

Association Between Hearing Loss and Neurodevelopment in Children Aged 1 to 60 Months: A Cross-Sectional Study Based on a Hearing Screening Program in Vaccination Centers and Preschools in Kinshasa, Democratic Republic of the Congo

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Abstract

Background

Early-onset hearing loss is now recognized as a condition that may be associated with neurodevelopmental disorders. Its onset before the age of 5—a critical period for brain development—justifies the focus on this population. The objective was to assess the impact of hearing loss on neurodevelopment among infants and preschool-aged children in Kinshasa.

Methods

The study included 488 infants and children recruited from vaccination centers and preschools in Kinshasa. Hearing screening was performed using DPOAE. Referred children underwent AABR with or without ABR, as well as tympanometry. Neurodevelopment was assessed using the ASQ-3 for children aged 1 to 35 months and the preschool S.I.F.T.E.R. questionnaire for children in preschool. Descriptive analyses were performed using IBM SPSS Statistics.

Results

Suspected hearing loss was observed in 2.5% (12/488) of the children. Tympanometric abnormalities were present in 84% of cases, primarily suggesting conductive hearing loss. Two specific cases were identified: bilateral mixed hearing loss and unilateral sensorineural hearing loss. Overall neurodevelopment was normal in children aged 1 to 35 months. However, among preschool-aged children, a significant association was found between hearing loss, reduced academic performance, and behavioral problems at school.

Conclusion

Neurodevelopmental disorders may be associated with hearing loss, even conductive hearing loss. These results underscore the importance of early hearing screening.

INTRODUCTION

Hearing loss in children is one of the most common sensory impairments in children and represents a major global public health challenge [1]. According to the WHO, hearing loss affects 1 to 2% of children under the age of 5, while more than 34 million children live with disabling hearing impairment, a significant proportion of whom reside in low- and middle-income countries. Without early diagnosis and intervention, hearing loss can permanently impair language acquisition, cognitive development, social interactions, academic learning, and, more broadly, quality of life [2].

These consequences are even more significant when hearing loss occurs before the age of 5, a critical period of neurodevelopment characterized by high brain plasticity [3].

In recent years, our understanding of the links between hearing loss and neurodevelopment has evolved considerably. Early-onset hearing loss is no longer considered an isolated sensory disorder but rather a condition frequently associated with broader neurodevelopmental abnormalities. Studies have highlighted significant links between hearing loss and autism spectrum disorders, cerebral palsy, or genetic abnormalities [4–5]. Advances in genetics confirm that more than 50% of congenital hearing loss is genetic in origin and involves mechanisms common to brain development, such as synaptogenesis and neuronal migration [6]. Furthermore, certain specific conditions, such as auditory neuropathies or cochlear nerve deficits, illustrate the interconnection between the auditory and neurological systems [7].

Hearing loss has numerous consequences for a child's development. In terms of language, it can lead to significant delays in the acquisition of spoken language. Cognitively, difficulties are observed in memory, attention, and executive functions [7, 8]. These impairments can also affect social interactions and behavior. However, the literature emphasizes the critical role of early screening and intervention. International guidelines recommend screening before 3 months of age and intervention before 6 months of age to optimize developmental outcomes [9, 10]. Interventions, such as hearing aids, cochlear implants, and early rehabilitation, have been shown to be effective in improving language and cognitive skills [11, 12].

In sub-Saharan Africa, the issue of hearing loss in children is of particular concern. The prevalence there is higher than the global average, exceeding 5% for disabling forms, with overall estimates reaching approximately 10% among children according to some meta-analyses [13]. The main causes include ENT infections, perinatal complications, and adverse socioeconomic conditions [2, 13]. From a neurodevelopmental perspective, studies show a significant association between hearing loss, cognitive impairments, and mental health disorders [14]. However, early screening systems remain underdeveloped, and resources for audiology and rehabilitation are limited. The lack of infrastructure, qualified personnel, and standardized tools constitutes a major obstacle to optimal care for children [15]. Thus, in this region, hearing loss occurs within a context of overall vulnerability that strongly influences neurodevelopmental trajectories.

