures (eg, audio-tapes, CO₂ response curves, mandibular movements, smartphone video, OLS, [eAppendix 3](#));
- Biomarkers (measured from exhaled breath condensate, urine, and blood; [eAppendix 3](#)) and combined measures and descriptors of OSA (OLS, [eAppendix 3](#)). (*Quality of evidence: Very low; Strength of recommendation: Weak*).

There were many index tests across the remaining 10 clinic assessment sub-groups covering a broad range of measures. While there were multiple studies of the OSA-18 questionnaire and BMI as index tests for OSA diagnosis, variations in the PSG definition of OSA and cutoffs precluded combining data for either of these index tests. Replication studies were not available for the remainder of the other index test sub-groups.

The panel suggests that none of the measures included in these index test sub-groups should be used to diagnose OSA in children.

Role of PSG in the diagnosis of OSA in children: The panel recognized that, in the absence of an alternative test that could replace PSG, PSG remains the standard for the diagnosis of OSA in children. While patient and family preferences support testing that is close to or in the home, this preference was expressed in the context of an accurate test. Accordingly, access to PSG must be maintained, if not enhanced. The panel recommends alignment with the AASM, as most sleep laboratories in Canada follow the PSG standards outlined by the AASM; this includes following the AASM definition of OSA that includes symptoms of OSA plus an

OMAH ≥ 1 event/h or obstructive hypoventilation in association with snoring, inspiratory pressure waveform flattening or thoracoabdominal paradox.²⁸

Discussion

This guideline provides recommendations on diagnostic testing for OSA in children. We did not identify a test that would be an acceptable alternative to the current standard of PSG. Where access to PSG is effectively absent, L3/HSAT can be used in children >5 years of age to increase access to testing. There is a need for L3/HSAT studies that include children of all age groups, including infants, that include comparison of L3/HSAT accuracy across age groups. Studies in children with comorbidities and varied medical complexity are needed to better understand factors that impact the accuracy of L3/HSAT and whether it may be considered more broadly as an alternative to PSG for all children. However, our findings suggest that, at least with the current diagnostic tools, it is highly unlikely that the need for PSG will be eliminated for all children. Investment in access to PSG is needed to reduce wait times and the burden for children needing this testing and their families. The PSQ and overnight oximetry, including the MOS, are often used in clinical practice as part of the assessment of suspected OSA but should not be used as diagnostic tests for OSA in children. While considerable investments have been made in assessing alternatives to PSG, larger studies of high methodological quality are required. Scientists and private industry should focus on improving existing tests that show promise and pursuing innovative approaches, including measures that use artificial intelligence and automated analysis techniques, to develop accurate and accessible diagnostic testing for all children with suspected OSA.

The systematic review completed to provide the evidence summary for this guideline supports the findings of previous systematic reviews addressing overlapping questions. A previous systematic review and meta-analysis of questionnaires for OSA in children identified 20 questionnaires with only two, the PSQ and OSA-18, that could be included in quantitative synthesis.⁶⁶ Using a PSG threshold of AHI ≥ 1 event/h, the results showed similar sensitivity and specificity for the PSQ as the current analysis, with minimal improvement in the performance of these parameters using AHI ≥ 5 event/h. The results of the previous analysis of the OSA-18 included studies excluded from the current review and showed low sensitivity and

variable specificity using PSG thresholds of AHI ≥ 1 event/h and AHI ≥ 5 event/h, respectively.⁶⁶ A systematic review comparing tonsil size to PSG-diagnosed OSA concluded that the association between tonsil size and OSA is, at best weak, with high quality studies supporting no association.⁸² In a systematic review and meta-analysis of machine learning approaches to the diagnosis of OSA in children, data were combined for studies that include SpO₂ and other sensors.⁸³ The results showed that pooled sensitivity decreased from 0.92 and specificity increased from 0.39 as the PSG threshold for AHI increased from 1 to 5 to 10 events/h. A previous systematic review and meta-analysis of type 2 and 3 studies (home full PSG and L3/HSAT respectively), which pooled studies with different PSG thresholds, showed pooled sensitivity and specificity of 0.76 and 0.76, respectively, with high heterogeneity across studies.⁴⁵ Finally, the British Thoracic Society conducted a systematic review as part of their guideline for diagnosing and monitoring pediatric sleep-disordered breathing;³⁹ while the data in this analysis combined different OSA and test definitions, and, for some tests, different tests, the overall results of these analysis, where comparable, are consistent with the current analysis. The current analysis adds to these results by adding data for additional clinical assessment types as well as separating quantitative data analysis by specific PSG definitions of OSA. Together, these data support that clinical history, physical examination, and traditional means of SpO₂ analysis cannot replace PSG as diagnostic tools in children with suspected OSA. Future efforts should be focused on home overnight physiological recordings, including overnight oximetry and HSAT/L3 testing and considering novel techniques to analyze physiological data signals.

