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ORIGINAL ARTICLE

# Polygraphy in hospitalized pediatric patients: A real-life practice

## Poligrafías en pacientes pediátricos hospitalizados: Una práctica de la vida real

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## Abstract

### Introduction

The gold standard test for diagnosing sleep-disordered breathing is polysomnography; however, its limited availability has led to the emergence of alternatives such as polygraphy, which is more accessible and cost-effective.

### Objective

To analyze the association between underlying conditions and obstructive sleep apnea-hypopnea syndrome in children with suspected sleep-disordered breathing.

### Methods

Retrospective cross-sectional study. Polygraphy studies of hospitalized children aged ≥1 year with suspected sleep-disordered breathing were included. Demographic, clinical, and polygraphic variables were collected. A logistic regression analysis was performed to evaluate the presence of obstructive sleep apnea-hypopnea syndrome according to underlying conditions.

### Results

Of 1,000 polygraphy studies, 407 were analyzed. The median age was 8.2 years (range 4.1–12.2), with 56% male patients. The main diagnoses were neurological impairment (19.4%), neuromuscular diseases (16.0%), upper airway obstruction (15.5%), and chronic lung disease (15.5%). Abnormal polygraphy was found in 56.0% of cases, with obstructive sleep apnea syndrome classified as mild in 63.0%, moderate in 21.0%, and severe in 16.0%, with obesity and neuromuscular diseases being most prominent. Significant differences were found in age (p=0.001) and apnea-hypopnea index (p=0.002) across diagnostic categories. Children with Down syndrome had a 5.5-fold higher risk of obstructive sleep apnea-hypopnea syndrome compared to those with chronic lung disease.

### Conclusions

There was a high prevalence of obstructive sleep apnea-hypopnea syndrome, particularly in children with obesity and neuromuscular diseases. Patients with Down syndrome had a higher risk of obstructive sleep apnea-hypopnea syndrome compared to those with chronic lung disease. Polygraphy is a potentially implementable tool in healthcare centers with similar characteristics.

**Conflict of interest:**

The authors report no conflicts of interest..

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## Resumen

### Introducción

El examen de elección para diagnóstico de los trastornos respiratorios del sueño es la polisomnografía; sin embargo, presenta disponibilidad limitada, emergiendo alternativas como la poligrafía, más accesible y de menor costo.

### Objetivo

Analizar asociación entre patologías de base y síndrome de apnea-hipoapnea obstructiva del sueño en niños con sospecha de trastornos respiratorio del sueño.

### Métodos

Estudio transversal retrospectivo. Se incluyeron poligrafías de niños ≥1 año hospitalizados con sospecha de trastornos respiratorios del sueño. Se recopilaron variables demográficas, clínicas y poligráficas. Se realizó un análisis de regresión logística para evaluar presencia de síndrome de apnea-hipoapnea obstructiva del sueño según patologías.

### Resultados

De 1,000 poligrafías se analizaron 407. Mediana de edad 8.2 años (4.1-12.2), varones 56%. Diagnósticos principales: daño neurológico (19.4%), enfermedades neuromusculares (16.0%), obstrucción de vía aérea superior (15.5%) y daño pulmonar crónico (15.5%). Poligrafías alteradas 56.0%; síndrome de apneas obstructivas del sueño leve 63.0%, moderado 21.0% y severo 16.0%, destacando obesidad y enfermedades neuromusculares. Se encontraron diferencias significativas en edad (p=0.001) e índice de apneas-hipoapnea (p=0.002) según diagnósticos. Los pacientes con síndrome de Down tuvieron un riesgo 5.5 veces mayor de síndrome de apnea-hipopnea obstructiva del sueño en comparación con los pacientes con daño pulmonar crónico.

### Conclusiones

Existió un alto porcentaje de síndrome de apnea-hipoapnea obstructiva del sueño, especialmente en obesidad y enfermedades neuromusculares. Los pacientes con síndrome de Down tienen más riesgo de síndrome de apnea-hipoapnea obstructivas del sueño respecto a daño pulmonar crónico. La poligrafía es una herramienta potencialmente implementable en centros asistenciales con características similares

## Remark

### 1) Why was this study conducted?

To evaluate the diagnostic utility of respiratory polygraphy in hospitalized children with suspected sleep-disordered breathing, given the limited availability of polysomnography in public clinical settings.