In the Democratic Republic of the Congo (DRC), specific data remain limited, but the observed trends are similar to those in sub-Saharan Africa. The causes of hearing loss in children are largely preventable, particularly infections, perinatal complications, and certain endemic diseases [2, 13].

The healthcare system faces several challenges, including the absence of routine neonatal screening, a shortage of specialists in audiology and speech-language pathology, and the high cost of treatment interventions [16]. These constraints often lead to delayed diagnosis and intervention, thereby compromising children's language and cognitive development. Furthermore, the lack of national

epidemiological data and longitudinal studies limits a precise understanding of the impact of hearing loss on neurodevelopment in this context.

Although knowledge regarding the links between hearing loss and neurodevelopment has advanced considerably, gaps remain, particularly in resource-limited countries such as the DRC. In this context, the objective of the present study was to assess the association between hearing loss and neurodevelopment in children aged 1 to 60 months recruited from vaccination centers and preschools in Kinshasa, Democratic Republic of the Congo. We hypothesized that hearing loss, even when primarily conductive, might be associated with impairments in neurodevelopmental performance, particularly among preschool-aged children.

METHODS

Study Type, Setting, and Population (Clinical trial not applicable)

This was a cross-sectional study conducted in the city-province of Kinshasa in the Democratic Republic of the Congo between October and December 2025. This megacity, with a population of 17,778,000 (2025) [17], is subdivided into four administrative districts. We used a two-stage random sampling method, in which each district, based on its population size, was assigned a quota of facilities and children to survey to ensure adequate representativeness, using proportional stratification. The facilities included were vaccination centers (CPS) for children aged 1 to 35 months and preschools for children aged 36 to 60 months. For the districts of Tshangu and Lukunga: 3 CPSs and 3 preschools, serving 150 children in each district; and for Funa and Mont Amba: 2 CPSs and 2 preschools, serving 100 children each.

In total, out of 500 eligible children, 488 infants and children whose parents gave informed consent were examined. Children whose parents did not give consent, those known to have hearing loss, those with a malformation of the external auditory canal, those over 5 years of age, and those with otorrhea were excluded from the study.

Data Collection Methods

A questionnaire to collect sociodemographic, anthropometric, clinical (ENT and craniofacial), and paraclinical data was developed and validated in collaboration between ENT physicians and pediatricians.

The ASQ-3 (Ages & Stages Questionnaire), a set of questionnaires assessing a child's overall development, was used to evaluate neurodevelopment in children aged 1 to 35 months.

This scale covers five domains: each domain is scored on a scale of 0 to 60 points, with 60 being the highest score. The cutoff point is the threshold below which the level of development is considered insufficient (either in the “gray zone” or a “failure” in the “black zone”). Each domain includes six questions, each scored as

0 (if the child does not perform the action), 5 (if the child sometimes performs the action), and 10 (if the child performs the action).

These different domains include

- Communication, for which the cutoff score is set at 34.60;
- Gross motor skills, with a cutoff score of 38.41;
- Fine motor skills, with a cutoff score of 29.62;
- Problem-solving, with a cutoff score of 34.98;
- Personal and social skills, with a cutoff score of 27.25.

Interpretation: Results below the cutoff point are considered indicative of an insufficient level of development in the respective domain.

- A neurodevelopmental assessment questionnaire for preschoolers (ages 3 to 5) using the preschool version of the S.I.F.T.E.R. (Screening Instrument for Targeting Educational Risk) scale, a tool for identifying educational risks. It consists of 5 items; each rated on a scale of 1 to 5 (with 5 being the highest score).

Here are the different items:

- Academic performance, where a score of 15–7 indicates success or a sufficient level, and a score of 6–3 indicates children at risk or at an insufficient level;
- Attention: a score of 15–9 indicates success or a sufficient level, while 8–3 indicates an insufficient level;
- Communication: a score of 15–9 indicates success or a sufficient level, and 8–3 indicates an insufficient level;
- Class participation: “successful” or “sufficient” ranges from 15 to 7, and “insufficient” ranges from 6 to 3;
- Social behavior: success or satisfactory level from 15 to 9 and unsatisfactory level from 8 to 3.

