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# Evaluating the Impact of Newborn Hearing Screening Programs and the Global Variability in Access

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## Abstract

Extensive research demonstrates that newborn hearing screening (NHS) can substantially lessen the developmental and functional consequences of permanent childhood hearing loss (PCHL), provided it is carried out within systems designed to reach virtually all infants at birth—commonly referred to as Universal Newborn Hearing Screening (UNHS). In two separate resolutions, the World Health Organization (WHO) has urged countries to establish such nationwide screening frameworks and to generate reliable, large-scale monitoring data. To understand how these recommendations are being implemented globally, we distributed a survey to professionals involved or likely to be involved in newborn and infant hearing screening (NIHS) across 196 countries and territories (all subsequently referred to as countries). We received responses from 158 of them. The collected data revealed that 38% of infants worldwide are born in countries where hearing screening is absent or only minimally available, while 33% are born in settings where at least 85% of newborns are screened—which aligns with the operational definition of UNHS. Marked differences were observed across countries with respect to program quality, data infrastructure, and the availability of diagnostic and intervention services for children identified with PCHL.

This article presents a synthesis of the survey results and situates them within the context of recent WHO publications, including the World Report on Hearing, which highlights the scale-up of NHS systems in Member States as one of three core indicators of global advancement in ear and hearing care (EHC).

**Keywords:** Neonatal, Newborn, Screening, Hearing, Universal, Infant

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## Introduction

Permanent hearing loss that occurs at birth or early in childhood can profoundly affect developmental outcomes across multiple domains [1, 2]. Children with permanent childhood hearing loss (PCHL) often face challenges in language acquisition, cognitive growth, social development, academic performance, and later employment and income opportunities [2, 3]. Extensive research shows that newborn hearing screening (NHS) enables PCHL to be identified much sooner, and that infants detected through NHS who rapidly receive diagnostic confirmation and appropriate intervention—such as hearing aids [4], cochlear implantation [5], or participation in early intervention programs [6]—demonstrate stronger outcomes in language [7–9], vocabulary [10], overall development, and quality of life [11] than those who were not screened in infancy. When

intervention begins within the first months of life, children with PCHL can even follow age-appropriate language, social, and emotional developmental trajectories [2, 6, 9, 12–18]. These benefits depend heavily on effective post-screening tracking and follow-up systems [19].

Longitudinal research supports the lasting advantages of early identification. In the Australian LOCHI (Longitudinal Outcomes of Children with Hearing Impairment) study, children who received hearing technology as early as possible showed better language progression over time [7, 20]. Another investigation of a birth cohort of 157,000 children from southern England found that adolescents who had undergone universal newborn hearing screening (UNHS) achieved superior reading comprehension compared with peers from the same cohort who had not received NHS [21].

Although NHS may introduce some temporary difficulties—such as parental uncertainty about early test results and questions about next steps for diagnosis or treatment [22]—studies on parental perspectives consistently indicate that the advantages of early detection and early intervention outweigh these concerns [23–26].

Economic analyses also support NHS, showing that screening is cost-effective [2, 8, 27, 28]. In its 2016 report, the WHO estimated that more than 60% of global hearing loss could be prevented—up to 75% in middle- and lower-middle-income countries and 46% in high-income countries [3]. Prevention efforts and UNHS both reduce the burden of PCHL, with UNHS having particularly strong effects in high-income settings and preventive strategies offering proportionally greater gains in low-income regions [29].

The WHO first encouraged governments to develop national programs to prevent avoidable hearing loss and to promote early detection in infants and young children in a 1995 resolution [30]. However, by 2012 only 32 countries had reported implementing such strategies, and the WHO noted that epidemiological data and information about ear and hearing care (EHC) remained limited [31]. A second resolution issued in 2017 reiterated these priorities and again urged member states to collect robust, population-level data on hearing loss and ear diseases [32].

In line with these objectives, a global survey was recently conducted to assess national approaches to newborn and infant hearing screening (NIHS), examining coverage levels, program characteristics, outcomes, and links to national socioeconomic indicators [33]. Screening of infants up to one year old was included in the survey because some countries carry out screening later, such as during immunization visits, rather than strictly in the newborn period.