### 2) What were the most relevant results of the study?

A high prevalence of obstructive sleep apnea-hypopnea syndrome (56%) was observed, particularly in children with obesity, neuromuscular diseases, and Down syndrome—the latter showing a 5.5-fold increased risk compared to those with chronic lung disease.

### 3) What do these results contribute?

These findings support the use of respiratory polygraphy as a viable and accessible diagnostic tool for identifying obstructive sleep apnea-hypopnea syndrome in at-risk pediatric populations, particularly in resource-limited settings.

## Introduction

Sleep-disordered breathing in the pediatric population encompasses a heterogeneous group of conditions, ranging from primary snoring to obstructive sleep apnea (OSA), the latter being classified into different grades according to severity [1]. OSA is characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, leading to disturbances in ventilation, gas exchange, and sleep architecture [2]. Recent studies report a prevalence of 4–5% among children and adolescents, with significantly higher rates in specific subgroups presenting predisposing factors such as adenotonsillar hypertrophy, obesity, craniofacial anomalies, neuromuscular diseases, cerebral palsy, and genetic syndromes [3,4].

The pathophysiological consequences of sleep-disordered breathing are multisystemic, with notable impacts on neurocognitive and cardiovascular function, showing a direct relationship between the severity of the disorder and the magnitude of its detrimental effects [5,6]. In this context, early diagnosis is essential, as it enables timely interventions that reduce the risk of medium- and long-term sequelae, improve quality of life, and potentially optimize the use of healthcare resources [7,8].

From a clinical perspective, the usefulness of guiding symptoms and signs is limited; therefore, complementary diagnostic studies are necessary to confirm the presence and characterize the severity of sleep-disordered breathing [9]. Conventional polysomnography remains the gold standard for this purpose, given its comprehensive and confirmatory nature. However, its limited availability, high cost, and technical complexity restrict its routine use in certain settings [10].

Respiratory polygraphy emerges as a valid and cost-effective diagnostic alternative to polysomnography for the evaluation of sleep-disordered breathing in pediatric populations. It allows the recording of cardiorespiratory variables (airflow, respiratory effort, oxygen saturation, and heart rate), with reported sensitivity and specificity of 90.9% and 94.1%, respectively, for an Apnea-Hypopnea Index (AHI) >5 events/hour—corresponding to moderate to severe cases [11–13].

Among its advantages, respiratory polygraphy stands out for its greater accessibility, lower cost, potential for home-based application, and rapid implementation in various hospital settings [3,4,14–17]. Its main limitations include underestimation of central events and microarousals not associated with desaturation, and the inability to assess the neurophysiological aspects of sleep, restricting its use in cases with suspected non-respiratory sleep disorders (such as epilepsy, parasomnias, bruxism, among others) [11].

Despite international recommendations, evidence on the use of polygraphy in pediatric populations remains limited and is even scarcer in resource-constrained settings such as Latin American countries, underscoring the need for local studies to support its applicability [11,12].

The objective of this study was to analyze the association between underlying conditions and the diagnosis of OSA in children over one year of age with suspected sleep-disordered breathing, seen at a public hospital in Chile.

## Materials and Methods

### Design

A retrospective cross-sectional study was conducted, including polygraphy records of children and adolescents aged 1 to 20 years with suspected sleep-disordered breathing, referred to Hospital Guillermo Grant Benavente in Concepción, Chile, between December 2011 and March 2023. Patients with acute respiratory infections were excluded. The study was approved by the institutional ethics committee. A convenience sampling method was used, and demographic, clinical, and polygraphic variables were collected, including total study duration, total sleep time, Apnea-Hypopnea Index (AHI), obstructive and mixed AHI (AHIOM), central apnea index (CAI), minimum oxygen saturation, mean oxygen saturation, and percentage of time with saturation

below 90% during the study. Polygraphies performed in children under 1 year of age, users of oxygen therapy and/or mechanical ventilation, repeated studies, technically deficient recordings, and those with insufficient information were excluded.

### Polygraphies

Patients were scheduled for evaluation at the hospital by the nursing team, which provided specific instructions, including maintaining their usual medication regimen, avoiding caffeinated or energy drinks, and refraining from daytime naps on the day of the study. No additional sleep-inducing agents were prescribed beyond those regularly used by the patient. Polygraphy was performed using the Alice Pdx system (Philips Respironics, Murrysville, PA, USA), which recorded the following channels: nasal airflow via pressure transducer, oxygen saturation, heart rate, microphone, and thoracic and abdominal effort bands. The setup was conducted by a trained professional knowledgeable in the technical and methodological aspects of the exam. The quality of polygraphic recordings was assessed twice—first by a trained respiratory therapist, and then by a pulmonologist specialized in sleep studies.

