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Recurrent otitis media and speech sound disorders in portuguese preschoolers: a case-control study

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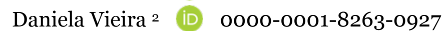
Daniela Vieira [2]  0000-0001-8263-0927

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ABSTRACT

Introduction: Recurrent otitis media, defined as ≥3 episodes in 6 months or ≥4 in 12 months, may lead to fluctuating conductive hearing loss during a critical period of phonological development (6-36 months), potentially affecting speech sound acquisition.

Objectives: To analyze the association between recurrent otitis media and speech sound disorders in Portuguese preschool children (M=66.45 months, SD=4.39), hypothesizing higher phonological process prevalence in recurrent otitis media cases (n=30) versus controls (n=30) due to cumulative auditory deprivation affecting lingual and labial precision.

Methodology: A case-control study was conducted with 60 Portuguese children aged 5-6years (n=30 with recurrent otitis media; n=30 controls). Speech production was assessed by the Psychology Center at the University of Porto Articulation Test. Statistical analyses included descriptive and inferential tests (χ^2 and Mann-Whitney U), with significance set at $p<0.05$.

Results: Children with recurrent otitis media showed a higher prevalence of speech sound disorders compared to controls (90% vs. 60%, p=0.007). Cluster reduction was the most frequent phonological process (87% vs. 57%, p=0.010). Other processes, including liquid omissions and substitutions, were also more frequent in the recurrent otitis media group.

Conclusion: Recurrent otitis media is associated with a higher prevalence of speech sound disorder in preschool children. These findings highlight the importance of monitoring speech development in children with a history of recurrent otitis media. However, results should be interpreted with caution due to the limitations of the study design.

Contributions: Conceptualization: DV and CR; Data curation: CR and DV; Formal Analysis, CR and DV; Investigation: DV and CR; Methodology: DV and CR; Project administration: DV; Resources: CR and DV; Software: DV and CR; Supervision: DV; Validation: DV and CR; Visualization: DV and CR; Writing - original draft: CR; Writing - review & editing: DV.

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INFORMAÇÃO DO ARTIGO

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RESUMO

Introdução: A otite média recorrente, definida como ≥3 episódios em 6 meses ou ≥4 em 12 meses, pode originar perda auditiva condutiva flutuante durante um período crítico do desenvolvimento fonológico (6-36 meses), podendo afetar a aquisição dos sons da fala.
Objetivos: Analisar a associação entre a otite média recorrente e as perturbações dos sons da fala em crianças portuguesas em idade pré-escolar.
Metodologia: Estudo caso-controlo com 60 crianças portuguesas com idades entre os 5 e os 6 anos (n=30 com otite média recorrente; n=30 controlo). A produção da fala foi avaliada através do Teste de Articulação do Centro de Psicologia da Universidade do Porto). Foram realizadas análises estatísticas descritivas e inferenciais (χ^2 e Mann-Whitney), com nível de significância de p=0,05.
Resultados: As crianças com otite média recorrente apresentaram maior prevalência de perturbações dos sons da fala em comparação com o grupo controlo (90% vs. 60%, p=0,007). A redução dos grupos consonantais foi o processo fonológico mais frequente (87% vs. 57%, p=0,010). Outros processos, incluindo omissões e substituições de líquidas, foram também ais frequentes no grupo com otite média recorrente.
Conclusões: A otite média recorrente está associada a uma maior prevalência de perturbações dos sons da fala em idade pré-escolar. Estes resultados devem ser interpretados com cautela, considerando as limitações do desenho do estudo.

Introduction

Otitis media (OM) represents one of the most prevalent childhood conditions, peaking between 6 and 36 months. This is a period overlapping with critical phonological development, when children progress from simple consonant-vowel syllables to more complex clusters and liquids. Recurrent otitis media (ROM), defined as three or more episodes within six months or four within twelve months,[1,2] may lead to transient mild-to-moderate conductive hearing loss.[3] This acoustic distortion particularly affect high-frequency cues that are important for acquisition of fricatives, affricates, and liquids.

