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Cognitive impairment and academic performance in students with sensorineural hearing loss in Kongo Central, Democratic Republic of the Congo

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ABSTRACT

Introduction

Several studies in the literature have highlighted the impact of cognitive impairment and academic performance (AP) in students with sensorineural hearing loss in specialised schools for the deaf. However, few studies have been conducted on this subject in our setting.

Purpose

The objective of this study was to determine the influence of hearing impairment (HI) and cognitive level on AP in students attending specialised schools for the deaf in Kongo Central.

Methods

This was a cross-sectional study conducted among 126 deaf students. The parameters collected included sociodemographic, clinical, and paraclinical data. HI was confirmed using pure tone audiometry (PTA) and classified according to WHO criteria. Cognition was assessed using Raven's Standard Progressive Matrices (SPM), a non-verbal intelligence test, to determine the intelligence quotient (IQ). Data were analysed using SPSS version 26.0.

Results

A total of 126 students, including 75 boys, were enrolled. The dominant age group was >18 years (44.4%). Most participants were Jehovah's Witnesses (38.1%) and lived in low-income households (62.7%). Nearly 85.7% of the students had severe to profound HI, with post-lingual onset in 60.3%, and 57.1% had a low IQ. The mean AP was 50.54 ± 6.56%. There was a weak negative correlation between hearing loss and AP ($r = -0.30$; $p < 0.001$). Students with above-average IQ had significantly higher AP scores compared to those with low or average IQ ($p = 0.005$). A significant negative correlation was also observed between advancing age and IQ ($p < 0.001$), indicating that IQ tends to decline slightly with age, explaining 10.7% of the variance.

Conclusion

The lack of schooling for deaf children is a significant issue in our context. Advancing age significantly impairs AP, underscoring the need to enrol these students at the appropriate school age.

INTRODUCTION

Deafness is defined as the inability to hear as well as someone with normal hearing (0 to 20 dB) in both ears (World Health Organization [WHO], 2021). Alterations in the structures of the outer and middle ear are responsible for conductive deafness, whereas damage to the structures of the inner ear, the auditory nerve, or the central hearing pathways causes sensorineural deafness (Bonfils, Couloigner, & Laccourreye, 2011).

Deafness is a frequent condition at birth, affecting 1 to 2 newborns per 1,000 live births. For instance, approximately 120 children are born each year in Belgium with severe hearing impairment (HI), which is a vital sense for speech and language development (Ligny et al., 2020; Ridal et al., 2014).

Hearing loss (HL) is a significant public health problem in Sub-Saharan Africa (SSA) and other developing countries. Of the estimated 278 million people with HL globally, more than two-thirds live in developing countries (Tucci, 2010). In these regions, over 180,000 babies are born annually with significant HL, and an estimated 1.2 million children aged 5–14 years have moderate to severe HL (Abdalla & Omar, 2011). The impact of HL on children is profound. Without timely intervention, children with HL often struggle to learn and communicate effectively (Tucci, 2010), which in turn limits cognitive development and reduces the likelihood of completing primary education (Abdalla & Omar, 2011). As a result, HL in children poses a challenge to achieving universal primary education, a key goal of the Millennium Development Goals (United Nations, 2010).

HL is also a risk factor for worsening cognitive impairment. It leads to overuse of cognitive resources to process degraded auditory information, resulting in fatigue and negative impacts on cognitive processes such as working memory, reasoning, and planning (Lin et al., 2011). Some studies suggest that deafness may account for approximately 8% of cognitive function variability (Masamba et al., 2025; Ameva Hélène et al., 2015). Beyond age-related factors, HI has been associated with atrophy in brain regions such as the hippocampus and the nucleus accumbens, affecting functions like memory and overall cognition (Van't Hooft, 2023).

The mental health of children with HI is also of concern, as their socio-emotional development can be negatively affected by communication challenges (Stevenson et al., 2015). A range of mental health issues—including depression, aggression, anxiety, somatisation, and delinquency—has been reported among children with HI (Theunissen et al., 2014).

HI in children presents a major public health challenge, particularly due to its impact on early speech and language development and, subsequently, on academic and professional performance. Even mild degrees of HL have been shown to negatively influence academic and social functioning (Su & Chan, 2017).

