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Challenges and Strategies of Newborn Hearing Screening Programs Worldwide: A Scoping Review

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Abstract

Background: Newborn hearing screening (NHS) programs are essential public health initiatives aimed at early detection of neonatal deafness, thereby reducing long-term developmental delays. However, resource limitations, including insufficient infrastructure, workforce shortages, and financial constraints, significantly hinder program effectiveness. This scoping review investigates the key challenges and strategies implemented across various global newborn hearing screening programs.

Methods: A systematic scoping review approach was employed, following established field review methodologies. Studies were retrieved from PubMed/Medline, Cochrane Library, Embase, INAHTA, Google Scholar, and regional academic databases using targeted search strategies tailored to each platform's protocol. Articles published between 2000/01/01 and 2024/01/30 were selected. Eligibility criteria and selection processes were defined to ensure comprehensiveness and study quality. Data extraction was conducted via a structured Excel 2013 form, systematically compiling general and specific study details.

Results: Improving newborn hearing screening programs requires strategic collaboration between decision-makers, healthcare providers, and researchers. Effective planning demands: Expert-driven policy frameworks incorporating scientific recommendations; optimal resource allocation through pilot assessments and real-world evaluations; and strengthened monitoring mechanisms, ensuring high program efficiency.

Conclusion: Addressing structural and operational challenges through strategic policy frameworks and resource optimization can substantially enhance newborn hearing screening programs. Scalable interventions—such as expanded telehealth solutions, AI-driven diagnostics, and universal screening implementation—have the potential to increase early detection rates and improve healthcare outcomes for infants with hearing impairments and their families.

Keywords: Newborn Screening, Hearing, Challenges, Strategies, Early Detection

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Introduction

Hearing impairment is a complex condition with diverse environmental and genetic origins (1). Each year, approximately 126,000–500,000 babies are born with significant hearing loss, and about 90% of them live in developing countries. This figure can vary from 500,000–2,000,000 when the estimated total population of children (less than 5 years old) in the year 2001 of 548,031,000 is considered (2).

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↑What is "already known" in this topic:
Hearing impairment is a complex condition with diverse environmental and genetic origins. Each year, approximately 126,000–500,000 babies are born with significant hearing loss, and about 90% of them live in developing countries. Hearing loss is considered significant if it is of such a degree that it would interfere with normal speech and language development. Children born with hearing impairments require specialized interventions to prevent further deterioration and optimize developmental outcomes.

→What this article adds:
This scoping review investigates the key challenges and strategies implemented across various global newborn hearing screening programs.

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Hearing loss is considered significant if it is of such a degree that it would interfere with normal speech and language development. Moderate bilateral permanent hearing loss (>40 dB) in early childhood can impede speech, language, and cognitive development (3, 4). It also has adverse effects on social, emotional, and academic development, with a high cost to society (5). Even children with mild or unilateral permanent hearing loss may experience difficulties with speech, language, educational, and psycho-social development (6, 7).

Children born with hearing impairments require specialized interventions to prevent further deterioration and optimize developmental outcomes (8). As one of the most prevalent sensory-neural disorders, hearing loss stems largely from auditory dysfunction (9) and is linked to an increased risk of psychological challenges and behavioral difficulties, primarily due to communication barriers and social isolation. Despite advancements in medical and technological interventions, hearing loss remains a pervasive health concern, affecting 2 to 3 of every 1,000 live births (10). Additionally, families with deaf children experience significant disruptions in interpersonal relationships, often facing challenges in maintaining effective communication and healthy family dynamics (11). These difficulties extend into severe social and linguistic deficits, which are pivotal for childhood cognitive development and social integration (12). Hence, infants with permanent congenital and early-onset hearing loss (PCEHL) identified by 6 months of age and given appropriate and timely support are reported to achieve better language outcomes than those identified later than 6 months of age (13). In contrast, children detected late may never catch up with their normal-hearing peers in their academic, social, and emotional development, even with the best rehabilitation. Consequently, the detection of significant bilateral hearing loss in infants before 3 months of age, followed by appropriate intervention no later than 6 months of age, is now being considered an essential component of primary healthcare delivery.