Hearing screenings were conducted using objective distortion product otoacoustic emissions (DPOAE) testing with an EROSCAN device (Germany) for screening purposes. In cases of a passing result (PASS), no further testing was necessary; however, in cases of a failing result, an automated auditory brainstem response (AABR) and tympanometry (AMPLIVOX, UK) were then performed. In cases of a failing AABR result, a confirmatory ABR was scheduled at the referral hospital at the University Clinics of Kinshasa.

Study Investigator Team

The team consisted of an ENT physician, an ENT resident, three young general practitioners who had participated in previous research, and a nurse, under the supervision of professors of ENT and Pediatrics. The team received 7 days of training in collecting sociodemographic information and data on risk factors for hearing loss; performing anthropometric measurements; conducting ENT and craniofacial physical examinations; completing the ASQ3 questionnaire with the child's mother; and using hearing screening tools, including DPOAE and AABR.

Teachers of selected children in preschool programs participated by completing the preschool S.I.F.T.E.R. scale.

This team was supervised by two professors of ENT and two professors of pediatrics.

Statistical Analyses

Descriptive statistics were performed using IBM SPSS Statistics software, version 27.0 for Windows (December 29, 2022, USA).

The descriptive analyses presented the studied variables in the form of frequencies, proportions, means, and standard deviations, illustrated by tables and figures. Univariate analyses described each variable individually, while bivariate analyses examined the associations between two variables. Pearson's chi-square test was used to compare categorical variables, with a p-value < 0.05 considered statistically significant.

RESULTS

- Audiological

A total of 488 children were examined. The mean age was 2.3 ± 1.8 years, with a median age of 1.7 years and a range of 1 month to 5 years. The mean weight was 8.2 ± 4 kg for CPS participants and 17.1 ± 2.6 kg for schoolchildren. The mean height values for the CPS were 71 ± 9.8 cm; and 103 ± 9.9 cm for schoolchildren. The prevalence of hearing loss was 2.5% ($n = 12/488$), with a sex ratio of 1.4 boys to 1 girl.

- Neurodevelopmental and Audiological Findings

Children screened for DPOAE at vaccination centers did not show a higher prevalence of abnormalities in the various areas of neurodevelopment on the ASQ3 scale (Fig. 1).

School-aged children referred to the DPOAE show higher rates of educational failure in the areas of academic performance and school behavior (Fig. 2).

Table I. Association between deficits in neurodevelopmental domains (S.I.F.T.E.R.) and the PASS/REFER outcome of DPOAE

Insufficient score / Domain	PASS n (%)	REFER n (%)	OR (95% CI)	p-value
Academic performance	81/236 (34.3)	7/8 (87.5)	13.35 [1.6–110.5]	0.01**
Attention	47/236 (19.9)	4/8 (50.0)	4.02 [0.9–17.5]	0.08
Communication	108/236 (45.8)	5/8 (62.5)	1.98 [0.45–8.5]	0.40
Class Participation	51/236 (21.6)	4/8 (50.0)	3.63 [0.82–15.9]	0.09
Behavior at school	53/236 (22.5)	6/8 (75.0)	10.34 [1.9–55.8]	0.01**

Note

P-values were calculated using Fisher’s exact test due to the small sample sizes in certain cells.

These two figures and the table show that overall neurodevelopment, as assessed by the ASQ-3 scale among children at vaccination centers, is not affected by hearing loss in this study, while a significant association ($p < 0.001$) is noted between hearing loss and an educational risk-specifically, a learning disability in two areas: academic performance and school behavior, as measured by the preschool S.I.F.T.E.R. scale administered to schoolchildren.

DISCUSSION

This study is the first in the Democratic Republic of the Congo to examine the association between hearing loss and neurodevelopment in children aged 1 to 5 years.

In 83% of cases, the hearing loss was conductive, associated with seromucous otitis media, with a predominance in the 21- to 48-month age group (detailed audiological results submitted and awaiting publication).