However, only a few studies have investigated the academic performance (AP) and psychosocial development (PSD) of children with HI in mainstream schools, and findings have been mixed. Many studies have demonstrated the benefits of cochlear implants (CIs) in improving speech perception, production, and language development (Choi et al., 2020; Nicolas & Geers, 2006). In recent decades, there has been a shift toward educating students with special needs in inclusive schools rather than in segregated institutions (Choi et al., 2020; Xie et al., 2014). Some research has found that children with CIs in regular schools perform satisfactorily in academic settings (Choi et al., 2020; Xie et al., 2014; Wu et al., 2013).

Nonetheless, great variability in PSD has been reported among such students, with inconsistent findings (Wauters et al., 2008). Additionally, inadequate infrastructure for students with HI can negatively affect their AP and future employment opportunities. In many developing countries, hearing-impaired and deaf children are seldom enrolled in school (WHO, 2022).

In Africa, an estimated 4.4 million people live with deafness, including 1% to 13.5% who are children—2.1% to 3.4% of whom have severe to profound HI (Tshimbadi et al., 2011). In the Democratic Republic of Congo (DRC), Kongo Central Province spans 53,920 km² with a population of approximately 5.58 million and about 2,780 schools, of which only two are specialised institutions for the deaf (Rapport Annuel, 2022). Parents of students with hearing disabilities often choose either special education or, more commonly, inclusive education (Kabongo &

Okongolango, 2022). Children with HI are frequently discriminated against and underrepresented in educational settings. Those who do attend school often drop out early, and very few complete secondary education.

Data from medical centres and specialised schools indicate that significant cognitive dysfunction negatively affects the AP of students with HI. While sign language is a valuable communication tool, it has not demonstrated a significant capacity to eliminate the cognitive and academic challenges these students face. Consequently, their futures are compromised, despite the fact that they already bear a disability.

Therefore, this study aims to determine the influence of sensorineural hearing impairment and cognitive disorders on the academic performance of students attending specialised schools for the deaf in Kongo Central.

METHODS

Study Design and Setting

This study employed a cross-sectional and analytical design, conducted from 2 October 2023 to 15 July 2024. It targeted two schools under Catholic convention in the Kongo Central province: the *Florentia School Complex* (established in 2011), located in Boma, and the *Espérance School Complex* (established in 2020), located in Matadi. These schools were selected because they are the only specialised institutions for the deaf among approximately 2,780 schools in the province.

Study Population

The study population consisted of students aged 7 years and above who met the following inclusion criteria: parental consent to participate; normal otoscopic and eye examination findings; normal tympanogram; ability to participate in pure tone audiometry (PTA) and cognitive testing; completion of the 2023–2024 academic year; and normal vision.

Data Collection Technique and Procedure

Data collection was carried out by the principal investigator, assisted by an educational psychology assistant, a senior ophthalmology assistant from UNIKIN, two sign language interpreters, and five final-year medical students from UKV/Boma. The team was briefed to ensure alignment with the study objectives. The briefing covered awareness-raising among teachers, parents, and students; survey form completion; data archiving; statistical analysis; and administration of the cognition test. The data collection technique was personalised and specific to each variable of interest.

The variables studied included sociodemographic information, clinical data (medical history, physical examination findings), results from auditory function assessments, academic performance data, and cognitive evaluation. All participating students underwent an ENT physical examination following an ophthalmological examination and a cognitive test. PTA was conducted using a *Sibelmed DUO* diagnostic audiometer, calibrated for frequencies from 125 to 8000 Hz and intensity levels from -10 to 130 dB.

Definitions and Classification Criteria

Hearing impairment (HI) was defined as any reduction in auditory acuity occurring before or after the age of two years, regardless of severity. The degree of HI was determined based on the average hearing threshold (in dB) at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, following the classification by the International Bureau of Audiophonology (BIAP):

- Normal hearing: 0–20 dB
- Mild HI: 21–40 dB
- Moderate HI: 41–70 dB
- Severe HI: 71–90 dB
- Profound HI: 91–120 dB
- Total HI (cophosis): >120 dB

Academic performance (AP) was assessed using both quantitative and qualitative indicators. Quantitative indicators included grades obtained in quarterly and semi-annual standardised assessments, class attendance, participation in school activities, and comprehension and application of taught concepts. Qualitative indicators were based on teacher remarks regarding student behaviour. Students were grouped into five performance categories based on their annual average score:

- Excellence (≥80%)
- Very good (70–79%)
- Good (55–69%)
- Fairly good (45–54%)

- Poor (<45%)

Cognitive function was assessed using the *Raven's Standard Progressive Matrices* (RSPM), which was scored and converted into an intelligence quotient (IQ). Each correct response was awarded one point, with total raw scores ranging from 0 to 60. Subscores were calculated for each section, and then the total raw score was converted into an IQ score using the formula:

- **Z-score** = (A − B) / C
- **IQ** = Z × D + E

Where:

- *A* = raw score of the participant
- *B* = mean score of the reference population
- *C* = standard deviation of the reference population
- *D* = standard deviation of IQ (usually 15)
- *E* = mean IQ (typically 100)

(Hogan, 2017).

