

## Improving Newborn Hearing Screening Through Collaboration and Communication

Mary E. Duncan, AuD<sup>1</sup>  
 Marissa Schuh, MPH<sup>1</sup>  
 Shannon Haynes, MSN<sup>1</sup>  
 Anita Taylor, RN-OBC<sup>1</sup>  
 Gwen Moreland, DNP<sup>1</sup>  
 Raleigh Jones, MD<sup>1</sup>  
 Matthew Bush, MD, PhD<sup>1</sup>  
 Jennifer Shinn, PhD<sup>1</sup>

<sup>1</sup> University of Kentucky, Lexington, KY

### Abstract

**Purpose:** Hearing loss is the number one birth defect among children. There are significant consequences of delayed diagnosis and failure to obtain timely intervention, particularly for a child’s speech and language development. Design and implementation of successful newborn hearing screening (NHS) programs can be challenging. The purpose of this paper is to demonstrate improved efficiency and effectiveness of a large NHS program through the implementation of a team approach engaging both ambulatory and hospital services.

**Methodology:** A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was used to develop an improved NHS program focused on improving patient care. The SWOT analysis outcomes were used to determine several key factors to be implemented, including dedicated technicians solely assigned to the NHS program and purchase of new equipment to improve accuracy and reduce disposable costs. In addition, a two-tiered approach was implemented whereby the dedicated technicians performed initial screenings, with all rescreens performed by an audiologist.

**Results:** Implementation of the new NHS program demonstrated numerous successes including a significant reduction in the failure rate, improved care coordination, and increased communication between ambulatory and hospital services.

**Keywords:** Newborn hearing screening, interdisciplinary collaboration, care coordination, congenital CMV

**Acronyms:** AABR = automated auditory brainstem response; ABR = auditory brainstem response; CMV = cytomegalovirus; EHDI = Early Hearing Detection and Intervention; NHS = newborn hearing screening; JCIH = Joint Committee on Infant Hearing; SWOT = Strengths, Weaknesses, Opportunities, and Threats

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**Correspondence concerning this article should be addressed to:** Mary E. Duncan, AuD, Department of Otolaryngology–Head and Neck Surgery, University of Kentucky, C300 Kentucky Clinic, 740 South Limestone, Lexington, Kentucky 40536-0284. Phone: 859-218-2177; Fax: 859-323-5951; Email: [Marybeth.duncan@uky.edu](mailto:Marybeth.duncan@uky.edu)

Between 1 and 3 of every 1000 live newborns are identified as having congenital hearing loss, making it the most common birth defect (Centers for Disease Control and Prevention [CDC], 2018; Vohr, 2003). It is well established that untreated hearing loss in the first few years of life can have devastating consequences on a child’s speech and language development. Hearing loss can also have significant psychosocial and academic ramifications for children (Tomblin et al., 2020; Wong et al., 2017). Key to improving these outcomes is prompt diagnosis and intervention to maximize early access to listening and

spoken language through hearing aids and cochlear implants or to visual language via manual communication (Singer et al., 2010; Yoshinaga-Itano et al., 1998).

Universal Newborn Hearing Screening (NHS) is a vital hospital program designed to ensure all infants with hearing loss are quickly identified. NHS programs also provide a framework for flagging infants at heightened risk for both congenital and late onset hearing loss, so they may be referred for more thorough testing and monitoring. This includes infants with craniofacial malformations, certain genetic syndromes, family history, in utero infections, other

serious health conditions such as meningitis, and history of medical treatments known to be associated with hearing loss (Joint Committee on Infant Hearing [JCIH], 2019). At notably increased risk are infants who receive care in the neonatal intensive care unit (NICU), a population whose rate of hearing loss has been reported as approximately 3% (Chang et al., 2020; Hille et al., 2007).