Newborn hearing screening refers to early auditory assessments conducted shortly after birth, aimed at distinguishing infants with potential hearing impairments from those with normal auditory function. When screening detects suspected cases, confirmatory diagnostic tests are required for accurate evaluation and intervention. These programs provide unparalleled benefits to infants and their families by reducing the burden of disability, preventing excessive healthcare costs, and contributing to national developmental goals through the preservation of societal cognitive potential (14).

The World Health Organization (WHO) has emphasized the urgent need for national strategic plans to tackle hearing loss and its growing global burden. WHO estimates indicate a steady rise in disabling hearing loss, increasing from 278 million affected individuals in 2005 to 360 million in 2013, and further reaching 466 million in 2018. Alarmingly, 34 million of these cases occur in children, with the majority residing in developing countries (15-17). These statistics highlight the critical need for scalable and sustainable intervention strategies.

Developing nations often lack comprehensive programs for hearing loss prevention, treatment, and rehabilitation, as well as specialized resources to support hearing-impaired individuals. Furthermore, insufficient training of healthcare personnel exacerbates these challenges. However, effective interventions—if cost-efficient and accessible—can be implemented by properly trained primary healthcare providers. When integrated into national health systems, these initiatives significantly mitigate the burden of ear diseases and hearing loss (18).

Evaluating health system performance plays a crucial role in ensuring compliance with evidence-based practices and identifying areas for strategic improvement (19). Comprehensive evaluation frameworks not only enable performance benchmarking across different time periods and healthcare systems but also facilitate the scaling of best practices (20).

In Iran, the national newborn hearing screening program serves as a fundamental component of child healthcare, aligning with global trends observed in industrialized and developing nations (21). Countries recognizing the substantial disease burden caused by pediatric auditory impairments have adopted integrated screening models, combining hearing assessments with metabolic disorder screenings to enhance infant health outcomes and reduce lifelong disability rates (22). These programs not only improve quality of life and decrease healthcare expenditures, but they also contribute to broader societal benefits, such as maintaining cognitive proficiency at the population level. Additionally, they offer valuable opportunities for conducting high-quality epidemiological and experimental research (23).

Despite its evident benefits, the successful implementation of newborn hearing screening programs relies on several critical factors, including strong leadership, stable health system governance, sufficient financial resources, advanced healthcare infrastructure, skilled human resources, and effective coordination among stakeholders. Resistance to policy reform, logistical constraints, and systemic healthcare barriers may obstruct efforts to expand and enhance screening initiatives (24). Given the existing challenges and resource limitations at national and international levels, large-scale early diagnostic programs through newborn hearing screening are imperative to effectively reduce the prevalence and impact of childhood hearing impairments. This scoping review investigates the key challenges and strategies implemented across various global newborn hearing screening programs.

Methods

To conduct this research, a scoping review methodology was employed, focusing on original peer-reviewed articles and gray literature sources. Gray literature included dissertations, review articles, conference summaries, and institutional reports. Unlike systematic reviews, scoping reviews do not evaluate study quality, as their primary goal is to explore key themes and gaps within a research domain. By addressing "what" and "why" questions, scoping reviews enable rapid evidence synthesis, accommodating broader inclusion criteria and reviewing a larger volume of articles within a shorter timeframe (25). As a result, scoping reviews often serve as foundational precursors to systematic

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reviews.

This study aimed to examine the experiences of various countries regarding newborn hearing screening programs, following these systematic steps:

1. Establishing Inclusion and Exclusion Criteria

Inclusion criteria

- Articles discussing challenges or solutions related to newborn hearing screening programs.
- Articles published in English.
- Articles published between 2000 (1 January) and 2024 (30 January).

Exclusion criteria

- Articles focusing on non-infant populations.

2. Initial Search and Keyword Identification

An initial exploratory search was conducted to identify relevant review articles and key terms. MeSH-derived keywords utilized in the search included: "Infant", "Hearing", "Screening", "Challenges", "Strategies".

3. Developing and Executing Search Strategies

Search strategies were tailored to individual databases to ensure comprehensive coverage. Literature searches were conducted across:

Major international databases: PubMed/Medline Cochrane Library Embase INAHTA

Search engines: Google Scholar Google

Iranian databases for regional studies: Academic Jihad (SID) MagIran IranMedex IranDoc.

To optimize the search process, ProQuest and Medline search strategies were employed, ensuring alignment with the research question and structured review components. Additionally, Google Scholar reference lists were screened for relevant secondary studies, supplementing the primary database searches.