Due to the absence of a Congolese calibration for the RSPM, the most recent Central African calibration was adopted. This calibration was developed by Nenty, Dinye, and Gaiya following a study involving 2,540 participants across four countries: Cameroon (640), Republic of Congo (620), Gabon (650), and Central African Republic (630) (Nenty et al., 2016). IQ scores were classified as follows:

- Debility: <70
- Low normal intelligence: 70–85
- Average intelligence: 86–115
- Superior intelligence: >115

Data Processing and Analysis

Data were entered into Microsoft Excel 2013, verified, coded, and transferred to SPSS version 26.0 for analysis. Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as percentages with 95% confidence intervals (CIs). Comparisons of quantitative variables were performed using Student's *t*-test or ANOVA, and comparisons of qualitative variables using Pearson's chi-square or Fisher's exact test.

Univariate and multivariate analyses were conducted, and odds ratios (ORs) with 95% CIs were calculated. A multivariate logistic regression model was used to adjust for confounding factors and identify independent determinants of hearing impairment. A p-value ≤ 0.05 was considered statistically significant.

Ethical and Regulatory Considerations

The study protocol received ethical approval from the *National Ethics Committee* (CNES) under reference number 593/CNES/BN/PMMF/2024. All procedures and data collection adhered to the principles outlined in the *Declaration of Helsinki*, ensuring participant anonymity. Informed consent was obtained from the students or their parents prior to participation.

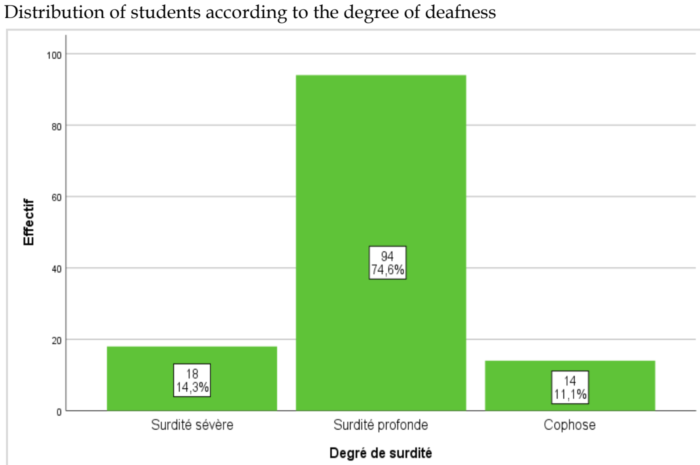
RESULTS

General Patient Characteristics

Degree of Deafness

All students in the study were deaf. The majority (74.6%, *n* = 94) were profoundly deaf, while 14.3% (*n* = 18) had severe deafness. Only 11.1% (*n* = 15) had total deafness (cophosis).

Chart 1:
Distribution of students according to the degree of deafness



Socio-Demographic Characteristics

Out of the 126 students surveyed, approximately 60% (*n* = 75) were male. About 44.4% of the students were over 18 years of age. The majority were in elementary school (55.6%), and 62.7% (*n* = 79) belonged to a low socio-economic background.

Among the students, 71% (*n* = 90) were born through eutocic delivery. About 30% (*n* = 38) had mothers who had used systemic ototoxic substances during pregnancy—of which 57.9% (*n* = 22) involved traditional products. Additionally, 28.6% (*n* = 36) had at least one deaf family member, 17.5% (*n* = 22) had a history of neonatal infection

(INN), and 15.9% (n = 20) had experienced neonatal jaundice.

Prelingual deafness was reported in 60.3% (n = 76) of the students, while 39.7% (n = 50) had postlingual deafness. The majority of respondents had low cognitive function, with 57.1% (n = 72) classified as having a low IQ. The mean scholastic rating (SR) of the students was 50.54, with a standard deviation of 6.556 and a range between 43.984 and 54.096.