Acceptability or validation criteria included recordings with at least four hours of total sleep time and less than 20% of the recording time affected by disconnections and/or artifacts. The severity of OSA was categorized based on the Apnea-Hypopnea Index (AHI) as follows: normal (AHI <1), mild (AHI 1–5), moderate (AHI 5–10), and severe (AHI >10) [9].

### Statistical analysis

Normality was assessed using Q-Q plots and the Kolmogorov-Smirnov test. Quantitative data were expressed as medians and interquartile ranges (IQR), while qualitative data were reported as frequencies and percentages. Non-parametric statistics were applied for variable analysis. Demographic and polygraphic variables were compared across diagnoses using the Kruskal-Wallis test, with post-hoc pairwise comparisons conducted via the Dwass-Steel-Critchlow-Fligner test. Categorical variables were compared by diagnosis using the Chi-square test. Diagnoses were further analyzed to assess the presence of OSA through simple binomial logistic regression. Three models were developed: unadjusted, adjusted for age, and adjusted for age and AHI. Groups with fewer than 10 patients (central hypoventilation syndrome and unspecified infant apneas) were excluded from diagnosis-based comparisons due to small sample size. The pattern of missing data was evaluated for randomness, association with other variables, or non-randomness. Incomplete cases were excluded if missing data accounted for less than 5%. Statistical analyses were performed using Jamovi software, version 2.3.28, with significance set at $p$ <0.05.

## Results

During the study period, 1,000 polygraphies were performed. A total of 267 (26.7%) were excluded due to repeated examinations, 33 (3.3%) due to the use of oxygen therapy or mechanical ventilation, 25 (2.5%) due to missing information, and 253 (25.3%) for being under one year of age. Of the remaining 422 polygraphies, 15 cases (3.5%) were excluded due to uninterpretable recordings: 7 due to insufficient recording time, 7 due to loss of flow sensor, and 1 due to clinical instability. In the end, 407 polygraphies were included in the analysis, meaning that 96% of the 422 studies met validity criteria (Figure 1).

The median age of the sample was 8.2 years (4.1–12.2), and 56.0% (n = 228) were male. Regarding patient diagnoses, 24.2% had ENM, 21% had chronic lung disease (CLD), and 19.5% had upper airway obstruction (n = 37). The median total duration of the polygraphy studies was 9.4 hours (8.6–10.2), with a validated period of 7.3 hours (6.1–8.0). The mean oxygen saturation during the study was 97% (96–98%), with a mean minimum saturation of 89% (85–92%). The median AHI was 1.6 (0.7–4.2), and the median AHIOM was 1.4 (0.5–3.7) (Table 1).

**Table 1.** General characteristics of polygraphy studies (n= 407)

| Characteristics | Median (IQR) |
|---|---|
| Age, years | 8.2 (4.1-12.2) |
| Male sex | 228 (56.0) |
| Total duration, hours | 9.4 (8.6-10.2) |
| Total sleep time, hours | 7.3 (6.1-8.0) |
| Mean oxygen saturation, % | 97 (96-98) |
| Minimum oxygen saturation, % | 89 (85-92) |
| Presence of saturation below 90% | 181 (45.6) |
| Apnea-Hypopnea Index | 1,6 (0.7-4.2) |
| Obstructive and mixed Apnea-Hypopnea Index | 1.4 (0.5-3.7) |
| Central Apnea Index | 0.0 (0.0-0.1) |

Quantitative variables are expressed as medians and interquartile ranges. Qualitative variables are expressed as frequency and percentage. Respiratory indices are expressed in events per hour

Regarding patient diagnoses, 19.4% (n= 79) had neurological impairment (NI), 16% (n= 65) had ENM, 15.5% (n= 63) had CLD, 15.5% (n= 63) had upper airway obstruction, 10.1% (n= 41) had upper airway malformations, 9.3% (n= 38) had Down syndrome (DS), 6.6% (n= 27) had other conditions such as stroke, congenital heart disease, hypertension, upper airway burns, aortic stenosis, or a genetic syndrome under investigation, 4.9% (n= 20) had obesity, 2.0% (n= 8) had central hypoventilation syndrome, and 0.7% (n= 3) had unspecified infant apneas.

