EARLY HEARING DETECTION: USING PRE-DISCHARGE EDUCATION AND STANDARDIZED REFERRALS TO REDUCE LOST-TO-FOLLOW-UP RATES

by

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Abstract

Background: There are lags in ensuring that infants who do not pass their hospital newborn hearing screens receive the follow-up testing they need by the recommended three-month benchmark. The purpose of this project is to address disparities in infants lost to follow-up (LTF) by implementing a program for pre-discharge education and referral plan to free follow-up care at a suburban hospital in a mid-Atlantic state.

Intervention: A partnership between the state department of health and a local university audiology program provided education and free follow-up testing of infants who did not pass the newborn hearing screen. Audiology technicians provided a screening result card to families, which also included hearing developmental milestones. Families received brief verbal education about the test result and the urgent need for a retest for those who did not pass. Infants requiring follow-up received appointments with the partner audiology clinic for a free evaluation.

Results: 216 infants were born at the site and 214 babies received the in-hospital hearing screens. All 214 babies passed the in-hospital screens and did not require referral. An additional three babies were referred to the university clinic from other sites.

Conclusion: This project did not yield opportunities for evaluation of LTF due to low birth volume during the short data collection period. However, this project indicated future potential for positive change. Families responded well to the cards and engaged with the education. This partnership provided opportunities for follow-up of at-risk infants in the region and is likely a model worth continuing and expanding.

Keywords: early hearing detection, academic partnership, pre-discharge referral

Early Hearing Detection: Using Pre-Discharge Education and Standardized Referrals to Reduce Lost-to-Follow-up Rates

Addressing childhood hearing loss is a significant health priority in the United States. Estimates for rates of childhood hearing loss nationwide can vary from between 1.4 per 1,000 babies to 14.9% of children (Centers for Disease Control, 2017). Without early interventions to help language development, children with hearing loss can face developmental delays that can result in educational and employment disparities into adulthood (Holden-Pitt & Albertorio, 1998). Infants can have hearing loss in the absence of other risk factors. Because of this, the Joint Committee on Infant Hearing recommends that all infants should be screened for hearing loss by one month of age. Those who do not pass their initial screening should have a diagnostic evaluation by three months of age, and those infants with confirmed hearing loss should be enrolled in hearing intervention services by six months of age in order to prevent developmental delays (Joint Committee on Infant Hearing, 2007). These benchmarks are also reflected in the Healthy People 2020 goals for infant hearing loss detection (Office of Health Promotion and Disease Prevention, 2018). Early Hearing Detection and Intervention (EHDI) programs in each state have been developed to collect data and ensure that infants reach these targets.

With more than 95% of infants receiving their initial screening before one month, the nation has made significant improvements in meeting benchmarks for initial screenings. However, 25.4% of infants nationwide who failed their initial screen in 2016 never received a diagnostic evaluation to confirm hearing loss (CDC, 2015). In Maryland in 2016, 1,015 of 69,279 babies born (1.5%) did not pass their initial hearing screen. Of these infants, 9.3% never received a diagnostic evaluation and were considered lost to follow-up (LTF) (CDC, 2016). Prince George's County, Maryland has worse LTF outcomes than the state overall: 44 infants

were LTF out of 178 failed initial screens in 2016, with an overall LTF rate of 24.7% (Maryland EHDI, 2018).

Infants who are lost to follow-up often come from a vulnerable population that is socioeconomically disadvantaged. Educational disparities, lack of knowledge among parents, low-income, rural location, minority ethnicities, and history of maternal smoking are associated with a greater risk for loss to follow-up (Ravi, et al., 2016; Cunningham, et al., 2017). Evidence shows that families with these risk factors should be the focus of education and close follow-up to increase rates of screening follow-up, hearing loss identification, and intervention enrollment (Cunningham, et al., 2017). The importance of determining an infant's hearing status can be difficult for families to comprehend when not properly emphasized during the discharge process. Research has indicated that educating families of infants who fail initial screens and arranging appointments prior to hospital discharge has helped improve rates of follow-up (Ravi, et al., 2016; Tran, et al., 2017; Cockfield, Garner, & Borders, 2012; Krishnan & Van Hyfte, 2014). Additionally, expanding availability of audiology testing to sites that deliver care to this vulnerable population has also expanded numbers of infants reached and reduced rates of LTF infants (Bhatia, Mintz, Hecht, Deavenport, & Kuo, 2013; Hunter, et al., 2016).