Table 1:
General profile of the study population

Variables	Frequency (n=126)	Percentage (%)
Sex		
Male	75	59,5
Female	51	40,5
Age groups		
≤12 years	18	14,3
13 to 18 years	52	41,3
>18 years	56	44,4
Studies		
Primary	70	55,6
Secondary	56	44,4
Socioeconomic Level		
Low level	79	62,7
High level	47	37,3
Medical History/Antecedents		
Use of ototoxic products	38	30,2
Aminglycosides	4	10,5
Indigeneous products	22	57,6
Childbirth		
Eutocic (normal)	90	71,4
Dystocic	19	15,1
Unkown	17	13,5
Neonatal Infection	22	17,5
Neonatal Jaundice	20	15,9
Meningitis	15	11,9
Family history of deafness	36	28,6
Intellectuel quotient		
Debility	72	57,1
Low normal Intelligence	24	19
Average Intelligence	18	14,3
Superior Intelligence	12	9,5

Academic Performance of the Study Population

The study found a weak but statistically significant negative correlation between hearing impairment and academic performance (r = -0.300, p < 0.001), indicating that hearing loss slightly decreases the SR. Approximately 9% of the variance in SR was negatively explained by hearing loss.

Students with severe hearing loss had a significantly higher mean annual score than those with profound deafness or cophosis (p < 0.00001). According to Raven's Progressive Matrices test, students with above-average IQ scored significantly higher than those with low or average IQ (p = 0.005) (Raven, 2000). However, psychological testing showed no statistically significant difference in SR between students with low IQ (IQ < 70) and those with acceptable IQ (IQ > 70) across each level of deafness.

School Performance, Degree of Deafness, and Psychological Testing

Univariate analysis of SR, degree of deafness, and IQ revealed significant associations with several factors: degree of deafness, use of ototoxic drugs during pregnancy, school attendance irregularity, class lateness, age group, and education level. However, no significant associations were observed with other variables.

Table 2:
Relationship between SR, degree of deafness, and psychological testing

Variables	School performance		p value
	Success	*Failure*	
Degree of deafness			
Severe deafness	11(44)	7(6,9)	
Profound deafness	13(52)	81(80,2)	<0,001
Cophosis (total deafness)	1(4)	13(12,9)	
IQ according MR test			0,053
Low	10(40)	62(39)	
Acceptable	15(60)	39(38,6)	
Medical history/Antecedents			
Use of ototoxic products	3(12)	35(34,7)	0,027
Mode of delivery			
Eutocic (normal)	22(88)	68(67,3)	
Dystocic (difficult)	1(4)	18(17,8)	0,109
Unknown	2(8)	15(14,9)	
Neonatale Infection	3(12)	19(18,8)	0,422
Méningitis	1(4)	14(13,9)	0,173
Family history of Deafness	6(24)	30(29,7)	0,572
Irrégular Attendance	9(36)	59(58,4)	0,044
Lateness to Classes	13(52)	79(78,2)	0,008
Age Groups			
<12 years	7(28)	11(10,9)	
13 to 18 years	15(60)	37(36,6)	<0,001
>18 years	3(12)	53(52,5)	
Education level			
Primary	22(88)	48(47,5)	<0,001
Secondary	3(12)	53(52,5)	

Factors Influencing Poor Academic Performance Among High-Achieving Students with Hearing Impairment

Table 3 presents the factors that may contribute to the poor academic performance observed among deaf students in the study. All socio-demographic, clinical, audiological, and cognitive factors with a p-value < 0.2 in the univariate analysis were included in the multivariate logistic regression model.

The following variables were significantly associated with poor academic performance ($p < 0.05$):

- Female gender (adjusted OR = 4.54, $p = 0.033$),
- Secondary education level (adjusted OR = 10.31, $p = 0.004$),
- Use of ototoxic products during pregnancy (adjusted OR = 5.49, $p = 0.034$),
- Profound deafness or cophosis (adjusted OR = 10.85, $p = 0.001$),
- Low IQ (adjusted OR = 6.20, $p = 0.006$).

These findings suggest that a combination of biological, cognitive, and environmental factors influence academic achievement in students with sensorineural hearing loss.