An important consideration coming out of the current evidence review, as well as guidelines published by a number of groups across the world,^{1,28,31,32,34,35,37,38,84} is the lack of consensus on the PSG definition of OSA in children. Overall, the published guidelines emphasize that a diagnosis of OSA requires symptoms that include, but are not limited to, snoring, signs of airway obstruction, and disruption of normal ventilation and sleep. Not all current guidelines endorse PSG or other objective testing as necessary for the diagnosis of OSA, with some endorsing polygraphy or HSAT/L3 studies as alternatives to PSG,^{32,34,37,38,84} with lack of universal access to PSG cited as a factor impacting testing recommendations. Most guidelines emphasize

obstructive respiratory events as important, with most using OAHI, rather than AHI, as the primary variable to define OSA by PSG, including in infants.^{28,32,37,38,84} The AHI, however, is the most commonly used metric across research studies. It is also important to consider that the optimal definition of OSA for clinical practice may be neither AHI nor OAHI, but rather other single or group of variables that better reflect the multifactorial nature of OSA and correlate with symptoms, consequences of untreated OSA, and treatment outcomes. This is supported by the results from three randomized trials of early adenotonsillectomy versus watchful waiting for three different populations of pediatrics OSA.⁸⁵⁻⁸⁷ No differences were found for the primary outcomes measures of neurocognitive function across these studies but the early adenotonsillectomy groups showed improvements in behavior, quality of life, and OSA symptoms across studies with improvements in arousal index and AHI in two of the three studies. New measures of OSA may include measures being tested as alternatives to the AHI in adult OSA,⁴³ measures of OSA phenotypes⁵ or combining data from different measures to provide more accurate characterization of OSA in children. A standard definition of OSA is vital to improving comparability of data across studies.

The generalizability of the recommendations in this and other guidelines to all children with OSA is another important consideration. The majority of studies included in the current review excluded children with comorbidities, with some studies being more restrictive than others. Most guidelines or other forms of recommendations for the diagnosis of OSA in children are focused on otherwise healthy children, excluding or not mentioning children with comorbidities other than obesity, and all but one of the current guidelines excluded children under 1 year of age.^{1,28,31,32,34,35,84} Diagnostic tests may perform differently when used in children of different ages or children with different levels of medical complexity. As an example, the PSQ has lower sensitivity and specificity for the detection of OSA in children with craniofacial disorders and sickle cell anemia, compared with broader groups of children with suspected OSA,^{88,89} it may under-estimate OSA in children with Marfan syndrome,⁹⁰ and performs poorly for identifying OSA in children with asthma.⁹¹ In a study of children who underwent PSG at a single site over a 10-month period, the PSQ sensitivity and specificity varied from 0.37-0.84 and 0.18-0.76, respectively, across different comorbidity groups.⁹²

While there is a general consensus that children with medical complexity, such as children with Down syndrome, neuromuscular disease, or sickle cell disease, should undergo PSG prior to consideration for treatment of OSA, the lack of testing alternatives to PSG in these high risk groups may perpetuate limitations in access to diagnostic testing and health disparities in children at risk for OSA.

Identified limitations in the available evidence should inform future studies of diagnostic tests for OSA in children.

Despite a large number of studies included in the broad criteria of the current review, there were limited data that could be combined for quantitative synthesis because of insufficient data reporting as well as variability in both PSG and index test definitions of OSA. High heterogeneity of data was seen across studies that were appropriate for synthesis. While sample size varied across studies, the median number of participants was 96. Larger sample sizes are needed to allow for analysis of subgroups, such as analyses by age groups, specific comorbidities, and sociodemographic factors. Only one study was identified that compared PSG to level 2 PSG (full PSG, unobserved) was identified in our search so this testing option was not included as part of the guideline. The use of artificial intelligence techniques, including machine learning algorithms, also require large sample sizes. Multi-centered data sets and accessing health services data that include discrete PSG variables may help to address this limitation as would standardized reporting of studies evaluating sleep diagnostic testing to include age groups (eg, <1 year, 2-5 years, 6-12 years, 13-17 years), and medical complexity (eg, otherwise healthy children, children with obesity only, children with medical complexity) to allow comparisons across subgroups. Replication of results in a range of environments and populations will be important to address generalizability and to ensure equitable access as new diagnostic testing methods are developed, tested and emerge into clinical care for children with suspected OSA.

Conclusion

There has been a considerable investment in identifying alternative tests to PSG for the diagnosis of OSA in children. Variability in PSG definitions of OSA and features of alternative tests limited the amount of data appropriate for quantitative synthesis. As a result, quantitative synthesis could only be performed for the

Pediatric Sleep Questionnaire and HSAT/L3 testing. Where PSG is effectively absent, we recommend the use of HSAT/L3 as an alternative (second line) option to diagnose OSA in otherwise healthy children >5 years of age. The PSQ and overnight oximetry are not appropriate for the diagnosis of OSA in children. Machine learning analysis of home oximetry and airflow measures show considerable promise. Future studies of alternatives to PSG should focus on investigating novel data analysis techniques of continuous physiological data and ensure that participants include children of all ages and medical complexity, children of diverse racial and ethnic background and children who are socioeconomically disadvantaged.

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