4. Screening Process

Three authors independently screened articles, resolving disagreements through discussion and consensus. If disputes persisted, two additional authors were involved for final arbitration. Screening was conducted in two phases:

Stage 1: Title and abstract screening, based on inclusion/exclusion criteria.

Stage 2: Full-text review of selected articles.

Study Selection Summary:

- Initial database search identified 6081 studies.
- Eighty-three duplicate studies were removed, leaving 5998 articles.
- 5867 studies were excluded after title and abstract screening.
- 131 articles underwent full-text review.
- Final inclusion: 27 studies, incorporated into the scoping review (Figure 1).

5. Data Extraction Process

A structured data extraction form was developed in Excel 2013, ensuring standardized collection of study details:

Extracted information: The extracted information included study title, year of publication, journal name, country, first author, study population, sample size, research purpose, and study type. All ethical considerations were strictly observed, ensuring adherence to scientific integrity protocols, mitigation of research bias, and prevention of scientific plagiarism.

Results

This study aimed to identify the challenges and strategies associated with newborn hearing screening programs across various countries. A total of 27 studies were selected from Australia, Spain, Oman, Denmark, Brazil, Iran, India, Pakistan, and other nations (Table 1). The results were systematically categorized into two primary themes: challenges and strategies.

The newborn hearing screening program plays a critical role in early identification of hearing loss, enabling timely medical interventions that enhance developmental outcomes. However, various systemic barriers hinder the ef-

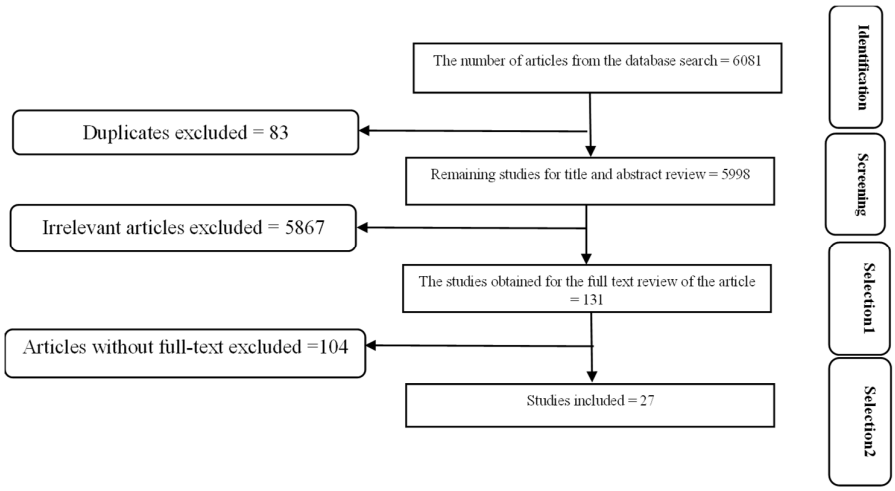


Figure 1. Study selection process

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Table 1. Studies of the Newborn Hearing Screening Program