It does not demonstrate an impact of hearing loss on overall neurodevelopment as measured by the ASQ3 scale in children aged 1 to 35 months. Our results are comparable to those of Thorsen et al. (2023), who noted that children with middle ear disease during the first three years of life did not exhibit any significant delay in neurological development by age 3 [18]. Louw et al. (2017) reached the same conclusion in a South African and Zambian study of children aged 2 to 60 months, assessed using the ASQ-3, showing preserved early performance in communication and motor skills. Only in 5-year-old children was a relative decline noted in fine motor skills and problem-solving [19].

This can be explained by the fact that the impact of conductive hearing loss manifests later than that of sensorineural hearing loss.

In fact, hearing loss associated with middle ear disease, particularly seromucous otitis media (OME)-although it causes mild hearing impairment that often resolves spontaneously [20] or has a fluctuating course-can have repercussions later on, during the child's neurodevelopment, particularly in cognitive skills, and/or communication, especially upon starting school.

This is the case for the second group of children in our study-preschoolers-among whom hearing loss (primarily related to OME) has an impact in two areas of education: academic performance and behavior. These long-term consequences of OME are corroborated by two other studies, which highlight the impact of a history of early OME on hearing, communication, and cognition-particularly in children aged 7 to 8-including difficulties with spatial speech recognition (high threshold even after recovery), effort to listen in noise (pupillary dilation), and on working memory and learning.

To prevent these long-term consequences of early fluctuating hearing loss, early identification and intervention are essential to address this challenge [21, 22].

The literature indicates that severe congenital sensorineural hearing loss has a greater impact on neurodevelopment, especially when it is syndromic, as in the study by Akrich S. et al., 2023 [23].

Despite the increasingly early diagnosis of hearing disorders-especially in highly developed countries-the impact of resulting developmental disorders and associated problems may not become apparent until later in a child's development [24-27].

However, early detection through hearing screening and appropriate interventions are essential for optimizing development and mitigating the potential negative outcomes associated with hearing loss, including delays in speech and language acquisition, impaired cognitive development, and negative effects on social interactions and academic performance [28-30].

A limitation of this study is the sample size. A larger-scale study is needed to confirm the trends observed in our study regarding neurodevelopmental trajectories in children aged 5 and under with hearing loss.

CONCLUSION

Neurodevelopmental disorders are indeed associated with hearing loss, even in cases of middle ear impairment alone-which in this study was primarily linked to seromucous otitis media-and this impact manifests later, during the preschool years. Screening for and managing hearing loss in infants and children-both preschool-aged and school-aged-is warranted to mitigate this impact.

ABBREVIATIONS

- AABR: automated auditory brainstem response
- ABR: auditory brainstem response

- S.I.F.T.E.R: Screening Instrument for Targeting Educational Risk
- ASQ-3: Ages & Stages Questionnaires, Third Edition
- SPSS: Statistical Package for the Social Sciences
- WHO: World Health Organization
- DRC: Democratic Republic of the Congo
- CPS:
- DPOAE: distortion product otoacoustic emissions
- PASS: passing result
- OME: otitis media

DECLARATIONS

Clinical trial not applicable

Ethics approval and consent to participate

This study received approval from the National Health Ethics Committee, reference: Opinion of the National Health Ethics Committee No. 563/CNES/BN/PMMF/2024 dated 20 August 2024. Approval was also obtained from the authorities of the aforementioned medical facilities. The study was conducted in accordance with the applicable guidelines and regulations and in compliance with the Declaration of Helsinki. The anonymity and confidentiality of the data collected were respected. The results obtained were communicated to the relevant authorities and published.

Written informed consent was obtained from the parents of all children who participated in this study.

Consent for publication

Not applicable.

Competing Interests

The authors state that they have no conflicts of interest to disclose in this study

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Author Contribution

Marie Ndungi was responsible for drafting the main text of the manuscript, while Christophe Mambueni handled the statistical analysis and prepared the figures and tables. All authors contributed to the review, modeling, and other aspects of this manuscript.

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Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information.