After the 2017 resolution, the WHO published the World Report on Hearing in 2021 [2], compiling global epidemiological and economic evidence and outlining strategies for achieving "integrated people-centered ear and hearing care" (IPC-EHC). The report highlighted NHS as an essential element of IPC-EHC and identified "effective coverage of newborn hearing screening services"—the proportion of infants with PCHL who receive intervention by six months of age—as one of three global tracer indicators for monitoring EHC progress [2]. It recommended that by 2030, countries increase effective NIHS coverage by 20%, with specific thresholds depending on their current level of coverage: nations with <50% should reach at least 50%; those with 50–80% should increase by 20%; those already above 80% should aim for universality; and countries with partially implemented screening should work toward ≥95% coverage [2].

The World Report on Hearing also projected strong economic returns: for every dollar invested, low- and middle-income countries would gain an estimated 1.67 international dollars, whereas high-income countries would gain 6.53. The lifetime value of disability-adjusted life years (DALYs) avoided was estimated at 21,266 international dollars per person in low- and middle-income settings, rising to 523,251 in high-income settings [2].

This article synthesizes the global status of newborn and infant hearing screening based on the recent survey [33] and reviews the role of NIHS in the early identification and management of PCHL in light of key WHO publications, including the World Report on Hearing [2] and the implementation guide Hearing Screening—Considerations for Implementation [1].

## Materials and Methods

The *World Report on Hearing* [2] cites the global survey on newborn and infant hearing screening (NIHS) [33], which relied on a 19-question instrument used to document NIHS conditions in 158 countries. The questionnaire, reproduced in the Supplementary Materials, gathered information for a selected reference year on multiple aspects of national screening activity:

(1) the percentage of infants, based on total live births, who underwent newborn or first-year hearing screening; (2) whether programs sought to screen all newborns at the national, regional, or facility level (universal screening) or only infants with identifiable risk factors for permanent childhood hearing loss (targeted screening); (3) the screening technologies applied—including otoacoustic emissions (OAE), automated auditory brainstem response (AABR), combined OAE-AABR two-stage protocols, questionnaire-based approaches, or other local procedures; (4) the share of all infants, and of those screened, who were referred for diagnostic audiology because hearing loss was suspected, as well as the proportion in whom hearing loss was confirmed; (5) the early PCHL prevalence per 1000 infants; (6) the

proportion of children with hearing impairment who were identified through screening; (7) the reported mean or median ages—as well as the range of ages—at diagnosis and at the start of intervention for both screened and unscreened infants with hearing loss; (8) the proportion of infants with hearing impairment who required and received prompt intervention, and the percentage—among all such infants and among those screened—who began treatment before six months of age; (9) whether hearing screening had been mandated by national authorities and, if so, when; (10) the type of screening (universal or targeted) required by mandate; (11) the setting in which screening was delivered and the professional qualifications of personnel involved; and (12) the percentage of birthing facilities in each country implementing NIHS activities.

For the purposes of the survey, PCHL was defined as a permanent hearing loss >20 dB HL in the better ear for bilateral cases or in the poorer ear for unilateral cases, calculated across 0.5, 1, 2, and 4 kHz. This definition aligns with the updated WHO classification for bilateral hearing loss and is even more sensitive than the threshold adopted for unilateral conditions in the *World Report on Hearing* [2].

Distribution of the questionnaire began via e-mail in 2014, and updated responses were accepted until 2019. Although the intended reference year was 2014, earlier data had to be used for many countries, resulting in a final dataset covering the years 2009–2019. The survey process began with efforts to identify knowledgeable individuals in as many countries as possible who were engaged in ear and hearing care and capable of reporting on their nation's NIHS status. In many regions—especially where audiology services were sparse—locating appropriate contacts required considerable time, occasionally spanning several years, particularly in parts of Africa, Latin America, and Asia.

Assistance in identifying respondents came from a number of professional and non-governmental organizations involved in ear and hearing care, including Hearing International, the International Society of Audiology (ISA), the Coalition for Global Hearing Health (CGHH), Hearing, the American Academy of Audiology (AAA), the International Association of Logopedics and Phoniatrics (IALP), the International Working Group on Childhood and NGOs such as Soundseekers and Christoffel Blindenmission (CBM). In francophone Africa, support was also provided by the Société Oto-rhino-laryngologie des pays francophones d'Afrique (SORLAF). These organizations contributed through formal endorsements, referrals, or by supplying data directly.

Additional individuals were identified through professional meetings, the authors' networks, the WHO's Programme for the Prevention of Deafness and Hearing Loss, national and state screening centers, ministries of health, regional WHO offices, and authors of pediatric audiology publications. Inquiries were made by e-mail, telephone, or in person by the first author. Respondents often forwarded questionnaires to other colleagues who were better placed to provide accurate information. Whenever feasible, submitted data were reviewed for consistency and validated by one or more independent contributors or by one of the supporting institutions.