Study	Author	Country	Result	Ref
Feasibility of Establishing a Neonatal Hearing Screening Program and Measuring Hearing Loss Among Neonates in Dakahlia Governorate	El-Ella et al (2023)	Egypt	The incidence of hearing impairment was 4 per 1000 newborns screened.	(26)
In Pursuit of Successful Hearing Screening: An Exploration of Factors Associated with Follow-Up Return Rate in a Risk-Based Newborn Hearing Screening Programme	Kanji et al (2018)	South Africa	Results indicated a significant, but weak association between the hospital and whether or not infants returned for the repeat screening. The mean maternal age of mothers who returned with their newborns for diagnostic assessment was significantly higher than that of those who did not return.	(9)
Loss to Follow-up After Newborn Hearing Screening and Its Related Factors	Ghavami et al (2022)	Iran	Among the mothers' personal causes of loss to follow-up, the feeling of no need to follow up with 36.7% and fear of COVID-19 with 26.7% were the most common causes	(10)
Challenges of Universal Newborn Hearing Screening in a Developing Country-a Double-Edged Sword	Jacob et al (2022)	India	The occurrence of hearing loss in this study population was 1.3 per 1000. Risk factors were noted in 38.9% of this subgroup with occurrence of hearing loss in ''at risk'' group being 3.32 per 1000.	(11)
Referral rate and false-positive rates in a hearing screening program among high-risk newborns	Thangavelu et al (2022)	Germany	Our study showed that the higher the birthweight or gestational age of the newborn, the lower the odds of the hearing screening results being false-positive, and the higher the chronological age of the infant at the time of screening, the higher the odds of the results being false-positive.	(12)
Comparison of newborn hearing screening results between well babies and neonates admitted to the neonatal intensive care unit for more than 5 days: Analysis based on the national database in Korea for 9 years	Chang et al (2020)	Korea	The prevalence of hearing loss in infants who were hospitalized in NICU for more than 5 days was about seven times higher than that in healthy newborns. However, different referral rates were noted depending on both institutions and the screening methods	(15)
Evaluation of newborn hearing screening program in Jordan	Obeidat et al (2024)	Jordan	The current status of the NHS program in Jordan is promising. The program has achieved most benchmarks recommended by the Joint Committee on Infant Hearing (JCIH), demonstrating encouraging outcomes.	(16)
Neonatal Auditory Screening is a Necessity in The Neonatal Intensive Care Unit: Single Center Study	ElGindy et al (2022)	Egypt		(17)
Neonatal hearing screening programme and challenges faced by the developing country: A tertiary care hospital experience	Pyarali et al (2023)	Pakistan	The current study was planned to screen neonates to diagnose any hearing impairment as part of a programme launched at health facility in Pakistan.	(18)
Neonatal hearing screening: Challenges of COVID-19 pandemic	Rockwell et al (2023)	USA	One of the 15 newborns (2.3% of total) had a pending maternal COVID-19 test result at discharge, and this patient was also lost to follow-up.	(19)
SWOT analysis of Russian universal newborn hearing screening program	Kreisman et al (2024)	Russian	The developed strategies can increase timely audiological service to hearing impaired children and their families and to plan the necessary resources in the face of modern challenges.	(20)

fectiveness and accessibility of screening programs globally.

Challenges in Newborn Hearing Screening

The key challenges affecting screening programs are summarized in Table 2, with the most significant barriers outlined below:

1. Poor Follow-Up Rates

Follow-up after newborn hearing screening (NHS) exhibits notable weaknesses, as evidenced by multiple studies.

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Table 1. Studies of the Newborn Hearing Screening Program

Study	Author	Country	Result	Ref
Neonatal hearing screening programs: quality indicators and access to health services	Dutra et al (2022)	Brazil	hearing screening was not universal. Access to the Hearing Health Care Network presents high evasion and interventions were offered to children with hearing loss.	(21)
Newborn hearing screening in Eastern Saudi Arabia: A tertiary hospital experience.	Sulaiman et al (2024)	Saudi Arabia	Emphasizing the importance of the screening program is crucial to raising awareness and improving the accuracy of prevalence rates	(22)
Neonatal hearing rescreening in a second level hospital: Problems and solutions	Gómez-Delgado et al (2023)	Spain	This is particularly serious in outpatient children with impaired screening. Referral to out-of-town centers leads to unacceptable follow-up loss. Legislative support for all these rescreening issues is necessary.	(27)
The cost-effectiveness of newborn hearing screening program: New approach of Iran Ministry of Health and Medical Education in 2022	Moradi-Joo et al (2024)	Iran	In this study, we evaluated the cost-effectiveness of the NHS program for detecting hearing impairment in over a million births in Iran.	(28)
Performance and characteristics of the Newborn Hearing Screening Programme in England: The first seven years	Wood et al (2015)	England	The age of identification and management is well within the first six months of life, although there remains scope for further improvement with respect to timely entry into follow up.	(29)
A universal newborn hearing screening program in Taiwan	Lin et al (2002)	Taiwan	The existence of many successful screening programs worldwide and the availability of fast, objective, reliable and inexpensive hearing screening procedures means that universal newborn hearing screening is becoming the standard of care.	(30)
Status of newborn hearing screening program in India	Kumar et al (2011)	India	While keeping in mind the incidence of hearing impairment in the neonatal population of India, the results of this survey warrant the need for an urgent implementation of universal neonatal hearing screening in all the health care facilities in the country, at large.	(31)
Main outcomes of a newborn hearing screening program in Belgium over six years	Vos et al (2011)	Belgium	The motivation and commitment of the professionals have to be supported in a variety of ways to improve outcome measures and thus, the quality of the program.	(32)
The universal newborn hearing screening in Brazil: From identification to intervention	Bevilacqua et al (2011)	Brazil	in a country such as Brazil, which presents large socioeconomic differences, the same type of analyses should be performed in several regions, so as to take into account specific aspects, to implement the newborn hearing screening along with the Public System.	(33)
Newborn hearing screening program in China: a narrative review of the issues in screening and management	Wen et al (2023)	China	A hearing screening and intervention system across the whole life course should be developed	(34)
The Milan Project: A newborn hearing screening programme	PASTORINO et al (2005)	Italy	Further improvement is obtained if the TEOAE measurements are repeated in cases of referral scoring before discharge.	(35)