National Early Hearing Detection and Intervention (EHDI) guidelines from the JCIH (2019) state that all newborns should be screened for hearing loss before age 1 month, receive a diagnosis before age 3 months, and begin early intervention before age 6 months. Meeting this critical “1-3-6” timeline is associated with improved language outcomes for children with hearing loss and earlier activation of cochlear implants in deaf children (Yoshinaga-Itano et al., 2018). Although screening by age 1 month is the target, the JCIH advocates it be completed prior to hospital discharge. The recommended standard for newborns referred for diagnostic assessment is less than 4% (JCIH, 2007). There are considerable challenges to developing and implementing NHS programs to effectively meet these goals. Obstacles may include financial, technological, organizational, logistical, and human resource needs (Winston-Gerson & Ditty, 2021).

At the University of Kentucky Medical Center (UKMC) 2500 infants are screened for hearing loss every year on average. All screenings are conducted prior to hospital discharge, using automated auditory brainstem response (AABR) equipment. UKMC does not conduct outpatient rescreens after discharge, only full diagnostic auditory brainstem response (ABR) evaluations. Screening failure rate in the 2017–2018 fiscal year was 18% for initial screens and 5% for repeat screens. In addition to exceeding the limit of the national failure benchmark,

the program’s high rate of initial failures resulted in inflated program cost and time investment. Screenings were conducted by a large team of general medical technicians who had numerous job responsibilities and minimal NHS training. Limited program oversight and poor interdepartmental communication left gaps in patient care, particularly for infants with complex needs. Through the implementation of a team approach engaging both ambulatory and hospital services, the present project aimed to improve the efficiency and effectiveness of the UKMC NHS program.

### Method

An interdisciplinary team was formed, including hospital leadership and specialists from audiology, neonatology, otolaryngology, and infectious disease. Additionally, the chief of audiology was in communication with the Kentucky EHDI Board regarding the program redesign. Collaborators met over the course of a year to design and implement the new NHS program, with the goal of reducing the screening failure rate and improving overall patient care. A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted. The results are outlined in Table 1. Based on the team’s discussion of the SWOT, it was determined that the fundamental weaknesses affecting screening rate and patient care were inadequate staffing, older and inefficient equipment, and poor ambulatory/hospital communication in cases of screening failure. To address these weaknesses, a list of potential solutions was generated. Cost versus benefit analysis of each solution was discussed with regard to financial, time, and human resource ramifications. Feedback from patient care technicians, care team members, and families was taken into consideration. It was ultimately decided that several key changes would be enacted.

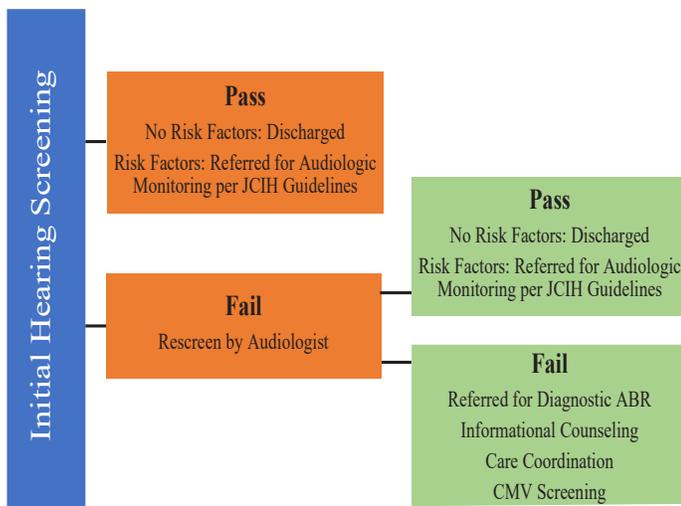
**Table 1**  
*SWOT Analysis of Pre-Existing Newborn Hearing Screening (NHS) Program*