## Results and Discussion

Responses were obtained from 158 countries. Analysis of the data revealed that fewer than one-third of the world's infants are born into regions or nations where universal NIHS—defined as screening of at least 85% of newborns—is in place, even though such programs are known to provide the best foundation for timely intervention for children who are deaf or hard of hearing. In contrast, approximately 38% of newborns enter life in countries where NIHS is either absent or reaches fewer than 1% of infants **(Figure 1)**. The countries contributing data to the survey collectively account for nearly 95% of the global population [33].

Across reporting countries, the prevalence of PCHL detected through NIHS varied widely, ranging from 0.3 to 15.0 per 1000 infants, with a median of 1.70. This median aligns closely with the WHO's estimate of roughly 2 cases per 1000 in the neonatal period [2].

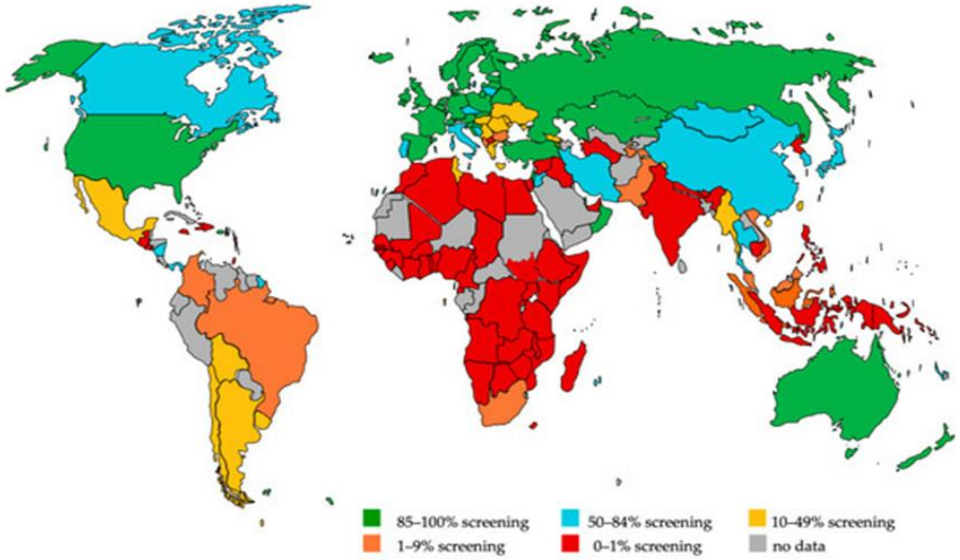


**Figure 1.** Distribution of infant hearing screening and newborn coverage by country (reproduced and adapted from [33] with permission).

Survey findings indicate that the majority of NIHS programs rely on objective, physiology-based screening techniques. These include otoacoustic emissions (OAE), which measure cochlear function; automated auditory brainstem response (AABR), which evaluates neural activity along the auditory pathway to the brainstem; and two-step OAE–AABR protocols in which infants who do not pass the OAE test proceed to AABR assessment. These approaches demonstrate strong test accuracy and outperform behavioral or questionnaire-based procedures [34].

Among infants screened with these standard physiological tools in the reference year, 66.5% received OAE alone, 14.3% underwent AABR alone, and 19.2% were assessed using a combined OAE–AABR sequence. Only six countries reported employing behavioral screening, and the use of caregiver questionnaires or tympanometry was uncommon. Overall, OAE was identified as the primary method in 57% of countries, with OAE–AABR used predominantly in 30%, and AABR alone in 11% [33].

**Figure 2** displays the dominant screening approach for each country. However, it is important to interpret this figure alongside **Figure 1**: in several countries, only limited or pilot hospital-based screening takes place. For these locations, the method labeled as "predominant" in **Figure 2** may give the misleading impression that it is nationally implemented. Countries such as Algeria—where screening has occurred only in research studies—are therefore marked as "no data available," as these studies do not reflect routine national practice. In addition, some countries show nearly equal use of the listed method and another technique, meaning the method highlighted in **Figure 2** may not be overwhelmingly dominant.