In a Mid-Atlantic state, there are lags in lost to follow-up rates after the initial failed in-hospital hearing screens. This Doctor of Nursing Practice (DNP) project addressed the lost to follow-up rate among infants who failed initial hearing screenings at a hospital in this region by implementing a standardized referral process and pre-discharge referral from audiology staff while the baby was in the postpartum unit.

The purpose of this DNP project was to implement and evaluate a program to provide an educational prescription with linkage to follow-up audiology care prior to hospital discharge for

families of infants who have failed their initial hearing screens. At the time of the initial in-hospital screen, an audiology technician provided patients with verbal education and literacy level-appropriate handout regarding the significance of the test result and, if applicable, the need for a diagnostic evaluation. The technician also provided families with referral information to an audiologist that can evaluate hearing loss on a low or no-fee basis if needed. The short-term goal of this project was to provide hearing education and audiology clinic information at the target hospital to 100% of families of infants who fail initial hearing screenings and have more than 80% of families follow through on the appointment referral. The long-term goal of this project was to generate a statistically significant improvement in follow-up rates of at-risk infants so that infants with hearing loss are identified and enrolled in intervention services before six months.

Theoretical Framework and Applications

The Plan-Do-Study-Act (PDSA) model for quality improvement was used to gauge outcomes and refine project actions using iterative cycles to help guide improvements. This process of testing continual changes can help pinpoint which interventions are most effective, evaluate how much improvement can be anticipated from an intervention, and help increase confidence and minimize resistance to a change. The planning stage defines the objective of the test, makes predictions about possible outcomes, and develops plans to collect and analyze data to gauge success. The "do" stage carries out the test on a small scale, records unexpected outcomes or problems, and begins data analysis. The "study" phase completes data analysis, compares data to the initial predictions, and reflects on what was learned. Finally, the "act" phase of the model refines the intervention and prepares a plan for implementing the new changes (Institute for Healthcare Improvement, 2018).

This DNP project used the Plan-Do-Study-Act cycle to test interventions on a small scale and plan project refinements with the goal of improving outreach to infant families and facilitating access to follow-up audiology evaluations. This project was an extension of the PDSA cycle from a previous DNP project that expanded access to audiology testing for at-risk infants to decrease the LTF rate by using a Women-Infant-Children (WIC) site and an academic partnership in a similar geographic region. The current DNP project built on the previous project by referring patients to these ongoing screening options from one suburban hospital in the region where many of the WIC participants were born, after infants' initial failed screen. PDSA cycles helped determine elements to keep and improve on in the previous project cycle and helped guide changes during this quality improvement project cycle.

Evidence Review

The focus of the evidence in this literature review was to evaluate interventions that decrease the LTF rate among infants who fail their initial screens. This review begins broadly by comparing interventions that have succeeded in increasing access to a population vulnerable to LTF. Evidence is discussed in favor of education near the time of the infant's failed initial screen and evidence for audiology appointment scheduling prior to hospital discharge.

Some researchers focused their efforts to reach a population with traditionally high LTF rates by increasing hearing screening accessibility. Bhatia, et al. (2013) investigated the effects of implementing hearing evaluations at seven federally qualified health centers in California that serve a vulnerable population. They provided follow up hearing evaluations for 1,696 individual patients, and ultimately identified sensorineural hearing loss in 5 patients. While these researchers did not specifically examine the LTF rate, the effectiveness of providing large-scale hearing evaluations at a primary care site was demonstrated. In a qualitative study, Russ et al.