<p style="text-align: center;"><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Large program with low rate of missed screenings</li> <li>• Audiology department with nine licensed audiologists on site</li> <li>• Access to large medical center resources such as patient care coordinators, social workers, etc.</li> <li>• Support from leadership for programmatic improvements</li> </ul>	<p style="text-align: center;"><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• High screening failure rate compared to national standard</li> <li>• High rate of missed diagnostic audiology follow-up appointments</li> <li>• Poor communication between medical services for newborn nursery and complex NICU patients</li> <li>• Disconnect between hospital and ambulatory care</li> <li>• Inadequate staffing for screenings</li> <li>• Lack of screening technicians with appropriate training and experience</li> <li>• High cost of disposable materials</li> </ul>
<p style="text-align: center;"><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Interdepartmental collaboration</li> <li>• Advance technology and medicine</li> <li>• Meet or exceed national screening guidelines</li> <li>• Improve patient care</li> <li>• Decrease loss to follow-up</li> </ul>	<p style="text-align: center;"><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Pressure to reduce costs while maintaining high standard of care</li> <li>• Time constraints of audiologists</li> <li>• Non-NHS responsibilities and time constraints of screening technicians</li> </ul>

*Note.* SWOT = Strengths, Weaknesses, Opportunities, and Threats.

First, two medical technicians were hired as dedicated hearing screeners who were solely responsible for completing and documenting the screenings. They were specially trained on EHDl principles, equipment use, and troubleshooting. The program also purchased new AABR screening equipment with improved accuracy and significantly lower disposable cost. Lastly, a two-tiered screening approach was implemented in which a newborn who failed the initial screening was rescreened by an audiologist from UKMC (see Figure 1). All babies who failed the second screening were referred for a diagnostic ABR evaluation in the outpatient audiology clinic. Babies who passed the screening but had risk factors for delayed onset or progressive hearing loss were referred for audiologic monitoring as recommended by JCIH 2019 guidelines. Babies who passed with no risk factors were discharged from audiology service.

**Figure 1**  
*New Two-Tiered Approach to Hearing Screenings*



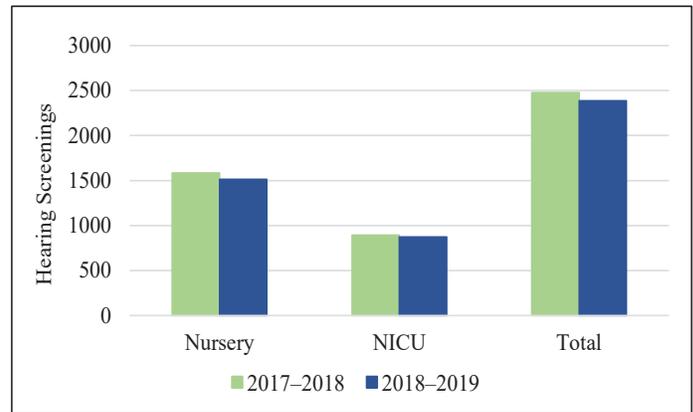
*Note.* ABR = auditory brainstem response; CMV = cytomegalovirus; JCIH = Joint Committee on Infant Hearing.

NHS program changes initiated with the 2018–2019 fiscal year and were compared with the 2017–2018 fiscal year to determine the impact of the program redesign on screening failure rate. Pass/fail data were collected by the hearing screening technicians and audiologists. Feedback regarding care coordination and interdepartmental communication was collected from providers, technicians, and families by their respective interdisciplinary team members.