Table 3:
Multivariate analysis of factors influencing academic performance among deaf students

VARIABLES	Univariate analysis OR Crude	CI 95%	p-value	Multivariate analysis OR adjusted	CI 95%	p-value
Sex (Female)	1,98	0,76 - 5,17	0,161	4,54	1,13 - 17,61	**0,033***
Age (> 18 years)	8,10	2,28 - 28,77	0,001	2,44	0,44 - 13,59	0,308
EducationLeavel (Secondary)	8,10	2,28 - 28,77	0,001	10,31	2,10 -50,54	**0,004***
School Attend (CS Espérance)	2,95	1,13 - 7,69	0,026	2,24	0,68 - 7,43	0,187
Use of ototoxic Products during pregnancy	3,89	1,09 - 13,90	0,037	5,49	1,14 - 26,48	**0,034***
Lateness to Classes	2,50	1,01 - 6,19	0,048	2,84	0,86 - 9,33	0,085
Irrégular attendance	3,31	1,33 - 8,28	0,010	1,61	0,44 - 5,5	0,466
Profond Deafness / Cophosis	10,55	3,51 - 31,74	< 0,001	10,85	2,75 - 42,80	**0,001***
IQ according to Raven's Matrice Test (Low)	2,38	0,97 - 5,83	0,057	6,20	1,67 - 23,04	**0,006***

DISCUSSION

General Description of the Study Population

In the present study, prelingual deafness accounted for 60.3% (n = 76) of cases, predominating over postlingual deafness, which constituted 39.7% (n = 50) of the respondents. This finding aligns with a study by Huber and Kipman (2012) in the USA, who reported 70% (n = 28) of cases as prelingual deafness. Conversely, Ogundiran and Olaosun (2013) in Nigeria found an even distribution of 50% (n = 25) for each type of deafness. The predominance of prelingual deafness in the present study may be due to the random nature of the sampling.

Threshold Pure Tone Audiometry (TPA) was the only method used in this study—as is common in most studies globally—to assess hearing function. Our study revealed a predominance of profound deafness at 74.6% (n = 94), followed by severe deafness at 14.3% (n = 18). Only 11.1% (n = 15) had total deafness (cophosis). In contrast, Vesseur et al. (2016) conducted a study in the Netherlands and found 19.2% (n = 9) of students with profound deafness and 14.9% (n = 7) with cophosis. Furthermore, Barros Bomfim et al. (2022) showed that all cases among sickle cell patients exhibited mild sensorineural deafness. These differences may be explained by the fact that the current study exclusively targeted deaf students, whereas Vesseur et al. (2016) included students with various disabilities, and Barros Bomfim et al. (2022) examined patients without hearing loss as the primary condition.

Although not statistically significant (p = 0.607), our study indicated that students with prelingual deafness were more academically applied than those with postlingual deafness. This may be attributed to the postlingually deaf being more accustomed to spoken language, whereas prelingual deaf individuals adapt more efficiently to sign language. Ogundiran and Olaosun (2013) similarly observed better academic performance among prelingually deaf students, though they also reported no statistically significant difference.

Notably, our study showed a statistically significant association between the degree of deafness and academic achievement ($p < 0.001$). This finding contrasts with the study conducted in a Nigerian middle school, where no significant difference was found between congenital and acquired deafness (p = 0.765) (Ogundiran & Olaosun, 2013). The statistically significant results in our study could be attributed to a larger and more inclusive sample size (n = 126; all courses) compared to the Nigerian study (n = 75; only Mathematics and English).

Age, Gender, and Socioeconomic Level

A descriptive analysis showed a male predominance in our sample, with a sex ratio of 1.47 in favour of males. This trend was similarly reported in studies conducted in the United States (Erickson & Quick, 2016) and the Democratic Republic of Congo (Kabongo et al., 2022). However, a female predominance has been noted in several studies globally (Van Ingen et al., 2017; Clercq et al., 2019; Choi et al., 2019; Golub et al., 2019; Huber & Kipman, 2012; Barros Bomfim et al., 2022). The male predominance in the present study may be explained by the limited number of specialised schools for the deaf in Kongo Central and parental preferences for educating male children.

Our study demonstrated a very weak negative relationship between IQ and age among the deaf; as age increases, IQ tends to decrease slightly. The inclusion criteria for this study—regular school enrolment and feasibility of auditory and cognitive testing—yielded a mean age (SD) of 17.99 (5.1) years. Other authors reported significantly lower mean ages, such as 10.1 (1.3) years (Huber & Kipman, 2012) and 11.0 (3.3) years (Choi et al., 2020). This difference is likely due to our study encompassing both primary and secondary education levels, whereas the cited studies were confined to elementary schools.