REFERENCES

1. World Health Organization. Deafness and Hearing Loss. Geneva: WHO; 2026.
2. World Health Organization. Global hearing loss estimates and reports. Geneva: WHO; 2021–4.
3. Guo Z, Ji W, Song P, Zhao J, Yan M, Zou X, Bai F, Wu Y, Guo Z, Song L. Global, regional, and national burden of hearing loss in children and adolescents, 1990–2021: a systematic analysis from the Global Burden of Disease Study 2021. BMC Public Health September. 2024;16(1):2521. 10.1186/s12889-024-20010-0.
4. Owrang D, Vona B. Neurogenetic Disorders with Hearing Loss: Mechanisms, Classifications, and Emerging Insights. Curr Neurol Neurosci Rep Nov 5. 2025;25(1):77. 10.1007/s11910-025-01466-y.
5. Bonino AY, Mood D, Dietrich MS. Rethinking the Accessibility of Hearing Assessments for Children with Developmental Disabilities. J Autism Dev Disord Oct. 2025;55(10):3711–21. 10.1007/s10803-024-06461-9.
6. Elbagoury NM. Hearing loss: a global perspective on gene therapy approaches and challenges. Eur J Pediatr Aug. 2025;27(9):578. 10.1007/s00431-025-06426-9.
7. Sun Y, Chen Y, Wang Q, Zhang H, Li Y, Xu L, et al. Analysis of the clinical features of neurocristopathy-related hearing loss and how these relate to outcomes after cochlear implantation. Front Neurol. 2023;14:1248639. 10.3389/fneur.2023.1248639.
8. Pierrat V, Marchand-Martin L, Marret S, Arnaud C, Benhammou V, Cambonie G, Debillon T, Dufourg MN, Gire C, Goffinet F, Kaminski M, Lapillonne A, Morgan AS, Rozé JC, Twilhaar S, Charles MA, Ancel PY. EPIPAGE-2 writing group. Neurodevelopmental outcomes at age 5 among children born preterm: EPIPAGE-2 cohort study. BMJ April. 2021;28:373:n741. 10.1136/bmj.n741.

9. Joint Committee on Infant Hearing. 2019 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs. *Journal of Early Hearing Detection and Intervention*. 2019;4(2):1–44. 10.15142/fptk-b748
10. Meinzen-Derr J, Wiley S, Choo DI. Impact of early intervention on expressive and receptive language development among young children with permanent hearing loss. *Am Ann Deaf*. 2011 Winter;155(5):580–91. 10.1353/aad.2011.0010.
11. Tawakkul Q, Alsanosi S, Alahmadi A, Alarifi S, Al-Momani M, Aldhafeeri A, Alhabib S. Comparative Outcomes of Cochlear Implantation in Children with Auditory Neuropathy Spectrum Disorder and Sensorineural Hearing Loss: A Systematic Review and Meta-Analysis. *Audiol Neurotol*. 2025;30(6):545–55. 10.1159/000546962.
12. Hatzopoulos S, Cardinali L, Skarzynski PH, Adewunmi AT, Zimatore G. Early Hearing Interventions for Children with Hearing Loss in Africa: A 21-Year Scoping Review (2004–2025). *Child (Basel)*. 2025;12(7):864. 10.3390/children12070864.
13. Mulwafu W, Kuper H, Ensink RJ. Prevalence and causes of hearing impairment in Africa. *Trop Med Int Health* Febr. 2016;21(2):158–65. 10.1111/tmi.12640.
14. Truter B, Slogrove AL, Ilhan E, Conradie P, Thompson L, Gillberg C, Billstedt E. Screening young children for neurodevelopmental differences in sub-Saharan Africa: a scoping review. *BMC Psychiatry* September. 2025;15(1):857. 10.1186/s12888-025-07279-0.
15. Olusanya BO, Neumann KJ, Saunders JE. The global burden of disabling hearing impairment: a call to action. *Bull World Health Organ*. May 1, 2014;92(5):367 – 73. 10.2471/BLT.13.128728. Epub Feb 18, 2014.
16. Fagan JJ, Jacobs M. Survey of ENT services in Africa: need for a comprehensive intervention. *Glob Health Action* March. 2009;19. 10.3402/gha.v2i0.1932.
17. [https://. www-macrotrends-net.translate.goog/global-metrics/cities/20853/kinshasa/population?_x_tr_sl=auto&_x_tr_tl=fr&_x_tr_hl=fr&_x_tr_pto=tc](https://www-macrotrends-net.translate.goog/global-metrics/cities/20853/kinshasa/population?_x_tr_sl=auto&_x_tr_tl=fr&_x_tr_hl=fr&_x_tr_pto=tc)
18. Thorsen J, Pedersen TM, Mora-Jensen AC, Bjarnadóttir E, Bager SC, Bisgaard H, Stokholm J. Middle ear effusion, ventilation tubes, and neurological development in childhood. *PLoS One* Jan. 2023;13(1):e0280199. 10.1371/journal.pone.0280199.
19. van Heerden A, Hsiao C, Matafwali B, Louw J, Richter L. Support for the feasibility of the Ages and Stages Questionnaire as a developmental screening tool: a cross-sectional study of South African and Zambian children aged 2–60 months. *BMC Pediatr* Febr. 2017;16(1):55. 10.1186/s12887-017-0802-3.
20. Browning GG, Rovers MM, Williamson I, Lous J, Burton MJ. Grommets (ventilation tubes) for hearing loss associated with otitis media with effusion in children. *Cochrane Database Syst Rev* Oct. 2010;6(10):CD001801. 10.1002/14651858.CD001801.pub3.
21. Graydon K, Rance G, Dowell R, Van Dun B. Consequences of Early Conductive Hearing Loss on Long-Term Binaural Processing. *Ear Hear* 2017 Sep/Oct;38(5):621–7. 10.1097/AUD.0000000000000431