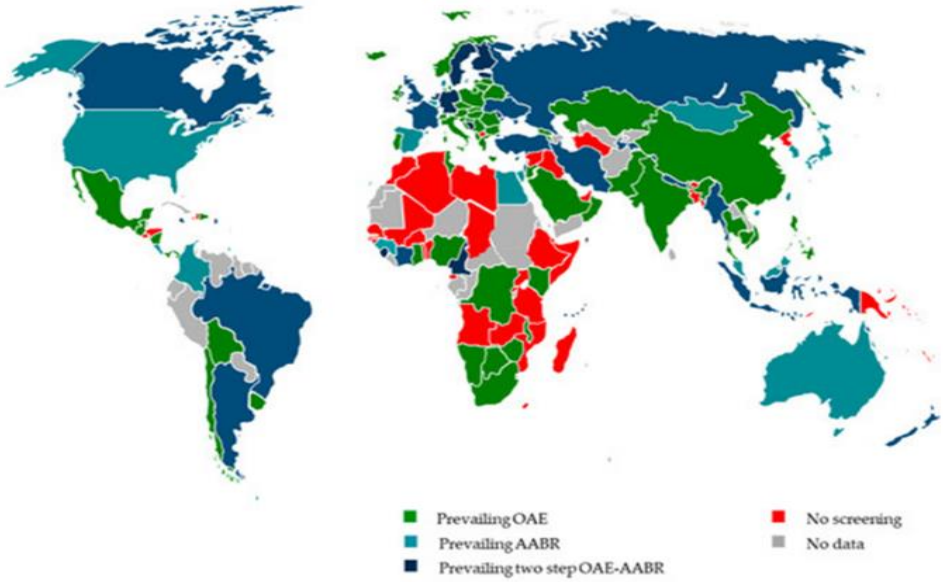


**Figure 2.** Prevailing screening method used for NHS by country.

Infants identified with PCHL through screening were typically diagnosed at about 4.6 months of age and began receiving intervention around 6.7 months. This finding is particularly encouraging, as it indicates that treatment generally starts during critical phases of auditory-system development—periods marked by rapid neural changes such as dendritic growth, synapse formation, stabilization of neural connections, and pruning—when the auditory pathway remains highly receptive to stimulation and therapeutic input [35, 36]. In contrast, children who were not screened were, on average, not diagnosed until 34.9 months of age and did not start intervention until approximately 36.7 months.

Across all countries, an average of 4.5% of newborns who underwent NIHS did not pass the initial screen. The proportion of infants who failed was notably lower and showed less variability (0.3–11.6) in nations where ≥85% coverage had been achieved, compared with countries where screening rates were lower. A major concern highlighted by the survey is that 17.2% of infants who did not pass the screening were lost to follow-up. This proportion was approximately seven percentage points lower in countries with high NIHS coverage [33].

A recurring challenge identified in many screening systems is the absence of robust data collection or centralized databases. Numerous programs reported insufficient mechanisms to track infants who either missed screening altogether or failed and required referral for diagnostic assessment and early intervention. Without systematic tracking, follow-up rates tend to be poor or impossible to determine, reflected in the wide and sometimes implausible reported range of lost-to-follow-up outcomes (0% to 98.2%) among infants who failed screening [33].

A striking pattern emerged linking NIHS performance with national economic indicators. Countries achieving ≥85% screening coverage had median nominal GDP per capita values roughly ten times higher than those with coverage below 10%. Nevertheless, substantial GDP variability existed even among high-coverage countries, several of which had GDP values under 10 (e.g., Belarus, China, Kazakhstan, the Marshall Islands, Micronesia, Russia). GDP was negatively correlated with screening-failure rates, PCHL prevalence, average age at diagnosis, and age at intervention onset. This disparity is especially concerning given that 80% of individuals with disabling hearing loss reside in low- and middle-income countries [37], where adverse birth conditions, limited vaccination programs, and insufficient access to hearing devices—all exacerbating risk for PCHL—are prevalent [38, 39].

A number of countries have successfully implemented NIHS programs with ≥85% coverage, including the United States, Uruguay, most European nations, Israel, Kazakhstan, Oman, Qatar, South Korea, the Seychelles, Australia, New Zealand, and several U.S.-affiliated Pacific Island nations. Others—such as Canada, Mongolia, Panama, and China—have established large-scale NIHS systems but have not yet achieved full national coverage. Notably, high performance is not limited to high-income economies; this suggests that factors such as political commitment, professional awareness, and prioritization of infant hearing health play a substantial role. Although national screening mandates were moderately associated with higher coverage (rho = 0.51), the presence of such mandates was not universally necessary, as nine of 38 high-coverage countries had no formal requirement [33].

