



Original Research Article

CROSS-SECTIONAL ANALYSIS OF NEONATAL HEARING SCREENING: EARLY DIAGNOSIS AND INTERVENTION OUTCOMES.

Anand Ranagol¹, Savita Ranagol², Nazeer Ahmad Zeergal³

^{1,2,3}Associate Professor, Department of Paediatric, Al Ameen Medical College, Athani Road, Vijayapur 586108, India.

Received : 07/12/2024
 Received in revised form : 25/01/2025
 Accepted : 09/02/2025

Corresponding Author:

Dr. Anand Ranagol,
 Associate Professor, Department of
 Paediatric, Al Ameen Medical College,
 Athani Road, Vijayapur 586108, India.
 Email: ranagolanand@gmail.com

DOI: 10.70034/ijmedph.2025.1.95

Source of Support: Nil,
 Conflict of Interest: None declared

Int J Med Pub Health
 2025; 15 (1);

ABSTRACT

Background: Neonatal hearing screening (NHS) is crucial for the early detection of hearing impairments, which can significantly affect language development and cognitive abilities if not addressed promptly. This study evaluates the outcomes of NHS programs focusing on the efficacy of early diagnosis and subsequent interventions.

Materials and Methods: A cross-sectional analysis was conducted on a cohort of 200 neonates who underwent NHS. Data were collected on the rates of successful early diagnosis, delayed diagnosis, and missed diagnoses. Additionally, the effectiveness of the interventions was assessed based on improvements in auditory and verbal capabilities. Factors influencing the success rates of interventions and long-term developmental outcomes were also analyzed.

Results: Of the neonates screened, 34% were diagnosed successfully at an early stage, 64% experienced delayed diagnosis, and 2% were missed. Interventions following early screenings showed that 41% of neonates improved in auditory capabilities and 42% in verbal capabilities. However, 17% showed no improvements. Key factors contributing to the success of interventions included parental involvement, follow-up compliance, and resource availability. Long-term developmental outcomes indicated that 53% of early-diagnosed neonates displayed better language skills, but 33.5% showed no significant differences in development compared to those with delayed diagnoses.

Conclusion: While NHS programs are effective in early detection for a significant portion of neonates, improvements are needed to reduce delayed and missed diagnoses. Enhanced follow-up protocols, increased resource allocation, and greater parental engagement are essential for maximizing the benefits of early interventions. These findings highlight the need for standardized practices and increased accessibility to ensure effective early hearing loss interventions across diverse healthcare settings.

Keywords: Neonatal Hearing Screening, Early Diagnosis, Intervention Outcomes.

INTRODUCTION

Hearing loss is one of the most common congenital disorders, affecting 1 to 3 per 1000 live births globally. Early detection and intervention are critical to the cognitive, speech, and language development of infants. Neonatal hearing screening (NHS) programs aim to identify hearing impairments shortly after birth to commence timely interventions

that can dramatically alter developmental trajectories. These programs have become increasingly prevalent, following the realization that later identification often results in significant developmental disadvantages.^[1,2]

The importance of early detection cannot be understated. Studies show that children with hearing loss who receive intervention by 6 months of age have significantly better outcomes in language, cognitive abilities, and social-emotional

development compared to those whose treatment begins later. This evidence supports the implementation of universal neonatal hearing screenings as part of routine postnatal care.^[3,4,5]

Despite their clear benefits, the efficacy and outcomes of NHS programs can vary significantly depending on several factors, including the screening methods used, the timing of the intervention, parental involvement, and follow-up compliance. A cross-sectional analysis of these programs provides insight into their effectiveness and the factors that contribute to successful early hearing loss intervention.^[6,7]

In high-income countries, NHS programs have become well-established and have demonstrated success in improving long-term outcomes for children with hearing loss. However, in low to middle-income countries, these programs face numerous challenges such as limited resources, lack of trained professionals, and poor follow-up services. This research aims to analyze the impact of early diagnosis and intervention through NHS programs across different settings and identify key factors that influence their success.^[8]

Aim

To evaluate the outcomes of neonatal hearing screening programs in early diagnosis and intervention.

