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Tympanometric screening for otitis media with effusion and Eustachian tube dysfunction in a pediatric population in Yaoundé: A cross-sectional study

Dépistage tympanométrique de l'otite séromuqueuse et du dysfonctionnement tubaire dans une population pédiatrique à Yaoundé

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Original Article

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ABSTRACT

Background: Otitis media with effusion (OME) and Eustachian tube dysfunction (ETD) constitute significant causes of pediatric hearing impairment. This study aimed to determine the frequency of OME and ETD and to identify associated factors.

Methods: A cross-sectional study was conducted among 255 children (127 males; mean age 6.1 ± 3.8 years) attending Yaounde Gyneco-Obstetric and Pediatric Hospital between January 1st to June 30th 2025. Sociodemographic and clinical data were collected through structured questionnaires. Tympanometry was performed using a tympanometer with a 226-Hz probe tone. OME was defined by type B or C2 tympanograms, and ETD by type C1 tympanogram. Univariate and multivariate logistic regression analyses were performed to identify factors independently associated with OME and ETD.

Results: The frequency of OME was 20.0% (51/255) and ETD was 20.4% (52/255). Prevalence was significantly higher in children ≤5 years compared to older age groups (OME: 80.4% vs 19.6%, ETD: 63.5% vs 36.5%; $p < 0.001$). Only 10.7% (11/103) of affected children had parental hearing concerns, and 47.6% (49/103) had abnormal otoscopic findings. In multivariate analysis, age ≤5 years remained the only significant independent factor associated with OME and ETD (adjusted OR: 5.59, 95% CI: 2.29-13.64, $p < 0.001$). The final model explained 19% of outcome variance (Nagelkerke $R^2 = 0.194$) with good fit (Hosmer-Lemeshow test, $p = 0.591$).

Conclusion: OME and ETD represent substantial unrecognized issue in Children. The discordance between objective findings and clinical detection highlights symptom-based surveillance inadequacy.

RESUME

Objectif : Déterminer la fréquence et identifier les facteurs associés à l'otite séromuqueuse (OSM) et au dysfonctionnement tubaire (DT) dans la population pédiatrique.

Méthodes : Une étude transversale a été menée auprès de 255 enfants (127 garçons ; âge moyen 6,1 ± 3,8 ans) fréquentant l'Hôpital Gynéco-Obstétrique et Pédiatrique de Yaoundé entre le 1er janvier et le 30 juin 2025. Les données sociodémographiques et cliniques ont été recueillies à l'aide de questionnaires et la tympanométrie. L'OSM a été définie par un tympanogramme de type B ou C2 et le DT par un tympanogramme de type C1. Les facteurs associés ont été recherchés grâce à une analyse par régression logistique multivariée.

Résultats : La fréquence de l'OSM était de 20,0 % (51/255) et celle du DT de 20,4 % (52/255). La prévalence était plus élevée chez les moins de 5 ans (OSM : 80,4 % vs 19,6 %, DT : 63,5 % vs 36,5 % ; $p < 0,001$). Une hypoacousie était signalée chez 10,7 % (11/103) des enfants affectés et chez 47,6 % (49/103) l'otoscopie était évocatrice. En l'analyse multivariée, seul l'âge ≤5 ans était associé à l'OSM et au DT (OR ajusté : 5,59, IC à 95 % : 2,29-13,64, $p < 0,001$).

Conclusion : L'OSM et le DT sont responsables d'une morbidité méconnue chez les enfants. Il existe une discordance entre résultats et objectifs, et la détection clinique pourrait soutenir le dépistage tympanométrique.

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Introduction

Otitis media with effusion (OME) and Eustachian tube dysfunction (ETD) represent significant under-diagnosed causes of hearing impairment in pediatric populations worldwide [1]. Characterized by the accumulation of non-purulent fluid in the middle ear cavity without signs of acute infection, OME affects an estimated 80-90% of children by age three, with peak incidence occurring between 6 months and 4 years of age [2]. In sub-Saharan Africa, where the burden of preventable hearing loss remains disproportionately high, the consequences of undetected middle ear pathology extend beyond temporary hearing impairment to encompass speech and language delays, academic underachievement, and reduced quality of life [3].

The challenge of early detection is particularly acute in resource-limited settings such as Yaoundé, Cameroon, where routine pediatric hearing screening programs are not systematically implemented [4]. Traditional diagnostic approaches relying on pneumatic otoscopy require specialized training and optimal examination conditions that are often unavailable in our settings [5]. Furthermore, the asymptomatic or oligosymptomatic presentation of OME—particularly in its chronic form—means that affected children may go unidentified until significant developmental sequelae have occurred [6].