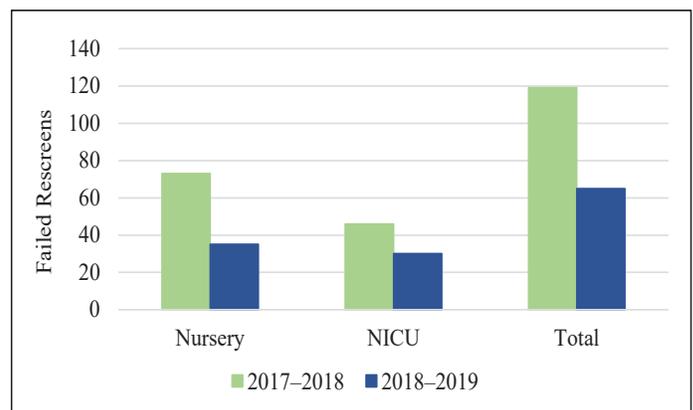
### Results

In the 2018–2019 fiscal year a total of 2,386 newborns received a newborn hearing screening at UKMC, including 1513 infants in the newborn nursery and 873 infants in the NICU (Figure 2). Of those screened, 9% failed the initial screening and 2% failed the second screening (Figure 3). This demonstrates a substantial decrease in the rate of failed screenings compared to the 2017–2018 fiscal year, in both the nursery and NICU populations (Figure 4). New NHS equipment achieved a disposable cost reduction of \$11 per screening, resulting in approximately \$30,000 savings to UKMC.

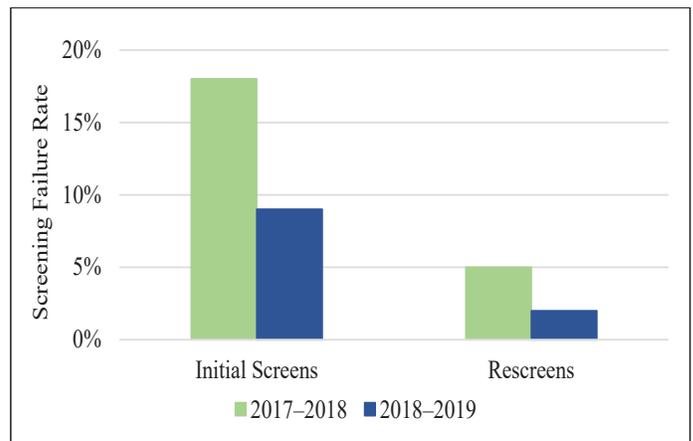
**Figure 2**  
*Total Number of Hearing Screenings Conducted*



**Figure 3**  
*Failed Rescreens Prompting Diagnostic Referral*



**Figure 4**  
*Screening Failure Rates*



Under the new screening program, clinical audiologists completed all NHS program rescreens prior to newborn discharge. Audiologists were scheduled to take call for the NHS program for one week at a time, on a rotating schedule. They conducted screenings during

administrative or unstructured periods to ensure no loss of revenue-generating clinic time. The process was typically completed in 30 minutes or less. Their responsibilities included: scheduling the outpatient diagnostic ABR appointment immediately upon second screening failure, counseling parents on the failed screening results, providing pretest instructions for the ABR appointment, and communicating the screening results and appointment dates with other key professionals involved in the infant's care. For infants in the newborn nursery this included an infectious disease physician and NHS program director. For infants in the NICU, a neonatology physician and patient care coordinators were also informed.

A targeted congenital cytomegalovirus (CMV) infection screening program was initiated for all infants in the newborn nursery who failed the second hearing screening. This policy change did not impact patients in the NICU, as all newborns treated in this unit are screened for CMV upon admission.

### Discussion

The collaborative redesign of the NHS program has yielded numerous successes in the areas of patient care, care coordination, and value. A major improvement with respect to patient care is the significant decrease in both initial and secondary screening failures; both rates have been reduced by approximately 50%. Ongoing analyses indicate this improvement has been sustained even in the face of the COVID-19 pandemic, during which the UKMS NHS program has remained in full operation. The program continues to exceed its goal of meeting the JCIH quality benchmark of 4% or less of final referrals for diagnostic audiological testing. Although superior technical accuracy of the new AABR equipment cannot be overlooked, it is suspected that strengthened program staffing also plays a significant role in achieving this goal. The quality of screenings improved by hiring two technicians designated as hearing screeners, modifying their clinical responsibilities to ensure adequate time for screenings, and training them in principles of newborn hearing, equipment use, and troubleshooting.