Contributing factors include:

- Sociodemographic barriers, such as low birth weight, racial minority status, rural residence, lack of insurance, low maternal education, young maternal age, unmarried maternal status, and maternal smoking (8).
- Residential mobility and maternal age as additional risk factors for lost follow-up cases (9).
- High follow-up loss rates (up to 20%), with many infants missing their second screening appointments (10).
- Challenges in Universal Neonatal Hearing Screening (UNHS) programs, where only one-third of newborns undergo initial screenings (11).

Addressing these follow-up challenges is essential to ensure timely intervention and improve healthcare equity.

2. Inadequate Infrastructure and Referral Systems

The absence of robust screening infrastructure and inefficient referral pathways severely hinders program effectiveness.

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Table 2. Challenges and Strategies of the Newborn Hearing Screening Program

Categories	Challenges	Strategies
COVID-19 Impact	- Missed initial hearing tests due to pandemic protocols. - Maternal COVID-19 status affected follow-up compliance.	- Adjusting screening policies during public health crises. - Implementing alternative follow-up methods, such as telehealth consultations.
Follow-Up and Referral Issues	- High variability in referral and follow-up rates. - Sociodemographic factors affecting follow-up (rural residence, low maternal education). - High loss-to-follow-up rates after initial screening.	- Developing centralized referral tracking systems. - Training audiologists and community workers for follow-up coordination. - Implementing the "1-3-6 model" (screening by 1 month, diagnosis by 3 months, intervention by 6 months).
Resource Constraints	- Insufficient audiologists and screening equipment. - Lack of training facilities for medical staff. - Low availability of screening programs in developing countries.	- Establishing hospital partnerships for resource sharing. - Developing specialized training programs for pediatric audiologists. - Promoting universal newborn hearing screening in all hospitals.
Structural and Systemic Issues	- Poor communication infrastructure and reporting inefficiencies. - Delays in rescreening and diagnosis due to poor coordination. - Limited awareness and insufficient research investment.	- Implementing digital reporting systems for transparency. - Expanding community-based screening through immunization clinics. - Conducting public awareness campaigns and boosting research funding.

• Second-level hospitals often experience rescreening delays, leading to missed follow-ups for referred infants (11).

• Prematurity, low birth weight, and screening timing increase false-positive rates, further complicating timely diagnosis (27).

• Referral process inconsistencies highlight the need for accessible follow-up locations, specialized audiologist involvement, and program integration (12).

Strengthening referral coordination and optimizing screening site accessibility are crucial for reducing delays in diagnosis.

3. Limited Resources

Resource constraints—including insufficient screening equipment and limited audiologist availability—pose significant barriers.

• A cohort study revealed disparities in referral rates based on screening methods and institutional capacities, emphasizing the need for targeted resource allocation (14).

• Expanding specialist capacity, optimizing resource distribution, and prioritizing training initiatives are essential to fortify newborn hearing screening programs.

Discussion

This study was conducted to investigate the challenges and solutions of the newborn hearing screening program. The results highlighted three major challenges: lack of follow-up and referral systems, insufficient infrastructure, and resource constraints. These challenges significantly impact the effectiveness and sustainability of newborn hearing screening programs worldwide.

These challenges significantly impact program effectiveness and sustainability, particularly in low-resource settings. Addressing these barriers requires multifaceted interventions tailored to policy frameworks, healthcare systems, and available resources.