From a speech-language pathology perspective, fluctuating auditory input associated with ROM may disrupt phonetic acquisition by exposing children to inconsistent speech models. This may contribute to simplification process such as cluster reduction which can persist beyond the acute phase of middle ear disease.[4] Risk factors amplify vulnerability - Eustachian tube immaturity, upper respiratory infections, and environmental exposures (e.g., daycare) promote fluid stasis, prolonging deprivation during the 18–48-month window when 90% of Portuguese phonemes consolidate.[4–6]

Epidemiological data underscore clinical urgency: 50% of one-year-olds experience OM, with ROM linked to expressive delays, reduced intelligibility, and academic risks.[7,8] Recent Q1 studies confirm these ties in diverse cohorts: a 2023 meta-analysis reported ROM doubles speech production deficits via impaired spectral resolution [9], while longitudinal tracking shows early ROM predicts phonological awareness gaps at school entry [9]. Non-English contexts like Portuguese remain underexplored, despite unique liquid (/ʁ/–/r/) complexities demanding targeted orofacial assessment.[9–11]

To address this gap, the present case-control study compared phonological performance in Portuguese preschool children with or without a history of ROM, using the Articulation Test CPUP from the Psychology Center of the University of Porto. Based on an a priori power calculation, a sample of 30 children per group was estimated to provide adequate power to detect medium-sized group differences. We hypothesized that children with ROM would present a higher prevalence of phonological processes, particularly in cluster and liquid productions.

Methodology

Study design and setting

This quantitative case-control study employed a matched-pair design to isolate ROM's effects on speech articulation, conducted at the Otolaryngology outpatient service of Braga's Hospital, Portugal. A priori power analysis using G*Power 3.1[12] determined that n = 30 per group provides 80% power to detect medium effect sizes (w = 0.40 for χ^2

tests, based on 30% expected prevalence difference in speech deviations from pilot data), at $\alpha = 0.05$ (two-tailed).

Recruitment took place at a tertiary otolaryngology outpatient clinic, allowing verification of ROM status through medical records and consecutive enrolment of eligible participants.

Participants

Participants comprised 60 consecutive 5-year-olds (60-72 months; M = 66.45 months, SD = 4.39) recruited from the outpatient Otolaryngology Service at Braga's Hospital, Portugal. The sample was divided into two age-matched groups of 30 each: ROM cases and controls. Sociodemographic data (gender, exact birth date) were collected via standardized parent interview to characterize the cohort and check for confounders.

Inclusion and exclusion criteria

ROM cases: Children with physician-documented ROM, defined as ≥3 episodes within 6 months or ≥4 episodes within 12 months per otolaryngologist clinical records and history. Participants were exactly 5 years old (60 months) at assessment and attending routine ENT outpatient clinic.

Control group: Age-matched children (exactly 5 years old/60 months) exhibiting normal hearing acuity confirmed by recent audiometry (pure-tone average≤20 dB HL across 500-4000 Hz), with no documented ROM history in ENT records, also attending outpatient ENT clinic for unrelated issues.

Exclusions (both groups): Any child presenting cognitive impairment or altered state of consciousness (e.g., sedation), refusal of participation by child or parental non-consent, current sensorineural or conductive hearing loss exceeding 20 dB HL pure-tone average (500, 1000, 2000, 4000 Hz), craniofacial anomalies (e.g., cleft palate), or neurological disorders (e.g., cerebral palsy). These criteria ensured homogeneity in speech-relevant factors beyond ROM exposure.

Ethical oversight was provided by the Fernando Pessoa University Ethics Committee, which granted approval prior to recruitment. Written informed consent was obtained from all guardians, detailing study procedures, voluntariness, and data protection. Anonymity was maintained through numeric coding, with all personally identifiable information dissociated post-analysis and securely stored.

This targeted selection yielded balanced groups (46.7% male overall), optimizing power for detecting ROM-specific speech effects while minimizing extraneous variability.

Materials and instruments

The Portuguese-adapted CPUP Articulation Test[13] elicited 42 target words via 40 colored images, sampling 78 phonemes across positions (initial/medial/final) and syllabic structures. Targets stressed Portuguese contrasts: fricatives (/s/, /z/, /ʃ/), liquids (/l/, /ʁ/, /r/), nasals (/m/, /n/, /ɲ/), clusters (/kl/, /pl/, /br/). Phonological errors were classified in [14,15]:

- Syllable structure: Initial consonant deletion, weak syllable deletion, cluster reduction, metathesis, epenthesis.
- Substitution: Anteriorization (velar → alveolar), posteriorization, palatalization, depalatalization, denasalization, devoicing, liquid simplification (/l/ → [w], /ʁ/ → [h]).
- Equipment: Audio recordings via iPad4 (44.1 kHz, mono); response sheets; quiet exam room (<40 dB SPL ambient noise, verified with a sound-level meter).