Regarding service delivery, screening was conducted in birthing facilities in 93% of reporting countries, in other clinical or community settings (e.g., pediatric clinics, immunization centers, hearing care facilities) in 51%, and in homes in 14% (settings may overlap, so totals exceed 100%). Personnel performing screening also varied widely: physicians carried out screening in 26% of countries; audiologists, audiology staff, or technicians in 69% and 16%, respectively; and nurses, midwives, or community health workers in 69% and 24% of countries [33].

As emphasized in the World Report on Hearing, newborn hearing screening can be organized in several ways. Programs may adopt a universal model, seeking to assess every infant in a given country or region, or they may restrict screening to newborns considered at elevated risk for early-onset hearing loss—an approach relevant to roughly 8–10% of infants [40]. However, evidence shows that relying solely on risk-based screening would overlook approximately 40–50% of children with hearing loss because many affected infants present no identifiable risk indicators [40]. Screening may also occur on an opportunistic basis [2], for example when parents independently seek testing due to concern. Our findings indicate that in a number of countries with coverage around 1%, screening appears to occur almost exclusively at parental request and often requires out-of-pocket payment, typically being limited to certain hospitals [33].

Despite these disparities, our survey suggests that universal screening models are gradually being adopted in more regions. Nevertheless, establishing a comprehensive NIHS system for an entire country or state remains resource-intensive, meaning that risk-based, opportunistic, or hospital-centered programs frequently continue alongside emerging universal or regional systems [33]. A large population study comparing long-term outcomes among children exposed to the three major screening models—UNHS, risk-based programs, and opportunistic screening—showed clear advantages for UNHS, including earlier diagnosis and better receptive language, expressive language, and vocabulary outcomes [41]. Consequently,

universal screening is the strategy endorsed by the WHO [1, 2], supported by our findings [33], and validated by previous research [42].

A major priority for improving NIHS effectiveness and cost-efficiency worldwide is reducing the high proportion of infants lost to follow-up. Among the 27 countries in our dataset that provided reliable information, nearly half (48%) reported follow-up rates below the minimum standard of 70% recommended by the Joint Committee on Infant Hearing (JCIH) [43, 44] and other groups [45]. This aligns with a meta-analysis by Bussé *et al*., which found that 44% of reviewed NIHS programs exceeded a 30% lost-to-follow-up rate, meaning that many infants who fail their initial screen never receive diagnostic confirmation [46]. Our survey similarly documented that follow-up gaps were, on average, 7% higher in countries with limited screening coverage compared with those operating well-established UNHS systems [33]. Poor follow-up is often linked to inadequate data systems, limited capacity for tracking and referral, insufficient audiology services, parental misinformation or low awareness, and broader educational barriers [47]. The WHO has additionally highlighted geographic distance, transportation difficulties, parental uncertainty or fear, procedural inefficiencies, and inadequate visibility of services as contributors to missed follow-up appointments [39]. Implementing strong data management and tracking systems is considered one of the most effective ways to address these issues [39, 47]. Other approaches—particularly in resource-limited settings—include integrating follow-up with routine child vaccination programs and expanding community-based ear and hearing care (EHC) services [48, 49]. WHO also recommends establishing national ear and hearing care committees responsible for centralized coordination, program quality assurance, and monitoring of screening effectiveness, all of which help minimize return-for-follow-up failures [2].

In terms of prevalence, the rates of PCHL reported in our survey ranged from 0.3 to 15 per 1000 births, with a median value of 1.70 [33]. These numbers are consistent with a recent meta-analysis estimating a global prevalence of roughly 2.21 per 1000 (range 1–6) [46]. The World Report on Hearing introduced a revised classification system in which hearing loss is defined at thresholds exceeding 20 dB HL and includes unilateral loss; this revision is expected to increase reported prevalence figures in the future and will likely require screening programs to give greater attention to mild and unilateral impairment [50].

Genetic etiologies are responsible for about half of neonatal hearing loss [51], with more than 250 genes linked to syndromic and nonsyndromic disorders inherited in autosomal dominant, autosomal recessive, or X-linked patterns [2]. Syndromic forms often involve comorbidities affecting vision, neurological development, endocrine systems, and other organ systems. Our survey found particularly high prevalence levels in countries where genetic contributions to sensorineural hearing loss are more common due to higher rates of consanguineous marriage, including Pakistan, Egypt, Algeria, Jordan, and Turkey [33]. These observations align with findings from the UK Millennium Cohort Study, which noted elevated PCHL risk among children of Pakistani and Bangladeshi heritage [52].