(2010) found positive feedback from clinicians and patients by linking an EHDI program to a medical home. Hunter, et al. (2016) investigated the effect of providing hearing evaluations at a Women, Infants, and Children (WIC) program clinic on the LTF rate in 260 WIC-eligible infants through a non-randomized controlled trial. The intervention arm infants had a statistically significant ($p<0.001$) reduction in the LTF rate compared to infants from the same hospitals receiving usual care. While all three studies had different designs with varying strengths of evidence, there were broadly positive results in increasing audiology availability to vulnerable infants.

Other researchers concluded that intervening prior to hospital discharge with education near the time of the infant's failed initial screen yielded positive results. Ravi, et al. (2016) performed a meta-synthesis of 53 recent publications on follow-up factors in infant hearing screening. Multiple studies concluded that parental education through distribution of written materials and health professional communication was particularly effective. Cockfield, et al. (2012) used a case series study design that utilized scripted nurse practitioner education and an appointment card for hearing screen that was provided to families of infants who failed their initial screens at two different hospitals in Georgia. Fourteen of the 17 newborns who met the inclusion criteria had attended audiology appointments within three months, while three newborns were lost to follow-up. The first site had a statistically significant ($P=0.01$) improvement in LTF rates; the second site improved its LTF rates from 70% to 40% but data analysis was not conducted due to small sample size.

Several research studies focused on reducing LTF rates by requiring appointment scheduling prior to discharge. Krishnan & Van Hyfte (2014) examined the effects of an Indiana policy change requiring an audiology appointment to be made prior to hospital discharge by

analyzing infant records at an audiology clinic before and after the policy change. The LTF rate dropped from 18% to 7% and time to confirmation of hearing loss decreased from 18.7 weeks to 7 weeks after the policy change. The population of infants studied were otherwise comparable in terms of socioeconomic factors and health status. These researchers did not perform a statistical analysis on the results due to a small sample size. Tran, et al. (2017) discusses a larger-scale analysis of the effects of pre-scheduled audiology appointments prior to discharge, using a case control study to examine 4,597 children born in Louisiana hospitals who failed their initial in-hospital screenings. Of these newborns, 56% had a follow-up appointment scheduled prior to discharge. After controlling for differences in demographics and health status, the newborns discharged with appointments experienced a statistically significant improvement ($p < 0.001$) in LTF rates and early follow-up initiation compared to those discharged without a hospital appointment. This research validates the findings from Krishnan & Van Hyfe (2014) with more rigorous statistical analysis and larger sample size.

While some of the settings of the research studies reviewed limited the sample size and the quality of the data analysis, these studies indicate that providing education and appointment referrals prior to discharge can decrease the LTF rate of infants who fail their initial hearing screen. These results are maintained in different geographic settings and across patients of different socioeconomic characteristics, including minorities and families of lower socioeconomic status that will be the focus of this intervention.

Methods

A quality improvement project to improve infant hearing screening education and referrals for follow-up was implemented at a suburban hospital in the Mid-Atlantic region. A project description was submitted to University of Maryland Baltimore (UMB) Institutional

Review Board (IRB), the IRB for the suburban hospital, and the state department of health for a Non-Human Subjects Research (NHSR) determination. Additionally, approval to implement the DNP project was obtained from the hospital organization's leaders. In this quality improvement project, all families of infants born in the labor and delivery unit at a Mid-Atlantic suburban hospital during the project period were included in the sample population. Families of infants who did not pass the in-hospital screens were identified to receive additional education and a follow-up appointment.

After adjustments to the timeline to accommodate the approval process for project protocols and educational handouts, this quality improvement project was conducted over a period of nine weeks. A detailed description of protocol updates can be found in Appendix A. During the first week, the interprofessional team was educated about infant hearing screening. The audiology technicians received one-on-one training about the importance of knowing an infant's hearing status, the educational handouts that families would receive, and the procedures for making follow-up appointments for infants who do not pass their in-hospital hearing screens (Appendix B). Postpartum unit nurses received several brief in-services during staff huddle times and information about the project was disseminated in staff updates, educating about the new referral procedure process and how to reinforce the education and importance of attending the follow up appointment during the discharge teaching process.