Forty-four percent (n= 178) of the polygraphies analyzed were normal. Among the abnormal studies, 63% (n= 145) were classified as mild OSA, 21% (n = 48) as moderate, and 16% (n= 36) as severe. Of the 407 patients, 34 had persistent hypoxemia; among them, 5 did not have OSA and 29 did. Since this did not affect the final results, these patients were categorized according to OSA severity.

Significant differences were observed between diagnostic groups, with higher AHI values in obese patients (3.6 [0.8–8.9]), ENM (2.6 [1.0–5.1]), DS (2.6 [1.0–5.1]), and NI (2.2 [0.7–5.7]). A higher AHIOM was also found in obese patients (3.0 [0.7–6.9]), ENM (2.3 [0.9–4.6]), DS (2.3 [0.8–5.2]), and NI (2.1 [0.6–5.1]). A post-hoc analysis showed no significant differences in minimum saturation, mean saturation, or percentage of time below 90% among the different pathologies (Table 2).

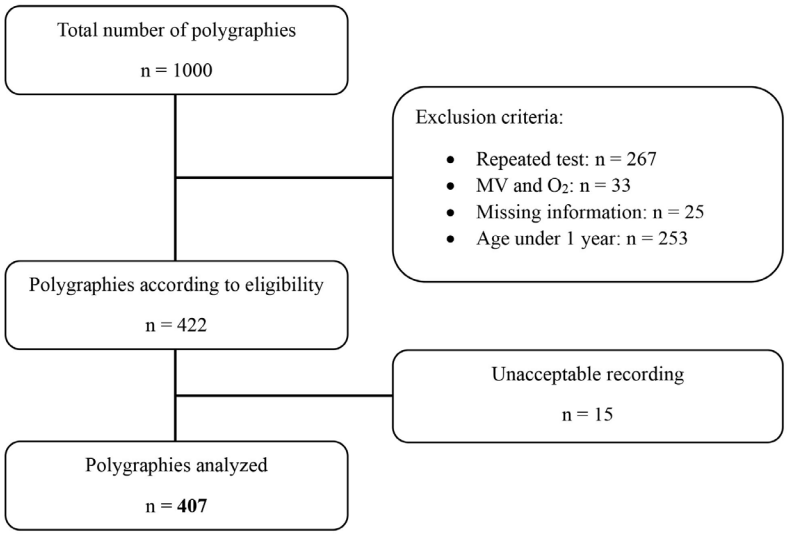


**Figure 1.** Flowchart of eligibility criteria. Abbreviations: MV: mechanical ventilation; $O_2$: oxygen therapy

**Table 2.** Polygraphy results by diagnosis

| Diagnosis | Patients | Age, years | Validated total time, h | Apnea-Hypopnea Index | Obstructive and mixed Apnea-Hypopnea Index | Central Apnea Index | Mean oxygen saturation, % | Minimum oxygen saturation, % | Presence of saturation below 90% |
|---|---|---|---|---|---|---|---|---|---|
| Neurological impairment | 79 (19.4) | 8 (5.0-10.3) | 6.9 (5.9- 8.1) | 2.2 (0.7-5.7) | 1.9 (0.6-5.0) | 0.0 (0.0-0.2) | 97 (95-97) | 87 (82-91) | 47 (59.5) |
| Neuromuscular disease | 65 (16.0) | 10.4 (5.1-13.2) | 6.9 (5.8-7.5) | 2.6 (1.0-5.1) | 2.3 (0.8-4.5) | 0.0 (0.0-0.1) | 97 (96-98) | 89 (85-92) | 23 (35.4) |
| Chronic lung disease | 63 (15.5) | 7.1 (3.6-11.6) | 7.3 (6.8-8.1) | 0.9 (0.4-2.1) | 0.8 (0.4-1.7) | 0.0 (0.0-0.1) | 97 (95-98) | 90 (85-92) | 24 (38.1) |
| Upper airway obstruction | 63 (15.5) | 7.2 (3.7-13.0) | 7.5 (6.5-8.1) | 1.1 (0.5-2.9) | 1.0 (0.4-2.7) | 0.0 (0.0-0.1) | 97 (96-98) | 91 (86.5- 92.5) | 24 (38.1) |
| Upper airway malformation | 41 (10.1) | 5.9 (2.3-10.9) | 7.6 (6.5-8.5) | 1.5 (0.7-3.2) | 1.5 (0.6-3.0) | 0.0 (0.0-0.2) | 97 (96-98) | 90 (87-92) | 18 (43.9) |
| Down syndrome | 38 (9.3) | 6.4 (3.4-10.8) | 7.1 (6.1-7.6) | 2.6 (1.0-5.2) | 2.4 (0.9-5.1) | 0.0 (0.0-0.1) | 97 (95-97) | 89 (86.2-92) | 18 (47.4) |
| Others | 27 (6.6) | 10 (5.2-13.2) | 7.3 (6.4-8.1) | 1.1 (0.6-2.6) | 1.1 (0.6-2.2) | 0.0 (0.0-0.0) | 96 (93.5-97) | 88 (85.5-92.5) | 17 (63.0) |
| Obesity | 20 (4.9) | 12.1 (9.9-14.1) | 7.0 (6.0-7.8) | 3.6 (0.8-8.9) | 2.9 (0.7-6.9) | 0.0 (0.0-0.3) | 97 (96-97) | 89 (88-91.2) | 9 (45.0) |
| Central hypoventilation syndrome | 8 (2) | 9.9 (5.6-13.4) | 6.8 (6.3-7.5) | 1.3 (0.9-2.1) | 1.3 (0.9-2.1) | 0.0 (0.0-0.1) | 98 (96-98) | 91 (87-94.5) | 1 (12.5) |
| Unspecified infant apneas | 3 (0.7) | 1.3 (1.1-2.0) | 6.9 (5.8-7.5) | 0.6 (0.3-1.6) | 0.0 (0.0-1.3) | 0.0 (0.0-0.0) | 98 (97-98.5) | 90 (89.5-90) | 0 (0.0) |
| p-value † | - | 0.001 | - | 0.002 | 0.009 | 0.154 | 0.013 | 0.220 | 0.057 ‡ |