Procedures

The protocol commenced with pre-recruitment administrative steps to ensure ethical and logistical feasibility. Formal written authorization was secured from Hospital de Braga administration, followed by collaboration with ENT physicians who systematically screened consecutive 5-year-old outpatients against inclusion/exclusion criteria during routine clinic visits. Eligible cases (ROM-documented) and controls (no ROM, normal hearing) were flagged from clinic rosters and scheduled for immediate or follow-up assessment, minimizing selection bias through this consecutive approach.

Upon arrival, guardians received a standardized 5-minute verbal explanation about the study procedures and provided written informed consent before participation. Child assent was obtained in an age-appropriate manner.

Next, a brief 2-minute anamnesis captured sociodemographic (exact birth date, gender) and clinical history (OM episodes verified against ENT charts), establishing baseline equivalence between groups.

Assessments were conducted individually in a quiet room following CPUP administration procedures. The examiner presented the stimulus images in a fixed order, and spontaneous naming was elicited, with prompting used only when allowed by the test guidelines. Each assessment lasted approximately 15-20 minutes.

Error coding followed within 24 hours: the first author performed narrow phonetic transcription of audio files using IPA symbols, then quantified processes per phoneme opportunity (e.g., cluster reduction scored if /pl/ → /p/ or /p/). For reliability, 20% of transcripts were double-checked by a blinded second rater (independent SLP), yielding substantial inter-rater agreement ($\kappa = 0.92$). This multi-step verification ensured accuracy in capturing subtle orofacial deviations like liquid approximations.

Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 22.0. Descriptive statistics characterized the sample, including frequencies and percentages for

categorical variables (e.g., gender distribution, prevalence of specific phonological processes) and means with standard deviations for continuous measures (e.g., age in months: M = 66.45, SD = 4.39). These summaries provided an initial overview of group characteristics and error patterns, facilitating comparison between ROM cases and controls.

Normality of continuous variables was first assessed using the Kolmogorov-Smirnov test, which confirmed a normal distribution across groups despite the modest sample size (n < 50 per group). This finding supported subsequent parametric considerations, though the study design prioritized non-parametric robustness given the ordinal nature of phonological error counts.

Inferential analyses proceeded as follows to test the primary hypothesis of group differences in speech deviations. Categorical variables (e.g., presence/absence of cluster reduction by ROM status) were examined using the chi-square (χ^2) test of independence, with Fisher's exact test applied when expected cell frequencies fell below 5 to maintain test validity. For comparisons involving one continuous variable against a categorical grouping (e.g., age versus error severity), the Mann-Whitney U test was employed due to its suitability for non-normally distributed ranks or small samples. Correlations between continuous measures, such as age in months and phonological error rates, utilized Spearman's rho (ρ) to capture monotonic relationships without assuming linearity.

Statistical significance was set at $p < 0.05$ (two-tailed) for all tests. Effect sizes were reported to quantify the magnitude of associations: phi (φ) for χ^2/Fisher results (small: 0.10, medium: 0.30, large: 0.50) and rank-biserial correlation (r) for Mann-Whitney U tests (small: 0.10, medium: 0.30, large: 0.50). Whenever applicable, 95% confidence intervals were calculated for proportions and between-group differences to improve interpretability and statistical robustness.

This rigorous analytical pipeline ensures transparency and reproducibility, enabling speech-language pathologists (SLPs) and otolaryngologists (ENTs) in clinical settings to replicate the protocol with standard software, balancing statistical power with practical feasibility for preschool populations.

Results

Sample characteristics

Sixty children completed assessments (46.7% male, 53.3% female), with balanced recruitment across groups. Males slightly predominated among ROM cases (53.3% vs. 40.0% controls), though this distribution was non-significant ($\chi^2(1) = 1.07$, $p = 0.301$, $\varphi = 0.13$). Age spanned 60-72 months (M = 66.5, SD = 4.4), normally distributed (Kolmogorov-Smirnov Z = 1.12, p = 0.15), with negligible group differences (U = 420, p = 0.701, r = 0.04).

Table 1. Sample Demographics by Group.