Regarding socioeconomic status, approximately 63% of respondents' households were classified as low-income. This contrasts with a Dutch study that reported a predominance of students from high-income households (Clercq et al., 2019). The lower socioeconomic status in the DRC may reflect the country's socio-political and military challenges, widespread unemployment, and weak wage policy.

Cognition

To assess cognition, our study employed the Raven Standard Progressive Matrices, a non-verbal intelligence test. Vesseur et al. (2016) used the same test and found that 58.5% (n = 24) of students had a low IQ (debility), 22.0% (n = 9) had a normal IQ (average intelligence), and 19.5% (n = 8) had a sub-normal IQ (low intelligence). Our results were similar, with 57.1% (n = 72) having **low IQ**, 19.0% (n = 24) with sub-normal IQ, and 14.3% (n = 18) with normal IQ. Only 9.5% (n = 12) exhibited an above-average IQ (superior intelligence). Differences in these distributions likely reflect variations in study populations.

Academic Performance

In a study involving 50 Nigerian students divided equally into congenital and acquired deafness, the mean school result (SR) was 60.8 ± 20.29% for both groups, with no significant difference observed (p = 0.973). Our study found a lower mean SR of 50.54 ± 6.56%, ranging from 26% to 69%. Students with severe deafness recorded higher mean annual scores than those with profound deafness or cophosis (p < 0.00001).

Huber and Kipman (2012) reported that **reading scores** were significantly and positively correlated with vocabulary (r = 0.65, p < 0.001), comprehension (r = 0.59, p = 0.001), digit span (r = 0.50, p < 0.001), and number sequences (r = 0.43, p = 0.005). However, no significant correlations were found between arithmetic scores and other cognitive measures. In our study, schoolchildren with above-average IQs scored significantly higher than those with low or average IQs (p = 0.005). This may be due to the broader coverage of all subjects in our study.

There was no significant difference in SR (p = 0.197) between CS Florentia and CS Espérance, indicating that both schools provided equitable academic support. As noted by Kabongo et al. (2022) and Tremblay (2014), specialised schools are designed to meet the unique needs of children with exceptionalities, often with adapted equipment and teaching strategies.

The first regression analysis revealed that age group (OR = 8.10, p = 0.001), education level (OR = 8.10, p = 0.001), school attended (OR = 2.95, p = 0.026), ototoxic drug use (OR = 3.89, p = 0.037), history of ear pathologies (OR = 2.5, p = 0.048), rhinitis (OR = 3.31, p = 0.010), and degree of deafness (OR = 10.55, p < 0.001) all influenced academic performance. The second regression analysis found that female sex (adjusted OR = 4.54, p = 0.033), secondary education level (adjusted OR = 10.31, p = 0.004), prenatal exposure to ototoxic substances (adjusted OR = 5.49, p = 0.034), profound deafness/cophosis (adjusted OR = 10.85, p = 0.001), and low IQ (adjusted OR = 6.20, p = 0.006) significantly influenced academic outcomes.

Our findings suggest that female gender may be associated with lower academic performance among deaf students. This may be due to the cultural role of girls as caregivers in the household, leaving them with limited time to study. However, existing literature suggests no significant difference in IQ between boys and girls. Notably, profound deafness/cophosis emerged as the most significant predictor of academic performance in this study. A study in China found that spatial ability was the strongest predictor of mathematics performance in regression models (Chen & Wang, 2020). Other studies have also reported associations between spatial ability and mathematics performance in hearing children (Mix et al., 2016; Carr et al., 2018).

CONCLUSIONS

This study concludes that there is a weak but statistically significant ($p < 0.001$) negative correlation between hearing loss and academic performance. Students with severe deafness achieved better annual results than those with profound deafness or cophosis ($p < 0.00001$). The severity of hearing impairment was also correlated with the severity of cognitive impairment. Female sex, secondary education level, profound deafness/cophosis, and low IQ are important markers for evaluating academic performance and may serve as tools for preventing school failure among students with sensorineural hearing loss in specialised schools in Kongo Central.

Ethical Approval: The study protocol received ethical approval from the National Ethics Committee (CNES) under reference number 593/CNES/BN/PMMF/2024.

Conflicts of Interest: None declared.

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