Tympanometry offers a promising solution to this diagnostic gap. As an objective, non-invasive, and relatively affordable assessment tool, tympanometry measures acoustic admittance of the tympanic membrane and middle ear system in response to variations in air pressure within the external auditory canal. The resulting tympanogram provides quantifiable parameters that can reliably differentiate normal middle ear function from OME and ETD, even in pre-verbal children [7] and in settings where direct visualization of the tympanic membrane is challenging. Studies from high-income countries have demonstrated sensitivity rates of 70-90% and specificity rates exceeding 80% for tympanometric detection of middle ear effusion when compared with myringotomy as the gold standard [8].

Despite these advantages, comprehensive data on the prevalence of OME and ETD in Central African pediatric populations remain scarce, and the feasibility of community-based tympanometric screening in these settings have not been adequately established. However understanding the local epidemiology is an essential prerequisite for implementing evidence-based interventions that can reduce the burden of preventable hearing loss in this vulnerable population. This study aimed to address these critical knowledge gaps by determining the prevalence and identifying associated sociodemographic, environmental, and clinical factors of OME and ETD among children in Yaoundé, Cameroon.

Patients and Method

We performed a descriptive cross-sectional study. The study was conducted from January 1st to June 30th 2025. (6 months) on patients attending the pediatric unit consultation at the Yaounde Gyneco-Obstetric and Pediatric Hospital, a first category hospital in Yaounde-Cameroon. Children aged 6 months to 15 years with a permanent residence in Yaoundé for at least 6 months were included. A written informed consent from parent or legal guardian and assent from children aged 7 years and above were also needed. We excluded patients presenting with acute otitis media at time of examination (presence of otalgia, fever >38.5°C, and bulging tympanic membrane), congenital craniofacial malformations affecting the ear or Eustachian tube (cleft palate, Down syndrome), tympanic membrane perforation or presence of tympanostomy tubes, external auditory canal obstruction preventing probe insertion, and those who were enable to cooperate with examination despite age-appropriate behavioral management techniques.

Sample size was calculated using the formula for estimating prevalence in cross-sectional studies ie $n = [Z^2\alpha \times P(1-P)] / d^2$ where $Z\alpha = 1.96$ (95% confidence level) ; P = expected prevalence of OME in Africa = 8% [9] and d = precision = 5%. This yielded a minimum sample size of 113 participants.

A structured questionnaire was administered to collect: sociodemographic data (age and sex); medical history (prematurity, history of acute upper respiratory infections episodes, allergies); environmental exposures (number of siblings, passive tobacco smoke exposure). A comprehensive otolaryngological examination was performed by an experienced otolaryngologist including: external ear inspection, assessment of tympanic membrane appearance: color (normal, amber, blue), position (neutral, retracted, bulging), mobility and presence of air-fluid levels or bubbles using a a Welch Allyn pneumatic otoscope. Tympanometry was performed using an Interacoustics Titan (Interacoustics A/S, Denmark) calibrated according to ANSI S3.39-1987 and IEC 60645-5 standards with a 226-Hz probe tone (standard frequency for children aged >6 months). Testing was conducted in quiet rooms with ambient noise levels <50 decibels. Tympanometric parameters recorded included : Peak Pressure : Pressure at which maximum acoustic admittance occurs (normal: -99 to +50 daPa for children), Static Acoustic Admittance (Compliance): Maximum acoustic admittance value (normal: 0.3-1.4 mmho for children), Tympanometric Width (TW) or Gradient: Width of tympanogram at 50% of peak height (normal: <150 daPa), Ear Canal Volume (ecv): Estimated volume between probe tip and tympanic membrane

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(normal: 0.4-1.0 cm³ for children depending on age). Tympanograms were classified according to the modified Jerger classification system, validated for pediatric populations [10]:

- Type A (Normal): Peak pressure: -99 to +50 daPa ; Static admittance: 0.3-1.4 mmho (age-adjusted) ; Tympanometric width: <150 daPa standing for « Normal middle ear function with no evidence of OME or significant ETD »
- Type A_s (Shallow/Stiff): Peak pressure: within normal range (-99 to +50 daPa) ; Static admittance: <0.3 mmho (abnormally low) ; Normal tympanometric shape standing for « possible early OME, tympanosclerosis, or otosclerosis »
- Type A_d (Deep/Hypercompliant): Peak pressure: within normal range ; Static admittance: >1.4 mmho (abnormally high) standing for « possible ossicular discontinuity, monomeric tympanic membrane, or healed perforation »
- Type B (Flat): No identifiable peak ; Static admittance: typically <0.2 mmho ; Flat tracing throughout pressure range and normal ecv standing for « primary diagnostic criterion of OME »
- Type C1 (Mild Negative Pressure): Peak pressure: -100 to -199 daPa ; Static admittance: usually within normal range (≥0.3 mmho) standing for « primary diagnostic criterion of ETD »
- Type C2 (Moderate to Severe Negative Pressure): Peak pressure: ≤-200 daPa ; Static admittance variable, often reduced standing for « Significant ETD with OME »