Objectives

1. To assess the effectiveness of early hearing detection and intervention programs in improving auditory and verbal capabilities in neonates.
2. To identify factors influencing the success rates of early interventions following neonatal hearing screenings.
3. To compare the long-term developmental outcomes of neonates with early detected hearing loss versus those with delayed diagnosis.

MATERIALS AND METHODS

Source of Data: This study utilized data from hospital records and direct clinical assessments of neonates undergoing hearing screening.

Study Design: A retrospective cross-sectional study was conducted.

Study Location: The study was carried out in tertiary care hospital with established NHS programs across both urban and rural settings.

Study Duration: Data collection spanned from January 2021 to December 2023.

Sample Size: A total of 200 neonates who underwent hearing screening were included in the study.

Inclusion Criteria: Neonates who received NHS within the first 48 hours of birth and had complete follow-up data for at least 12 months were included.

Exclusion Criteria: Neonates with known genetic disorders affecting hearing, those with severe congenital anomalies, and those who were critically ill and could not undergo screening were excluded from the study.

Procedure and Methodology: Hearing screening was performed using Automated Otoacoustic Emissions (AOAE) and Automated Auditory Brainstem Response (AABR) methods. Neonates who failed initial screening underwent a detailed audiological assessment and, if diagnosed with hearing loss, received early intervention services.

Sample Processing: No specific sample processing was necessary as the data collected were non-biological and involved audiometric evaluations and intervention records.

Statistical Methods: Data were analyzed using SPSS software. Descriptive statistics, chi-square tests for categorical variables, and t-tests for continuous variables were used to determine the impact of early screening and intervention on neonatal hearing outcomes.

Data Collection: Data were collected from medical records, including results from the hearing screenings, follow-up interventions, and developmental assessments at 6, 12, and 24 months.

RESULTS

Table 1: To evaluate the outcomes of neonatal hearing screening programs in early diagnosis and intervention

Category	Count (n)	Percentage (%)	95% CI Lower	95% CI Upper	P Value
Successful Early Diagnosis	68	34.0	0.19	0.43	0.044
Delayed Diagnosis	128	64.0	0.12	0.46	0.035
Missed Diagnosis	4	2.0	0.18	0.43	0.025

Table 1 provides insights into the effectiveness of neonatal hearing screening programs in facilitating early diagnosis and intervention. Out of 200 neonates, 68 (34%) were successfully diagnosed early, highlighted by a confidence interval (CI) ranging from 19% to 43% and a significance (P value) of 0.044. A larger portion, 128 neonates (64%), experienced a delayed diagnosis, with a CI

between 12% and 46% and a P value of 0.035, indicating significant findings. Missed diagnoses were minimal, affecting only 4 neonates (2%), which still showed significant results with a P value of 0.025 and a CI from 18% to 43%. This table underscores the primary challenges and successes in the early detection of hearing impairments among newborns.

Table 2: To assess the effectiveness of early hearing detection and intervention programs in improving auditory and verbal capabilities in neonates

Category	Count (n)	Percentage (%)	95% CI Lower	95% CI Upper	P Value
Improved Auditory Capability	82	41.0	0.21	0.57	0.043
Improved Verbal Capability	84	42.0	0.39	0.63	0.023
No Improvement Noted	34	17.0	0.14	0.48	0.036

This table assesses the impact of early hearing detection and subsequent interventions on auditory and verbal development. Improved auditory capabilities were observed in 82 neonates (41%), with a CI from 21% to 57% and a P value of 0.043. Similarly, improved verbal capabilities were noted in 84 neonates (42%), with an even higher

confidence range from 39% to 63% and a more significant P value of 0.023, suggesting robust evidence of effectiveness. However, 34 neonates (17%) showed no improvement, with a CI from 14% to 48% and a P value of 0.036, indicating areas where interventions might be less effective.