## Conclusion

Drawing on the findings of our global survey and aligning them with WHO guidance, several actions are needed to strengthen and expand NIHS initiatives worldwide [1–3, 33, 34, 53].

- Government leadership is essential. National authorities must assume responsibility for setting strategic priorities and embedding comprehensive hearing-loss interventions within public health systems [2, 30, 32]. The limited progress in past decades reflects an ongoing global deficit in governmental stewardship in ear and hearing care [31].
- National ear and hearing care committees should be established. These bodies, ideally coordinated by ministries of health and guided by a designated national EHC coordinator, should formulate country-specific strategies that position NHS programs as a central component of broader EHC planning [54, 55]. Their membership should represent all relevant professional and stakeholder groups.
- Countries should take advantage of WHO support. WHO provides structured guidance for designing, implementing, managing, and evaluating NHS and wider EHC systems—including the World Report on Hearing [2], the Ear and Hearing Care Situation Analysis Tool [53], the Planning & Monitoring Manual for National Strategies [55], and the Hearing Screening—Considerations for Implementation handbook [1], among others [34].
- Raising awareness among the public and decision-makers is critical. The WHO identifies advocacy and communication as foundational for securing resources and implementing national EHC strategies. National committees should coordinate messaging, training, procurement planning, infrastructure development, and advocacy efforts. Standard operating procedures (SOPs) should clarify workflow standards, such as how many times a failed screen should be repeated and the required follow-up pathways for infants who do not pass screening [53,

55]. Routine data analyses (e.g., screening coverage, referral and fail rates) should function as key indicators of program quality [55].

- Legal frameworks should support NIHS implementation. Enacting legislation can help formalize and stabilize national screening systems.
- Robust data systems and tracking mechanisms must be developed. Ideally introduced at the start of the NIHS rollout, such systems should track infants who miss or fail screening, document coverage and service quality, and monitor diagnostic and rehabilitation outcomes. Incorporating telemedicine and enabling two-way data flow between local screening sites and centralized NHS centers can further enhance these systems [12].
- Opportunities for case review and professional exchange should be integrated. Regular expert discussions can enhance clinical decision-making and program quality [54].
- Governments must ensure equitable access to pediatric audiology services. This includes making hearing technologies affordable and accessible—potentially through bulk procurement of hearing aids and implants or other cost-reducing strategies [29, 30, 54].
- Hearing rehabilitation requires stronger representation. In many countries, rehabilitation services remain underdeveloped. The WHO's developing Package of Rehabilitation Interventions (PRI), produced in partnership with Cochrane, identifies evidence-based approaches and resource needs for effective rehabilitation and includes a strong focus on hearing loss [56]. Ensuring that EHC professionals understand and apply these interventions is crucial for improving outcomes for children with PCHL [57].
- Countries with established NIHS programs should help support others. Nations with high coverage should work to guarantee equitable access domestically while also offering technical or organizational expertise to countries with emerging or limited screening infrastructure.
- Prevention of neonatal hearing loss must accompany NIHS. Preventive actions—outlined in WHO publications [2, 3]—should reflect local epidemiology and resources. These include reducing maternal CMV infection risk, limiting ototoxic medication use in neonatal care, and improving outcomes for premature infants. Identifying risk factors and etiologies is important for guiding interventions [58]. Early identification of congenital CMV is particularly valuable, as it can cause late-onset hearing loss in roughly half of affected infants—a form of impairment not typically detected by NIHS [59]. Genetic information may also influence family planning and intervention choices. Given elevated risks associated with consanguinity—which accounts for 20–50% of marriages in some regions [2] and increases the likelihood of congenital hearing loss [60–64]—non-directive genetic counseling and public education may serve as important preventive tools [2, 51, 55, 65].
- NIHS, followed by prompt intervention and supported by preventive strategies, is a sound investment. Evidence consistently demonstrates that early detection and treatment of PCHL are effective and cost-efficient. Our survey provides the first global confirmation that newborn hearing screening leads to earlier diagnosis and intervention, while also revealing striking disparities between countries. Achieving the 2015 Sustainable Development Goals and universal health coverage requires that children with hearing loss not be overlooked. Ensuring that NIHS forms part of national health coverage strategies is therefore a matter of fairness and equal opportunity—allowing all children the chance to attain the "highest attainable standard of health."

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