22. Yosef M, Trau-Margalit A, Harel-Arbeli T, Taitelbaum-Swead R. How does a history of otitis media with effusion affect spatial auditory processing and listening effort? *Eur Arch Otorhinolaryngol* Dec. 2025;282(12):6177–84. 10.1007/s00405-025-09570-y.
23. Akrich S, Parlato de Oliveira E, Favrot-Meunier C, Rebichon C, de Clerck A, Ettori S, Rouillon I, Prang I, Loundon N. Analysis of specific risk factors for neurodevelopmental disorders in hearing-impaired infants under ten months of age: EnTNDre, a pioneering research project stemming from a transdisciplinary partnership. *Int J Pediatr Otorhinolaryngol* March. 2023;166:111453. 10.1016/j.ijporl.2023.111453.
24. Fortnum HM, Marshall DH, Summerfield AQ. Epidemiology of the UK population of hearing-impaired children, including characteristics of those with and without cochlear implants—audiology, etiology, comorbidity, and socioeconomic status. *Int J Audiol*. 2002;41(3):170–9. 10.3109/14992020209077181.
25. Martens S, Dhooge I, Dhondt C, Vanaudenaerde S, Sucaet M, Van Hoecke H, De Leenheer E, Rombaut L, Boudewyns A, Desloovere C, Vinck AS, de Varebeke SJ, Verschueren D, Verstreken M, Foulon I, Staelens C, De Valck C, Calcoen R, Lemkens N, Öz O, De Bock M, Haverbeke L, Verhoye C, Declau F, Devroede B, Forton G, Deggouj N, Maes L. Three Years of Vestibular Infant Screening in Infants With Sensorineural Hearing Loss. *Pediatr* July. 2022;1(1):e2021055340. 10.1542/peds.2021-055340.
26. Okely JA, Akeroyd MA, Deary IJ. Associations Between Hearing and Cognitive Abilities From Childhood to Middle Age: The National Child Development Study 1958. *Trends in Hearing*. Jan–Dec. 2021;25:23312165211053707. 10.1177/23312165211053707.
27. Percy-Smith L, Wischmann S, Josvassen JL, Schiøth C, Cayé-Thomasen P. Language Development for the New Generation of Children with Hearing Impairment. *J Clin Med* May. 2021;27(11):2350. 10.3390/jcm10112350.
28. Shojaei E, Jafari Z, Gholami M. Effect of Early Intervention on Language Development in Hearing-Impaired Children. *Iran J Otorhinolaryngol* January. 2016;28(84):13–21.
29. Kasai N, Fukushima K, Omori K, Sugaya A, Ojima T. Effects of early identification and intervention on language development in Japanese children with prelingual severe to profound hearing impairment. *Ann Otol Rhinol Laryngol Suppl* April. 2012;202:16–20. 10.1177/000348941212100402.
30. Lang-Roth R. Hearing impairment and language delay in infants: Diagnostics and genetics. *GMS Curr Top Otorhinolaryngol Head Neck Surg*. 2014;13:Doc05. 10.3205/cto000108.