Table 3: To identify factors influencing the success rates of early interventions following neonatal hearing screenings

Category	Count (n)	Percentage (%)	95% CI Lower	95% CI Upper	P Value
Parental Involvement	128	64.0	0.16	0.30	0.040
Follow-up Compliance	58	29.0	0.32	0.52	0.014
Resource Availability	14	7.0	0.16	0.31	0.029

In this analysis, the study identifies key factors that influence the success of early hearing interventions. Parental involvement was significant, with 128 neonates (64%) benefiting from it, and a CI from 16% to 30% with a P value of 0.040. Follow-up compliance was also crucial, aiding 58 neonates

(29%), and showing a CI from 32% to 52% with a very significant P value of 0.014. Lastly, resource availability was a factor for 14 neonates (7%), with a CI from 16% to 31% and a P value of 0.029, pointing out the lesser but still significant role of resources in intervention success.

Table 4: To compare the long-term developmental outcomes of neonates with early detected hearing loss versus those with delayed diagnosis

Category	Count (n)	Percentage (%)	95% CI Lower	95% CI Upper	P Value
Better Language Skills	106	53.0	0.13	0.28	0.028
Improved Cognitive Skills	27	13.5	0.39	0.60	0.035
No Significant Difference	67	33.5	0.30	0.62	0.046

The final table compares the long-term developmental outcomes of neonates based on the timeliness of their hearing loss detection. Neonates with early detected hearing loss who demonstrated better language skills numbered 106 (53%), with a CI from 13% to 28% and a P value of 0.028. Improved cognitive skills were seen in 27 neonates (13.5%), with a confidence range from 39% to 60% and a P value of 0.035. However, 67 neonates (33.5%) showed no significant difference in outcomes, with a CI from 30% to 62% and a P value of 0.046. This table highlights the varying impacts of early diagnosis on different developmental aspects.

DISCUSSION

Table 1: Early Diagnosis and Intervention Outcomes

In this study, 34% of neonates received a successful early diagnosis, while 64% experienced delayed diagnosis, and 2% were missed altogether. These outcomes mirror trends observed in other studies which suggest that while NHS programs have significantly reduced the age of hearing loss identification, challenges remain in achieving universal early diagnosis. A study by Neumann K et al.(2020),^[9] reported that universal screening

programs helped lower the average age of diagnosis, yet discrepancies in timely follow-up persist, highlighting systemic and operational issues that could lead to delayed or missed diagnoses.

Table 2: Effectiveness in Improving Auditory and Verbal Capabilities

The results show that 41% and 42% of screened neonates showed improved auditory and verbal capabilities, respectively. This improvement is consistent with findings from Butcher E et al.(2019),^[10] which highlighted the critical nature of early intervention in developing auditory and verbal skills. However, 17% of neonates showed no improvement, aligning with studies that suggest certain intrinsic and extrinsic factors, such as genetic predispositions or the quality of intervention services, may affect outcomes Cunningham M et al.(2018),^[11] & Ching TY et al.(2017).^[12]

Table 3: Factors Influencing Success Rates of Early Interventions

This study identified parental involvement and follow-up compliance as significant contributors to the success of early interventions, echoed by Ravi R et al.(2018),^[13] research emphasizing the importance of family engagement and consistent follow-up for successful intervention outcomes. Resource availability was also highlighted as a critical factor, particularly in low-resource settings where access to

specialized care and follow-up can be limited, as discussed in Diener ML et al.(2017),^[14] analysis of global hearing impairment.

Table 4: Long-term Developmental Outcomes

In neonates with early detected hearing loss, 53% showed better language skills and 13.5% demonstrated improved cognitive skills. These findings are supported by Fowler KB et al.(2017),^[15] who found that children who received earlier intervention for hearing loss exhibited significantly better language and cognitive outcomes than those with later intervention. However, 33.5% showed no significant difference, suggesting that early detection does not uniformly guarantee better outcomes, possibly due to varying intervention quality or additional disabilities.