Thus, tympanometric diagnostic criteria applied in this study were for OME, a Type B or type C2 tympanogram with normal ecv and for ETD, a type C1 tympanogram with normal ecv.

SPSS® 24.0 (IBM, Chicago, Illinois) software was used for statistical analysis. Quantitative variables were represented by their measure of central tendency and dispersion, namely, mean ± standard deviation and range. Categorical variables were expressed as percentages. In univariate analysis, we used Chi-square test or Fisher's exact test to compare percentages between groups. Variables with p<0.20 in univariate analysis were included in multivariate models. A Multivariate logistic regression model was used to identify independent associated factors of OME and ETD with Odds ratios (OR) and its 95% confidence interval (IC) estimating the strenght of association. The Model fit was assessed using Hosmer-Lemeshow goodness-of-fit test with the Nagelkerke R-square value indicating the proportion of variance in the dependent variable that is explained by the independent variables.

All the statistical tests were bilateral and p values ≤ 0.05 were considered statistically significant. From an ethical point of view, the authorization from the directorate of the Yaounde Gyneco-Obstetric and Pediatric Hospital was obtained. An informed consent from parent or legal guardian and assent from children aged 7 years and above were obtained. The tests were carried out free of charge.

Results

A total of 281 children were initially recruited, of whom 26 were excluded (14 with acute otitis media, 8 with cerumen impaction, 4 unable to cooperate). The final analysis included 255 children (127 males, 128 females) with a mean age of 6.1 ± 3.8 years (range 6 months to 15 years). The Table I that follow illustrates the sociodemographic characteristics of the study population. According to the diagnostic criteria, 51 children (20%) presented with OME while 52 (20,4%) presented with ETD.

Table I: socio-demographic characteristics of study participants (N=255)

Characteristic	n (%)
Age groups	
≤5 years	125 (49)
6-10 years	90 (35.3)
10+ years	40 (15.7)
Sex	
Male	127 (49.8)
Female	128 (50.2)
Prematurity at birth	12 (4.7)
History of recurrent URTIs	62 (24.4)
Parental smoking	14 (5.5)
Household crowding (>4 people/room)	224 (87.8)
Known allergies	6 (2.4)

URTI : Upper respiratory tract infections

Figure 1 details the distribution of tympanometry results in the study population.

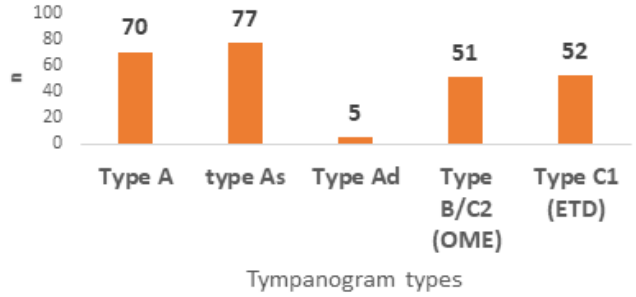

Figure 1 : Distribution of tympanogram types in the study population (N=255)

OME and ETD were more prevalent in children aged less than 5 years than in those of the others age groups (41 vs 10 and 33 vs 19 respectively, $\chi^2 = 40.57$, $p < 0.001$) like showed in table II. Of 103 children with abnormal tympanometry: only 11 (10.7%) had parental concerns about hearing, 6

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(5.8%) reported ear fullness or pressure, 8 (7.8%) had documented speech or language concerns, 49 (47.6%) had an abnormal otoscopic examination (presence of air-fluid levels or bubbles or retracting tympanic membrane).

Table II: Prevalence of abnormal Tympanometry by age group

Age Group	Normal n (%)	OME n (%)	ETD n (%)
≤5 years	51 (33.6)	41 (80.4)	33 (63.5)
6-10 years	70 (46.0)	9 (17.6)	11 (21.2)
10+ years	31 (20.4)	1 (2.0)	8 (15.3)
Total	152 (100)	51 (100)	52 (100)

$\chi^2 = 40.57$, $p < 0.001$

In univariate analysis, age less than 5 years (71.8% vs 33.5% ; OR (95%CI) : 5.05 (2.9 -8.7) ; p <0.001) and reccurent URTIs (32% vs 19% ; OR (95%CI) : 2.02 (1.1 - 3.6) ; p = 0.018) were significantly associated with OME and ETD as illustrated in table III below. Variables with a p < 0.20 were entered into the multivariate logistic regression model to identify factors independently associated with OME and ETD as shown in table IV.