Figures

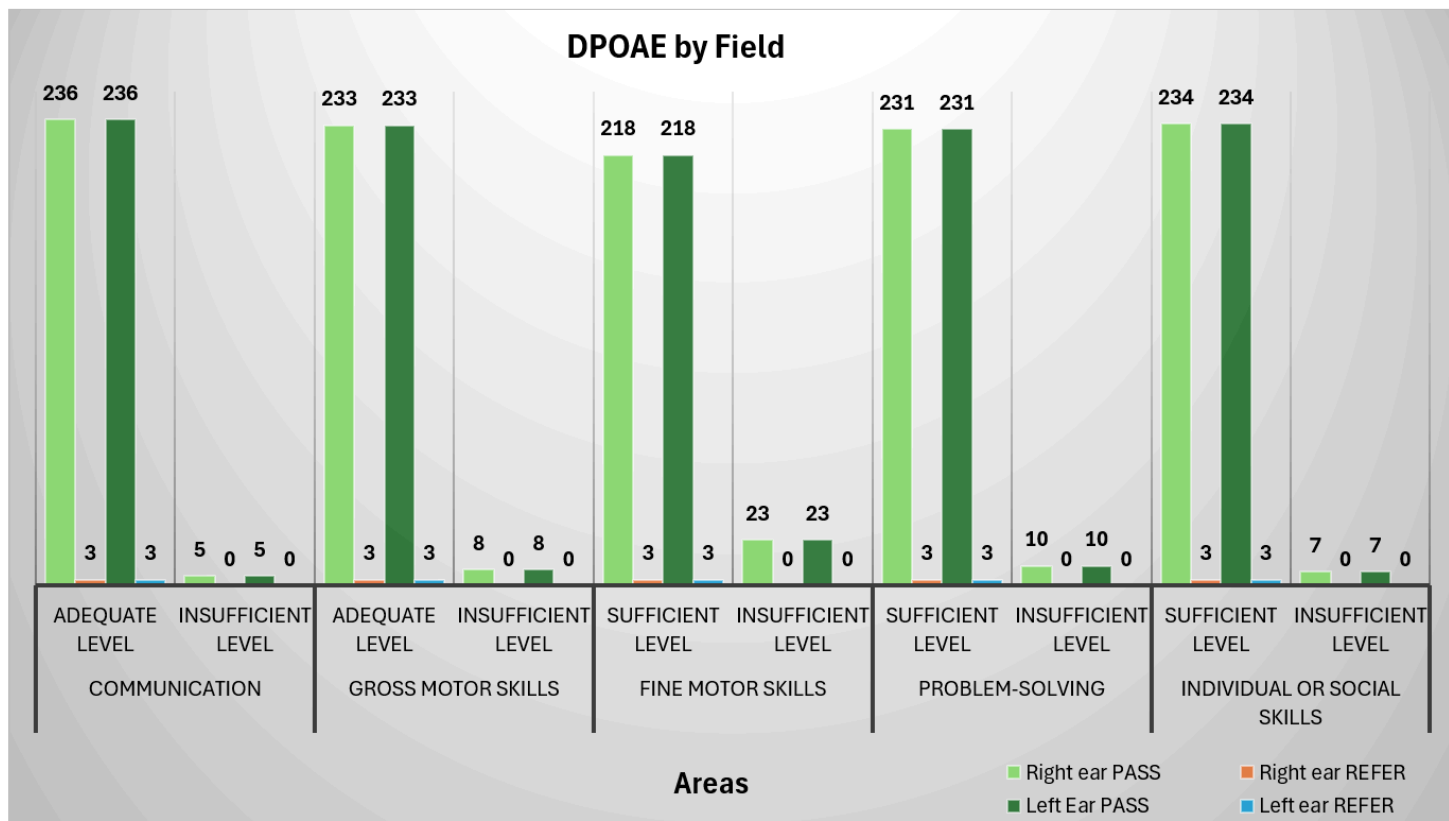


Figure 1

ASQ3 scores among children aged 1–35 months in CPS and DPOAE.