The next phase of project implementation occurred during weeks two and three. Due to a delay in the availability of the educational handouts, audiology technicians conducted the education and referral process in the absence of the handouts. Data regarding failure rates and referrals continued to be collected during this period. At the beginning of week four, the cards were delivered to the site and brief re-trainings were conducted with the audiology technicians.

Audiology technicians were able to provide a card with the results of the hearing screenings to families of infants immediately after the hearing screen. Families of babies who passed received a card confirming the test result and a list of hearing developmental milestones to anticipate. Families of infants who did not pass received short verbal education from the technician about the significance of the test result and the need for a retest. At that point, the audiology technicians helped the family in making an appointment with the partner audiology clinic. The appointment was written on the card given to the family, which would also reinforce the education explaining the importance of determining an infant's hearing status (Appendix C). Infants who passed the screen but had additional risk factors for delayed hearing loss received a separate card explaining the risk factors and a recommendation for an appointment at the audiology clinic at the appropriate time. At discharge, nurses reinforced the importance of follow-up to the families of those who needed it. Weeks four through nine were used for data collection for this process.

Week nine was used for preliminary project evaluation. The process was examined for adherence through analysis of how many cards had been distributed compared to the number of babies screened. Additional feedback was gathered through informal interviews with technicians and nurses about process adherence and areas for improvement. Finally, data on in-hospital test results, referral rates, and appointment follow-through were collected from the existing state-wide infant hearing database management system.

Data and outcomes of this education and referral program were tracked with the existing state-wide database contracted by Oz Systems. Results of every infant's hearing screen must be entered into the database within 48 hours of the hearing screen, in addition to risk factors for later onset hearing loss, follow up hearing test results, referrals made, and follow up kept. This

project tracked the total number of births at the target hospital, the number of hearing screenings performed, the number of hearing screenings passed and failed, the number of follow-up appointments kept, and the number of infants who were lost to follow-up. Process adherence was determined by identifying whether infants who had failed their initial screens at this hospital were referred to the audiology clinic and by comparing the number of hearing screening cards distributed to infant families compared with the number of screenings performed. Data analysis compared rates of infants lost to follow up at this hospital in the preceding year compared to the rates of infants lost to follow up from this hospital during the project analysis period.

Data security and confidentiality of patient information were maintained by the existing password-based security systems that protect the OZ database and limit access to authorized individuals. Reports of project data were de-identified prior to data analysis performed by the researcher.

Results

Throughout the project period, audiology technicians were trained in project protocols. Four audiology screeners were trained in person and one additional screener was advised of the process via phone message. This accounted for most but not all of the screeners at this site due to staff turnover. Screeners from other sites often had to step in to cover screening needs during this period and not all screeners were able to be formally trained in project protocols.

Compliance with the education and referral process was to be assessed by comparing the number of screenings performed after the card delivery with the number of appropriate cards distributed to patient families. However, after the start of the data collection period, an unknown quantity of additional cards was introduced from the printer and it was not possible to determine precisely how many cards were distributed. Per verbal reports from the audiology technicians,

the primary screener at that site maintained a 100% distribution rate. However, screeners from other locations helping out at the project site may not have consistently distributed cards. There were no infants who failed their in-hospital screening and required referral during the project period; as a result, education and referrals for this category of patients was unable to be assessed.

Two hundred and sixteen infants were born at the project site. Of these infants, 214 received the in-hospital hearing screens, one infant was deceased, and one infant remained in the Neonatal Intensive Care Unit (NICU) unable to receive a screening during the project period. Each of the 214 babies passed their hearing screens as an inpatient (Appendix D). Twelve of these infants did not initially pass in-hospital screens, but subsequent screens while the baby was still an inpatient resulted in a hearing pass for all of these infants. As a result, there were no referrals to initiate and this part of the process could not be examined. Additionally, no babies were identified during the project period as having risk factors requiring future follow-up. However, a review of the database shows that nine infants meet the risk factor criteria of a stay greater than five days in the NICU.