Table III: Univariate Analysis of factors associated with OME and ETD in the study population

Risk Factor	OME / ETD n (%)	Normal n (%)	OR (95% CI)	p
Age ≤ 5 years	74/103 (71.8)	51/152 (33.5)	5.05 (2.9-8.7)	<0.001
Male sex	48/103 (46.6)	79/152 (51.9)	0.80 (0.5-1.3)	0.445
Reccurent URTIs	33/103 (32.0)	29/152 (19.0)	2.02 (1.1-3.6)	0.018
Parental smoking	4/103 (3.9)	10/152 (6.6)	0.5 (0.2-1.9)	0.414
Household crowding	86/2103 (83.5)	138/152 (90.8)	0.5 (0.2-1.1)	0.117
Known allergies	3/103 (2.9)	3/152 (1.9)	1.5 (0.3-7.5)	0.688
Prematurity at birth	6/103 (5.8)	6/152 (3.8)	1.5 (0.5-4.8)	0.553

OR : odd ratio ; CI: confidence interval

Table IV: Multivariable Logistic Regression Analysis

Variable	Adjusted OR	95% CI	p-value
Age ≤5 years (vs others age groups)	5.587	2.289-13.635	<0.001
Recurrent URTIs	1.328	0.705-2.502	0.380
Household crowding	1.283	0.564-2.919	0.552

OR : odd ratio ; CI: confidence interval

After adjustment for the variables included in the model, age ≤5 years (OR = 5.587; 95% CI: 2.289-13.635; p<0.001) was significantly associated with OME and ETD. In contrast,recurrent URTIs and household crowding were not significantly associated (p = 0.38 and 0.552 respectively). This logistic regression model showed a good fit (Hosmer-Lemeshow test, p = 0.591) and explained 19% of the variance in the outcome (Nagelkerke $R^2 = 0.194$).

Discussion

This cross-sectional study provides epidemiological data on the prevalence of OME and ETD in a pediatric population in Yaoundé, Cameroon, utilizing objective tympanometric screening. The findings reveal a substantial burden of middle ear pathology, with combined prevalence rates of 40.4% for OME and ETD, predominantly affecting younger children and frequently remaining clinically undetected.

Prevalence and Burden of Disease

The observed prevalence of OME (20%) in the present study aligns with international pediatric studies[11-12], positioning Yaoundé within the upper range of the 10-30% global distribution reported by Monasta et al. [13]. However, a meta-analysis conducted by Choffor et al. on the prevalence and associated factors of OME in Africa reported an overall prevalence of OME of 8% in children [9] somewhat lower than our observations. These differences may reflect population variation, methodological differences, or age distribution.

Additionally, the similar prevalence rates of OME and ETD (20% vs 20.4%) support the pathophysiological continuum between these conditions, wherein Eustachian tube dysfunction facilitates the development and persistence of middle ear effusions through impaired ventilation and pressure regulation [14]. This relationship underscores the importance of assessing both conditions simultaneously in pediatric screening programs.

Age-Dependent Disease Distribution

This study emphasized an age-related decline in both OME and ETD prevalence. Children aged ≤5 years were 5.59 time more susceptible for developing these conditions compared to older children, even after adjustment for potential confounders. This finding corroborates well-established developmental principles: the Eustachian tube in young children exhibits a more horizontal orientation (approximately 10° versus 45° in adults), shorter length (17-18mm versus 35-38mm), and reduced cartilaginous support, collectively predisposing to inadequate middle ear ventilation [15]. Moreover, the immature immune system of younger children increases susceptibility to upper respiratory tract infections—a primary precipitant of middle ear pathology. The maturation of both anatomical structures and immunological defenses by age 6-7 years explains the reduction in disease prevalence observed in older age groups (17.6% and 21.2% for OME and ETD in 6-10 year-olds, declining to 2.0% and 15.3% in children over 10 years) [16]. The persistence of relatively elevated ETD rates (15.3%) in the oldest age group, compared to near-resolution of OME (2.0%), merits some attention. This may potentially represent measurement bias favoring detection of negative middle ear pressure

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over effusion in cooperative older children.