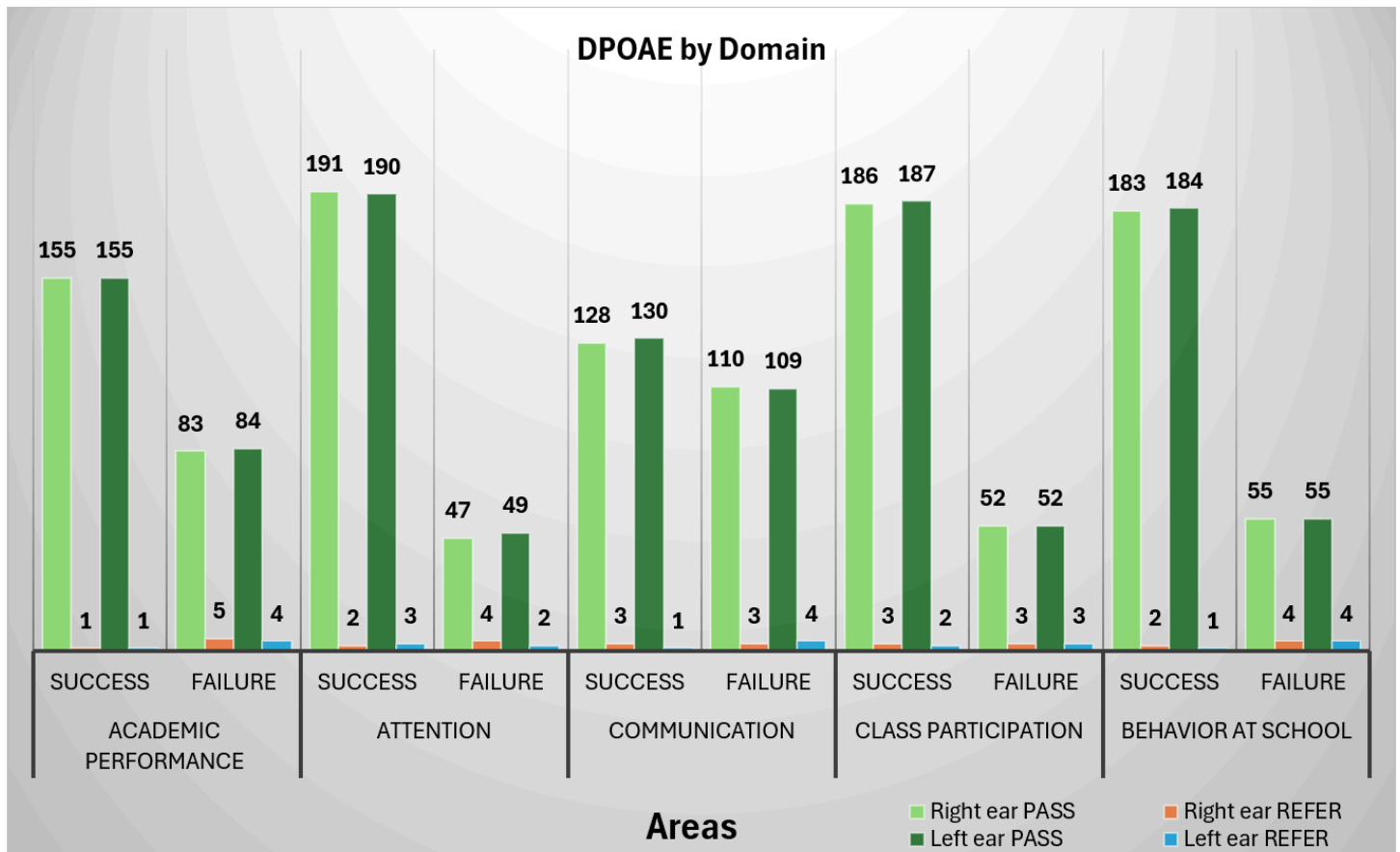


Figure 2

S.I.F.T.E.R. scale among schoolchildren in the DPOAE.