Introduction of experienced audiologists to the secondary screening phase has also been essential to improving patient care. The audiologists provide expertise in hearing assessment and advanced equipment troubleshooting as needed. Perhaps more importantly, they also provide individualized counseling to families whose newborns fail the rescreen. The focus of counseling was basic principles of newborn hearing screening and diagnostic testing, and pre-test instructions to support a successful outpatient ABR. Informational counseling from a clinical audiologist was included in the program redesign with the hope of improving caregiver knowledge and reducing loss to follow-up. UKMC is currently collecting and analyzing loss to follow-up data to determine if the program changes positively impacted loss to follow-up rates.

Another success of the redesigned NHS program is improved care coordination and communication between ambulatory and hospital services. Ensuring proper time

for conducting and communicating results of a hearing screen can be challenging amidst a newborn's many initial evaluations. This is particularly true for medically fragile babies who require lengthy hospital admissions and for whom hearing screening is not a priority. Typical communication and planning channels can also be interrupted by instability of a newborn's social situation, such as changes in custody or foster care. Deploying UKMC's audiologists as hearing care coordinators seeks to overcome these challenges. Immediately scheduling outpatient appointments, communicating results with families, and directly contacting medical team members ensures all stakeholders are informed of needed follow-up. Appointments can be scheduled on a timeline sensitive to the caregivers' logistical needs, which is another factor believed to play a significant role in loss to follow-up (Ravi et al., 2016). Designation of an NHS program director has also proven essential to care coordination and communication. The program director serves as a chief point of contact between hospital and ambulatory services, coordinates any emergent testing needs (e.g., congenital CMV or meningitis), oversees program implementation and statistic tracking, and resolves any programmatic issues or concerns that arise.

Lastly, NHS program changes have achieved significant time and financial savings to UKMC. The use of dedicated hearing screeners has allowed nursery and NICU directors to redeploy non-screening technicians to their primary job duties. Experienced screeners using new equipment with greater accuracy has greatly reduced the number of repeat screenings required, cutting both physical costs and time investment. The new equipment also requires significantly less disposable costs, at only \$2.50 per screening. The original AABR equipment required nearly \$14 in supplies per screening. Taking into account both initial screenings and rescreens, it is estimated that this substantial cost reduction has saved UKMC approximately \$30,000 annually since the changes were implemented. Such savings have more than accounted for the initial cost of new equipment.

An unanticipated outcome of the program redesign has been development of a targeted CMV screening policy in the newborn nursery. CMV is the most common congenital viral infection in the United States, affecting approximately 1 in 200 newborns (CDC, 2020). It can result in significant central nervous system deficits, including congenital and delayed onset hearing loss. Early diagnosis allows for swift initiation of antiviral therapy, which may improve hearing outcomes in some affected newborns (CDC, 2020). Additionally, early diagnosis allows for initiation of close audiologic monitoring during a child's critical developmental years. This new collaborative screening policy elevates the standard of care provided to newborns at UKMC, in addition to bolstering interdisciplinary team involvement in the NHS program. It is the authors' hope that early identification of both congenital CMV infection and hearing loss will result in earlier involvement of other critical medical specialties and intervention services.

Future directions for this project will include outcome measures beyond hospital screenings, to see if successes in this phase do in fact result in lowered age of hearing loss

diagnosis and initiation of intervention at UKMC. Also of interest is probing the efficiency of the program's diagnostic phase, through measures such as outpatient ABR no-show rates and number of appointments required to obtain a diagnosis. Additionally, after the successful establishment of a working relationship between audiology and infectious disease, the authors are looking to expand partnerships with other key services to develop standardized hearing care paths for infants at higher risk of hearing loss.

### Conclusion

The NHS program at UKMC was collaboratively redesigned using results from a SWOT analysis completed by a multidisciplinary team. Key changes included designating two medical technicians as the sole hearing screeners, purchasing new equipment with improved technical accuracy and lower disposable costs, and implementing a two-tiered screening protocol by which audiologists completed all repeat screenings and provided information counseling and hearing care coordination. These changes resulted in decreased screening failure rates, increased communication between hospital and ambulatory services, improved care coordination, significant cost savings, and a new targeted CMV screening protocol in the newborn nursery.

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