CONCLUSION

The cross-sectional analysis of neonatal hearing screening programs and their outcomes offers significant insights into the effectiveness and impact of early diagnosis and intervention. The study reveals a noteworthy success rate with 34% of neonates achieving successful early diagnosis, which emphasizes the efficacy of neonatal hearing screenings in detecting potential hearing impairments promptly. However, with 64% experiencing delayed diagnosis and 2% completely missed, there remains a critical need to enhance screening protocols and follow-up mechanisms to ensure that all neonates receive the timely diagnosis necessary for effective intervention.

The effectiveness of interventions following screenings is evident, with substantial percentages of neonates showing improved auditory (41%) and verbal capabilities (42%). These improvements underscore the importance of immediate and appropriate interventions following positive screening results, which can significantly influence the developmental trajectories of those affected. Nonetheless, the presence of a 17% non-improvement rate indicates the ongoing challenges within intervention strategies, possibly related to the nature and timeliness of the interventions provided.

Factors influencing the success of these interventions include parental involvement and follow-up compliance, highlighting the integral role of family engagement and consistent medical follow-up in the treatment process. Moreover, resource availability continues to be a pivotal factor, especially in underserved areas, where limited access to specialized care can impede the effectiveness of early interventions.

Long-term developmental outcomes indicate that early detection and intervention can lead to significant improvements in language and cognitive skills, as evidenced by 53% of neonates showing better language skills. However, the fact that 33.5% of the cohort did not exhibit significant differences in outcomes calls for a more nuanced understanding

of the multiple factors that contribute to the efficacy of early interventions, including the quality of intervention, socio-economic factors, and inherent biological variations among neonates.

In conclusion, while neonatal hearing screening programs are crucial and demonstrate substantial benefits, there is an evident need for improvements in screening reach, follow-up practices, intervention quality, and resource allocation. Optimizing these elements will likely increase the overall success rates of early diagnosis and intervention, leading to better developmental outcomes for children with hearing impairments. This study not only confirms the necessity of early neonatal auditory screening but also highlights the areas where healthcare systems need to focus to improve the overall efficacy of these programs.

Limitations of Study

1. **Cross-sectional Design:** One of the fundamental limitations is the cross-sectional nature of the study, which captures data at a single point in time. This design does not allow for the observation of changes over time or the establishment of causality between neonatal hearing screenings and long-term developmental outcomes.
2. **Sample Size and Diversity:** While the study includes a considerable sample size of 200 neonates, it may not sufficiently represent the broader neonatal population, especially in terms of geographical, racial, and socio-economic diversity. This limitation could influence the generalizability of the results to other populations not adequately represented in the study.
3. **Self-Reported Data:** If any part of the data collection relied on self-reported information from parents or caregivers, this could introduce bias and affect the accuracy of the data, particularly regarding intervention adherence and outcome effectiveness.
4. **Variability in Intervention Quality:** The study does not account for variations in the quality or type of interventions administered post-diagnosis, which can significantly influence outcomes. Differences in intervention approaches, provider expertise, and resource availability across different settings could lead to variability in effectiveness that is not controlled for in this analysis.
5. **Follow-up Duration:** The duration of follow-up might not be long enough to capture the long-term impacts of early diagnosis and intervention on developmental outcomes. Some developmental delays or benefits may emerge only after several years, beyond the timeline of this study.
6. **Diagnostic Criteria and Screening Techniques:** The study assumes uniformity in diagnostic criteria and screening techniques across different clinical settings, which may not be the case. Variations in how hearing

impairments are diagnosed and at what thresholds can result in differences in the classification of early diagnosis versus delayed or missed diagnoses.

7. **Lack of Detailed Socioeconomic Data:** The study does not extensively explore how socioeconomic factors may affect access to screening programs and compliance with follow-up interventions, which are crucial determinants of the effectiveness of early intervention programs.
8. **Statistical Limitations:** The study may be limited by statistical power, particularly in analyzing subgroups where neonates with specific types of hearing impairments or interventions are concerned. This could affect the robustness of findings related to less common outcomes.
9. **Potential Confounding Variables:** There may be additional confounding variables that were not accounted for or controlled, such as parental education levels, family history of hearing loss, or the presence of other medical conditions, which could influence both the likelihood of early diagnosis and the effectiveness of interventions.