The lack of infants who did not pass their in-hospital screens was an unexpected finding when compared to rates of infants who do not pass their in-hospital screens from previous years. In the same time period during the preceding year, 223 infants were born at the site. Of these infants, eight did not pass their initial in-hospital screenings and one infant opted out of services. With a significance level of $p<0.05$, a chi-square test comparing the pass rates in the comparable periods of 2017 and 2018 shows a statistically significant difference in the pass rates, with $p=0.0052$. It is possible that certain external procedural factors may have affected the infants' in-hospital pass rates.

Discussion

This quality improvement project did not have the opportunity to evaluate the referral process and gauge the efficacy of the linkage to follow-up care as all babies born during the project period passed their initial hearing screens. However, this project yielded positive and useful results that align with goals of implementing and evaluating a program for education and referrals for all babies evaluated. Families responded positively to the results cards and engaged with the content of the education, which increases family awareness of milestones and the possibility of hearing loss later in the infant's life.

Due to a short data collection window and low birth volume at the facility hosting the intervention, the sample size of infants examined in this quality improvement project was smaller than the sample size generally examined in the literature. As such, this project was unable to compare its findings to those in the literature. However, the fundamental principles of increasing follow-up access, in-hospital education, and pre-discharge appointment scheduling run parallel to findings in the literature.

This quality improvement project encountered some unanticipated complications that required mid-course adjustments. There was significant staff turnover in hearing screeners at the implementation site, which required additional training to be scheduled for new screeners hired during the project period. There were occasionally screeners from other sites who would cover individual shifts at the project site. These screeners had not been trained in project protocols and may not have adhered to the parameters. Additionally, due to delays in the approval and printing process for the cards that contained the referral and educational information, the cards were not able to be utilized until the fourth week of data collection. Though this did not end up affecting

any referrals since all infants passed their initial screens, it might have affected the experience of families' education and ability to follow up in the case of later hearing loss.

During the data collection period, no infants were identified as having had risk factors for hearing loss that would require a hearing evaluation later. However, review of the babies born in that period showed that at least nine infants met the risk factor criteria for greater than five days spent in the NICU. Missed identification of risk factors represents a lost opportunity for education and a possible lapse in appropriate follow up later. While the mother/baby unit where the project was focused had a process for reporting the presence or absence of risk factors to the audiology technicians for entry into the Oz database, the NICU did not have a similar process. While this is an incidental finding to the project overall, adjusting the risk factor reporting process in the NICU can be incorporated into future spread of this quality improvement process.

Even despite the short timeframe for data collection and low birth volume, the 100% pass rate of infants' hearing screens was unexpected: it showed a statistically significant increase from the pass rate from the equivalent time period in the previous year. While the same audiology contractor company was utilized for screenings in both 2017 and 2018, there were different primary personnel used for day-to-day screenings between the two years. The audiology contractor policy is to rescreen infants who have not passed an initial screen before discharge. The presence of the quality improvement project itself may have prompted more thorough efforts among audiology technicians to rescreen infants prior to hospital discharge.

Conclusion

Despite the results of this project not generating further referrals, the fundamental model was supported by the literature and the supporting educational elements of the quality improvement project were well-received by families. This model is worth continuing at this site:

the academic partnership with the audiology school will continue beyond the project for ongoing referrals, which, in turn, will allow for additional data collection. Broader data regarding the success of audiology evaluation referrals and its effects on the LTF rate will help gauge whether this process is worth replicating in other sites. The audiology clinic at the local university has stated an interest in continuing free or low-cost screenings to infants beyond the terms of the contract with the Department of Health due to the scarcity in available clinical opportunities with children for their audiology graduate students. This audiology clinic would likely be able to accommodate hearing evaluation of patients referred from other sites in the region as well. In the suburban teaching hospital, the commitment of leadership to this process change and the low costs of maintaining the new procedures will help sustain this practice beyond the implementation period of the project. Potential spread of this education and academic partnership referral model other sites will be partially limited by the need for similar geographic proximity to audiology schools to make this intervention successful.