Quantitative variables are expressed as medians and interquartile ranges. Qualitative variables are expressed as frequency and percentage. Respiratory indices are expressed in events per hour. The central hypoventilation syndrome and unspecified infant apneas groups were excluded from diagnosis-based comparisons. † Kruskal-Wallis test, ‡ Chi-square test.

In the simple binomial logistic regression analysis to determine the presence of OSA, only certain conditions showed significant differences compared to those with CLD. In the unadjusted model, patients with ENM had an odds ratio (OR) of 2.97 (95% CI: 1.40–6.28), NI had an OR of 2.10 (95% CI: 1.10–4.15), obesity had an OR of 3.88 (95% CI: 1.17–12.90), and DS had an OR of 8.23 (95% CI: 2.61–25.95) for higher risk of OSA compared to CLD. In model 2, adjusted for age, these associations remained. In model 3, adjusted for age and AHI, only patients with DS maintained a significant association, with an OR of 5.54 (95% CI: 1.50–20.41) for OSA compared to those with CLD (Table 3).

## Discussion

This study presents 12 years of experience with polygraphy in pediatric patients over one year of age, evaluated at a tertiary-level public hospital in Chile, considering the wide range of clinical conditions that require assessment through accessible diagnostic tools.

Our team previously published a study in 2019; however, the current work covers a significantly longer data collection period (12 years vs. 6 years) and includes more than twice as many patients, both overall and within diagnostic subgroups. This allowed for more reliable results and the application of more complex and precise statistical methodologies, as reflected in the development of this article. The distribution of pathologies, the proportion of altered studies, and their severity were comparable in both studies. However, an increase in the proportion of validated studies was observed, from 90% to 96%, likely due to the greater experience of the healthcare team responsible for the installation and interpretation of the exams [14].

**Table 3.** Binomial logistic regression analysis for the presence of OSA according to different conditions

| Predictor | Model 1† | | | Model 2 ‡ | | | Model 3 * | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% confidence interval | p value | OR | 95% confidence interval | p value | OR | 95% confidence interval | p value |
| Chronic lung disease | Ref. | - | - | Ref. | - | - | Ref. | - | - |
| Down syndrome | 7.97 | 2.52-25.15 | <0.001 | 8.00 | 2.53-25.29 | <0.001 | 5.54 | 1.50-20.41 | 0.010 |
| Obesity | 3.75 | 1.13-12.49 | 0.031 | 3.69 | 1.09-12.47 | 0.035 | 1.69 | 0.36-7.93 | 0.509 |
| Neurological impairment | 2.02 | 1.02-4.03 | 0.031 | 2.03 | 1.02-4.03 | 0.044 | 1.06 | 0.43-2.60 | 0.896 |
| Neuromuscular disease | 2.87 | 1.35-6.09 | 0.006 | 2.85 | 1.34-6.08 | 0.007 | 1.48 | 0.56-3.89 | 0.429 |