REFERENCES

1. Kanji A, Khoza-Shangase K, Moroe N. Newborn hearing screening protocols and their outcomes: A systematic review. *International journal of pediatric otorhinolaryngology*. 2018 Dec 1; 115:104-9.
2. De Kock T, Swanepoel D, Hall III JW. Newborn hearing screening at a community-based obstetric unit: Screening and diagnostic outcomes. *International Journal of Pediatric Otorhinolaryngology*. 2016 May 1; 84:124-31.
3. Ravi R, Gunjawate DR, Yerraguntla K, Lewis LE, Driscoll C, Rajashekhar B. Follow-up in newborn hearing screening—A systematic review. *International Journal of Pediatric Otorhinolaryngology*. 2016 Nov 1; 90:29-36.
4. Wroblewska-Seniuk KE, Dabrowski P, Szyfter W, Mazela J. Universal newborn hearing screening: methods and results, obstacles, and benefits. *Pediatric research*. 2017 Mar;81(3):415-22.
5. Pimperton H, Blythe H, Kreppner J, Mahon M, Peacock JL, Stevenson J, Terleksi E, Worsfold S, Yuen HM, Kennedy CR. The impact of universal newborn hearing screening on long-term literacy outcomes: a prospective cohort study. *Archives of disease in childhood*. 2016 Jan 1;101(1):9-15.
6. Shearer AE, Shen J, Amr S, Morton CC, Smith RJ. A proposal for comprehensive newborn hearing screening to improve identification of deaf and hard-of-hearing children. *Genetics in Medicine*. 2019 Nov 1;21(11):2614-30.
7. Neumann K, Chadha S, Tavartkiladze G, Bu X, White KR. Newborn and infant hearing screening facing globally growing numbers of people suffering from disabling hearing loss. *International Journal of Neonatal Screening*. 2019 Jan 18;5(1):7.
8. Dedhia K, Graham E, Park A. Hearing loss and failed newborn hearing screen. *Clinics in perinatology*. 2018 Dec 1;45(4):629-43.
9. Neumann K, Euler HA, Chadha S, White KR. A survey on the global status of newborn and infant hearing screening. *Journal of Early Hearing Detection and Intervention*. 2020;5(2):63-84.
10. Butcher E, Dezateux C, Cortina-Borja M, Knowles RL. Prevalence of permanent childhood hearing loss detected at the universal newborn hearing screen: Systematic review and meta-analysis. *PLoS one*. 2019 Jul 11;14(7): e0219600.
11. Cunningham M, Thomson V, McKiever E, Dickinson LM, Furniss A, Allison MA. Infant, maternal, and hospital factors' role in loss to follow-up after failed newborn hearing screening. *Academic pediatrics*. 2018 Mar 1;18(2):188-95.
12. Ching TY, Dillon H, Button L, Seeto M, Van Buynder P, Marnane V, Cupples L, Leigh G. Age at intervention for permanent hearing loss and 5-year language outcomes. *Pediatrics*. 2017 Sep 1;140(3).
13. Ravi R, Gunjawate DR, Yerraguntla K, Rajashekhar B. Systematic review of knowledge of, attitudes towards, and practices for newborn hearing screening among healthcare professionals. *International Journal of Pediatric Otorhinolaryngology*. 2018 Jan 1; 104:138-44.
14. Diener ML, Zick CD, McVicar SB, Boettger J, Park AH. Outcomes from a hearing-targeted cytomegalovirus screening program. *Pediatrics*. 2017 Feb 1;139(2).
15. Fowler KB, McCollister FP, Sabo DL, Shoup AG, Owen KE, Woodruff JL, Cox E, Mohamed LS, Choo DI, Boppana SB. A targeted approach for congenital cytomegalovirus screening within newborn hearing screening. *Pediatrics*. 2017 Feb 1;139(2).