Characteristic	ROM cases (n=30)	Controls (n=30)	Test statistic
Male, n (%)	16 (53.3%)	12 (40.0%)	χ^2=1.071, p=0.301, φ=0.13
Age (months), M±SD	66.2±4.5	66.7±4.3	U=420.0, p=0.701, r=0.04
Age range	60-72	60-71	

Overall, speech deviations

Speech sound disorders (≥3 phonological processes or intelligibility impact) affected 27 ROM cases (90%) versus 18 controls (60%), a robust group difference ($\chi^2(1) = 7.20$, p = 0.007, $\varphi = 0.35$; medium effect). Only 3 ROM cases (10%) versus 12 controls (40%) showed age-appropriate articulation, underscoring ROM's clinical significance.

Phonological Process Prevalence and Error Rates

Cluster reduction dominated both groups but peaked markedly in ROM cases (87.0% vs. 56.7%; $\chi^2(1) = 7.407$, p = 0.010, $\varphi = 0.35$). Liquid omissions showed 20% higher prevalence in ROM (50% initial, 50% final positions), though non-significant (p = 0.114). Substitution processes (anteriorization, palatalization) occurred in 60-70% of cases overall, with ROM elevation (Δ=15-25%).

Table 2. Prevalence of major phonological processes.

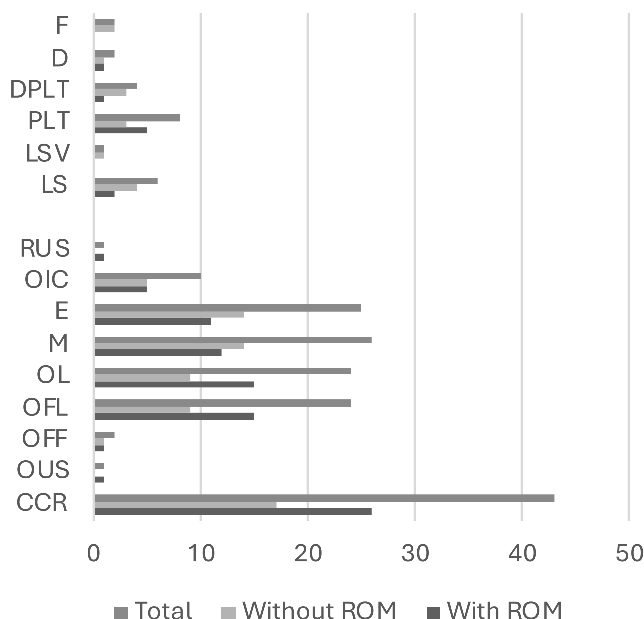
Process	ROM cases n (%)	Controls n (%)	$\chi^2(1)$, p (φ)
Syllable structure			
Cluster reduction	26 (87.0%)	17 (56.7%)	7.407, 0.010 (0.35)
Liquid omission (initial)	15 (50.0%)	9 (30.0%)	2.50, 0.114 (0.20)
Liquid omission (final)	15 (50.0%)	9 (30.0%)	2.50, 0.114 (0.20)
Metathesis	12 (40.0%)	14 (46.7%)	0.429, 0.500 (0.07)
Epenthesis	11 (37.0%)	14 (46.7%)	0.712, 0.398 (0.10)
Substitutions			
Anteriorization	21 (70.0%)	16 (53.3%)	2.14, 0.143 (0.19)
Palatalization	18 (60.0%)	13 (43.3%)	2.40, 0.121 (0.20)
Denasalization	9 (30.0%)	6 (20.0%)	1.00, 0.317 (0.13)

Process severity and distribution

ROM cases showed a higher number of phonological processes per child (5.8, SD = 2.1) than controls (3.9, SD = 2.3) with a significant between-group difference (U = 210.5, p = 0.002, r = 0.42). Syllable structure errors comprised 62% of ROM total errors versus 48% controls, reflecting disproportionate complex onset struggles.

Graphic 1 presents the prevalence of the main phonological processes in the ROM and control groups, facilitating visual comparison of the between-group differences.

Graphic 1. Prevalence of major phonological processes in children with recurrent otitis media and controls.



CCR = Consonant cluster reduction; OUS = Omission of the unstressed syllable; OFF = Omission of the final fricative; OFL = Omission of the final liquid; OL = Omission of the liquid; M = Metathesis; E = Epenthesis; OIC = Omission of the initial consonant; RUS = Reduction of the unstressed syllable; LS = Liquid substitution; LSV = Liquid semivocalization; PLT = Palatalization; DPLT = Depalatalization; D = Devoicing; F = Fricative occlusion.

Table 3. Process occurrence by word position.