Follow-Up and Referral Challenges

The findings indicate that timely follow-up and structured referral processes are critical for early diagnosis and intervention in infants with hearing loss (24)(27). However, high loss-to-follow-up rates and delays in screening completion reduce the overall efficacy of screening programs (27).

Recommended interventions

• Regional tracking centers with standardized quality control systems (12).

• Mandatory participation of maternity facilities and systematic performance reporting to enhance follow-up rates (12).

• Legal and organizational support to strengthen staffing, improve workflow efficiency, and enhance hospital-based time management.

• Digital health tools, such as automated notifications and telehealth services, to enhance patient follow-up, particularly in rural regions.

Referral Systems and Infrastructure

An effective referral system depends on robust infrastructure; however, many screening programs struggle due to limited access, logistical delays, and technological gaps (12). Several studies have highlighted key risk factors—including growth failure, low birth weight, and pregnancy complications—that must be incorporated into screening protocols for greater accuracy (17, 18).

Key considerations

• Community-based screenings during routine immunization visits to enhance access.

• Advanced audiological techniques, such as automated auditory brainstem response (aABR), enhance diagnostic precision (20).

• Policy-driven strategies, including SWOT-based implementation models, to leverage strengths while addressing systemic weaknesses (20).

COVID-19 disruptions exacerbated referral challenges

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by limiting maternal access to screening facilities, leading to delayed diagnoses (19). Policy adjustments ensuring screening continuity during public health crises remain crucial for program sustainability.

Resource Limitations

Staffing shortages, financial constraints, and limited medical equipment pose significant barriers to program efficiency (20, 36). Secondary hospitals, in particular, experience delays in rescreening, leading to gaps in early identification (20, 36). Financial limitations further hinder the procurement of essential screening tools, particularly in low- and middle-income countries.

Recommended solutions

- Legislative backing and policy-driven funding increases for neonatal hearing programs.
- Collaborations between hospitals, universities, and NGOs to optimize resource allocation.
- Decentralized training centers to enhance pediatric audiology expertise.
- Integration of AI-based technologies for screening optimization and real-time diagnostics.

Strengthening Newborn Hearing Screening Programs

A comprehensive approach is required to improve program outcomes, integrating modern screening technologies, policy interventions, and resource allocation strategies.

Recommendations for program improvement

- SWOT-based implementation models to balance strengths with resource limitations (20).
- Pilot studies and structured needs assessments to prioritize resources effectively (14).
- Adoption of universal newborn hearing screening (UNHS) as per WHO recommendations, ensuring high coverage and robust quality assurance frameworks (36).
- Standardized regional tracking centers, with mandatory reporting from maternity hospitals, to enhance program oversight (23).

Limitations

This study encountered several limitations:

- Limited availability of managers and specialists due to their busy schedules, which affected data collection.
- Qualitative research constraints, given that interviews can be time-consuming.
- Newborns typically undergo only one hearing screening, whereas multiple follow-up sensitivity tests are often required for accurate diagnosis.
- Variability in healthcare systems across the studied countries contributes to heterogeneity in findings.

Integrating AI-driven health technologies could overcome workflow inefficiencies and standardize screening protocols, ensuring consistency across diverse health systems.

Conclusion

Improving newborn hearing screening programs requires strategic collaboration between decision-makers, healthcare providers, and researchers. Effective planning demands: ✅ Expert-driven policy frameworks incorporating scientific recommendations. ✅ Optimal resource allocation through pilot assessments and real-world evaluations. ✅ Strengthened monitoring mechanisms, ensuring high program efficiency.

By addressing challenges and enhancing implementation strategies, screening programs can increase early detection rates and improve long-term developmental outcomes for affected children and their families.

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Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

EM: Study design, data collection, writing the proposal; SN, MD, MB: Assistance in the preparation of the manuscript; HG: Data collection; HH, SM: Data analysis, manuscript preparation, supervision. All authors have read and approved the final draft of the manuscript.

Ethical Considerations

This research was approved by the Ethics Committee of the Ministry of Health of Iran with the number IR.ABADANUMS.REC.1401.091. All protocols in this study were conducted in accordance with the ethical guidelines of the Declaration of Helsinki.

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Data availability

The datasets generated and the code used for the analysis are available from the corresponding author upon reasonable request.

AI Use Statement

N/A.

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