OR: Odds Ratio, Ref.: Reference. † Unadjusted; ‡ Adjusted for age; * Adjusted for age and Apnea-Hypopnea Index

Epidemiological studies report that 4–5% of children have OSA; however, this percentage increases significantly in the presence of risk factors and/or conditions such as ENM, craniofacial malformations, obesity, genetic syndromes, and chronic lung disease [2,3]. In our study population, we found a high percentage of OSA (56%), mainly in patients with obesity, ENM, DS, and NI. Singh et al. [18], in a similar study involving 51 hospitalized patients aged 2 to 18 years evaluated with polygraphy—90% of whom had significant comorbidities—found a 76% prevalence of OSA. This high percentage is explained by the fact that the patients included in both studies had relevant underlying conditions. In our experience, patients were primarily recruited through a sleep clinic and referred to after evaluation by specialist professionals, often in complex clinical scenarios, making this study relevant for guiding decisions such as ventilatory support and/or specific surgeries.

It is important to highlight that polysomnography is the gold standard for diagnosing sleep-disordered breathing; however, its access is very limited in public healthcare centers in Chile, which restricts therapeutic approaches. In contrast, polygraphy is a more accessible and internationally recognized abbreviated diagnostic tool [11,19]. It shows a high level of concordance with polysomnography in the evaluation of sleep-disordered breathing and has been used and recommended in various high-risk patient groups [20,21].

Veloso et al. [15], evaluated the technical and economic feasibility of polygraphy in children aged 3 to 11 years who were surgical candidates, finding that the cost of polygraphy was equivalent to 63% of that of polysomnography. Although only 71% of the polygraphies were validated, the method demonstrated significantly greater economic feasibility. In contrast, validation rates are much higher in other studies; in our study, 96% of polygraphies met validity criteria, meaning only 4% had to be repeated, suggesting a potentially greater diagnostic and economic impact [10,17,21]. The main reasons for invalid studies were insufficient recording time and incomplete information.

Among the different pathologies, there were practically no significant differences in the presence of OSA; however, DS, obesity, ENM, and NI were associated with a higher risk of OSA compared to CLD, where the risk was lower. This may reflect that therapeutic decisions in these patients are less dependent on cardiorespiratory sleep studies. These findings are expected and consistent with the literature, as the pathophysiological basis of obstructive events is mainly related to anatomical-functional alterations of the upper airway and/or impairment of the respiratory musculature [22,23]. Notably, after adjusting for age and AHI, patients with DS were still 5.5 times more likely to have OSA than those with CLD. The high risk of OSA in this genetic condition is well documented, with recommendations for evaluation at 4 years of age and subsequently whenever clinical suspicion or related consequences arise [24,25].

Our results with pediatric polygraphy demonstrate that this type of study is feasible in developing countries like ours and may serve as an alternative for other Latin American countries with similar sociocultural and economic realities. This approach offers an accessible, low-cost diagnostic tool, especially in regions where access to reference tests such as polysomnography is limited, highlighting its potential to improve the management of sleep-disordered breathing in the region.

This study has limitations that must be addressed. There is a potential selection bias, as patients were referred from specialty consultations within the same hospital, implying a population with greater clinical complexity and a more defined suspicion of sleep-disordered breathing. These were not referrals from lower-complexity centers, which may have influenced case severity and limited the representativeness of the sample. Additionally, a convenience sampling method was used, limiting the generalizability of the findings. The retrospective design precludes causal inferences and relies on the quality and availability of existing clinical records, with incomplete cases excluding to reduce the risk of bias due to missing data. Finally, the single-center nature of the study limits extrapolation of the results to the local setting rather than the national context.

## Conclusion

A high proportion of OSA was observed in at-risk pediatric patients, particularly among those with obesity and ENM. A high percentage of polygraphy studies met validation criteria for interpretation. Patients with Down syndrome showed a higher risk of OSA compared to those with CLD.

These findings support the value of polygraphy as a diagnostic tool in these patient groups. The experience gained suggests that its use could be considered in other centers with similar clinical profiles and resource availability, especially in contexts where access to polysomnography is limited. This could contribute to optimizing the diagnosis of sleep-disordered breathing in at-risk pediatric populations, enabling timely interventions to mitigate their multisystemic consequences.

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