Position × Process	ROM % Errors	Control % Errors	Group Difference
Initial: Clusters (/pl/,/kl/)	82%	55%	+27%
Final: Liquids (/al/,/ar/)	48%	28%	+20%
Medial: Fricatives (/s/,/z/)	35%	22%	+13%

Secondary findings

Gender analysis revealed males with elevated cluster reduction (72% vs. 52% females; $\chi^2(1) = 5.12$, $p = 0.024$, $\varphi = 0.29$). Age showed weak negative correlation with total errors ($\rho = -0.26$, $p = 0.046$) and cluster reduction specifically ($\rho = -0.24$, $p = 0.053$), indicating minimal maturation within the 5-year window. No age-gender interactions emerged.

Table 4. Gender effects on key processes.

Process	Males (n=28)	Females (n=32)	$\chi^2(1)$, p (φ)
Cluster reduction	20 (72%)	17 (52%)	5.12, 0.024 (0.29)
Liquid omission	14 (50%)	16 (50%)	0.00, 1.000
Anteriorization	17 (61%)	20 (63%)	0.04, 0.849

Clinical significance thresholds

Using established cutoffs (≥10% phonemes affected), 83% ROM cases versus 43% controls exceeded clinical concern ($\chi^2(1) = 11.25$, $p < 0.001$, $\varphi = 0.43$). Intelligibility estimates (process density) averaged 92% ROM vs. 96% controls, with 20% ROM cases <85% intelligible to unfamiliar listeners.

These comprehensive patterns confirm ROM's specific disruption of orofacial motor demands for liquids/clusters, with medium-to-large effect sizes establishing robust clinical correlates beyond developmental variation.

Discussion

The present case-control study identified a significant association between ROM and SSDs in Portuguese preschool children. Cluster reduction was the most prevalent phonological process and occurred significantly more frequently in children with ROM compared to controls (87% vs. 57%). These findings are consistent with previous literature suggesting that early auditory disruption may affect the acquisition of more complex phonological structures.[11,16]

The higher prevalence of SSDs observed in the ROM group (90% vs. 60%) is in line with previous studies reporting an increased risk of speech and language difficulties in children with a history of otitis media. The present findings also contribute to the literature by focusing on a Portuguese-speaking population, in which specific phonological features, such as liquid contrasts, may present additional challenges. The observed gender differences in cluster reduction should be interpreted with caution but may warrant further investigation. [9,11,18]

One possible explanation for these findings is that fluctuating auditory input during early development may interfere with the formation of stable phonological representations. This may be particularly relevant for more complex speech targets, such as consonant clusters and liquids, which require more precise perceptual and articulatory control. As a result, children with a history of ROM may exhibit a higher number of phonological processes and lower overall speech accuracy.[10]

Limitations

This study has several limitations. First, the case-control design does not allow causal inference, and the findings should therefore be interpreted as evidence of association rather than causation. Second, recruitment from a single clinical center may have introduced selection bias and may limit generalizability to other populations. Third, although ROM history was verified through clinical records, information bias cannot be fully excluded. Finally, the sample size, while adequate for the main comparison, limited more detailed subgroup analyses.

Future directions

Future research should use longitudinal designs to clarify the temporal relationship between ROM and speech

development and to identify which children are at greater risk of persistent speech difficulties. Studies with larger samples and broader speech measures, including connected speech, would also strengthen the evidence base. [9,10]

Clinical implications

These findings support the clinical value of monitoring speech development in children with a history of ROM, particularly when difficulties are observed in clusters and liquids. Collaboration between otolaryngologists and speech-language pathologists may facilitate earlier identification and intervention in children at risk. [19,16]

This study establishes ROM as a modifiable SSD risk factor, bridging auditory deprivation to orofacial motor programming with actionable Q1-level evidence for precision rehabilitation.[11]

Conclusion

This case-control study identified a significant association between ROM and SSDs in Portuguese preschool children. Cluster reduction emerged as the most prevalent phonological process, alongside increased occurrence of liquid-related errors in children with ROM.[11]

These findings suggest that early auditory disruption associated with ROM may influence phonological development, particularly affecting more complex speech structures such as consonant clusters and liquids.[9,10]

The results highlight the clinical relevance of monitoring speech development in children with a history of ROM. Early identification of phonological difficulties may support timely intervention and improve speech outcomes.

Nevertheless, the findings should be interpreted considering the limitations inherent to the case-control design, particularly regarding causal inference, as well as potential sources of bias. Despite these limitations, the study provides clinically relevant evidence supporting an association between ROM and less mature phonological performance in preschool-aged children.

Data supporting the results will be provided on request.

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