Associated factors Analysis

The multivariate analysis revealed that recurrent URTIs, while significantly associated with OME/ETD in univariate analysis (OR: 2.02, p=0.018), lost statistical significance after adjustment for age (adjusted OR: 1.33, p=0.380). This likely reflects age as a powerful effect modifier: younger children experience both higher URTI frequencies (6-8 episodes annually versus 2-3 in older children) and possess anatomical vulnerabilities that amplify each infection's impact [17]. Age may therefore capture much of the relevant pathophysiological risk, with URTIs serving as an intermediate variable rather than an independent risk factor. The absence of significant associations with traditionally implicated factors—parental smoking, household crowding, and prematurity— [18] requires contextualization. The remarkably high prevalence of household crowding (87.8%) and low prevalence of parental smoking (5.5%) likely limited statistical power due to insufficient variability. When exposure prevalence approaches saturation or zero, the ability to demonstrate associations becomes severely compromised.

Moreover, unmeasured confounders—including indoor air pollution from biomass fuel combustion, maternal education, breastfeeding duration, nutritional status, and vitamin D deficiency[19]—were not captured. The modest explanatory power of our model (Nagelkerke R^2=0.194) suggests substantial unexplained variance attributable to these unmeasured factors and the multifactorial nature of middle ear disease.

The Clinical Detection Gap: Implications for Screening

One of the main finding of the present study was the discordance between objective tympanometric evidence and clinical recognition. Only 10.7% of children with abnormal tympanometry had parental hearing concerns, and merely 7.8% had documented speech or language concerns. Even otoscopic examination identified abnormalities in only 47.6% of cases. This detection gap reflects OME's typically silent presentation—no fever, minimal discomfort—and associated hearing loss (20-30 dB range) subtle enough to escape parental notice [20]. Therefore, reliance on symptomatic presentation or routine clinical examination will miss approximately 90% and 50% of cases respectively, allowing persistent pathology to continue undetected during critical periods of speech and language development. Our findings provide empirical support for implementing objective screening programs, particularly tympanometry, which offers high sensitivity (90-95%), non-invasive assessment, brief administration (2-3 minutes), and decreasing equipment costs suitable for resource-limited settings [7].

Moreover, the convergence of high prevalence, age-specific vulnerability, and poor clinical detection creates a compelling rationale for systematic screening. Nevertheless, implementation must consider the complete cascade: detection, diagnostic confirmation, treatment access, and monitoring. For OME, guidelines recommend 3-month watchful waiting before intervention, as 75-90% resolve spontaneously [21]. Screening programs must therefore be coupled with strengthened referral systems and treatment capacity, including hearing assessment, speech-language evaluation, and surgical intervention access for persistent cases. For ETD, clinical pathways are less defined. Risk stratification using serial tympanometry at 4-6 week intervals could distinguish children requiring intervention from those suitable for observation [22]. Developing context-appropriate algorithms represents an important next step for translating screening findings into actionable clinical pathways.

Limitations of the study

Several limitations constrain interpretation. The cross-sectional design precludes assessment of disease natural history—a single measurement cannot distinguish transient from chronic conditions. Longitudinal designs with serial measurements would provide more accurate estimates of persistent disease requiring intervention. Recruitment from a single urban center limits generalizability to rural populations with different environmental exposures and healthcare access. Risk factor assessment relied on parental report, introducing potential recall bias, particularly for URTI frequency. Unmeasured confounding—socioeconomic status, parental education, daycare attendance, breastfeeding, nutritional status—likely affects risk factor analysis, as reflected in our model's modest explanatory power.

Conclusion

This study establishes that OME and ETD represent a substantial but largely unrecognized issue in pediatric populations in Yaoundé, with combined prevalence exceeding 40% and disproportionately affecting children under 5 years of age. The profound gap between objective disease detection and clinical recognition highlights the inadequacy of symptom-based surveillance and supports the implementation of systematic tympanometric screening programs, particularly targeting younger age groups. However, screening implementation must be coupled with strengthened diagnostic and treatment pathways to ensure that detection translates into meaningful health improvements. The identification of young age as the predominant risk factor, robust across analytical approaches, emphasizes the importance of developmental considerations in middle ear pathology and suggests that interventions during this critical period could yield maximal impact

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on preventing the long-term educational and developmental consequences of undetected hearing impairment. Future longitudinal investigations with comprehensive risk factor assessment will be essential for refining screening strategies and developing context-appropriate clinical management algorithms for this vulnerable population.

Conflict of interest: The authors declare no conflict of interest

Contributions of authors: ALC analyzed the data and wrote the manuscript, NEY designed the study and collected the data, and MBRC, MY, DF, and NR subsequently reviewed the manuscript

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