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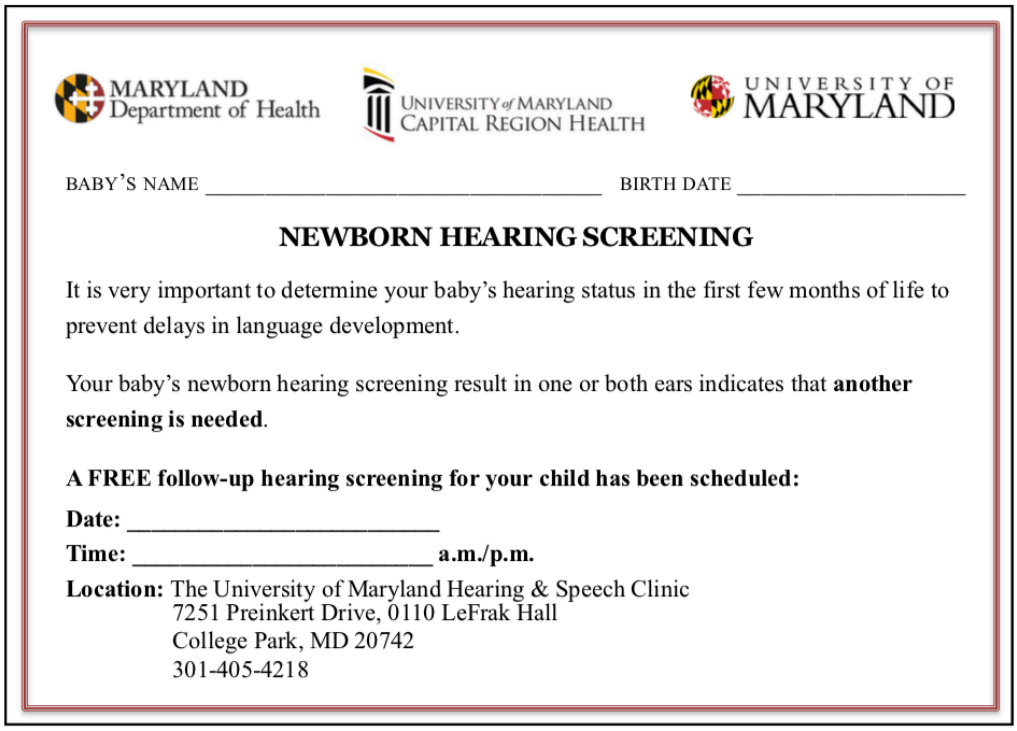
Appendix A
Protocol Updates to Infant Hearing Screening Protocol

1. Initial hearing screening should be performed prior to hospital discharge; ideally as close as possible to discharge
2. Rescreening should be performed by one month of age
3. Infants who fail their screenings should be referred for a diagnostic audiological evaluation
4. Families of infants who fail hearing screenings will be educated about the significance of the test result and the importance of determining the baby's hearing status
    a. The technician performing the screening will use the following script as a starting point for education:
        i. "Your baby did not pass the screening test that we gave him/her today. There could be many reasons for this, most of which do not mean your baby has a hearing problem. Because of the chance your baby could be hard of hearing, it's important to do a follow-up test to figure out your baby's hearing status. If a problem with hearing isn't identified early, then that can get in the way of a baby's development. We've made an appointment for you for a free hearing test for your baby at an audiology clinic. This handout has appointment information for you and information about hearing testing for you to read."
    b. The technician performing the screening will provide the family with a card that indicates the baby's test results, the importance of receiving a follow up evaluation, and when the free appointment is scheduled.
    c. At discharge, nursing staff will review the appointment and the importance of audiology follow up as part of the newborn discharge teaching.
5. The results of the infant's hearing screen will be documented in the patient's medical record and will be entered into OZ, the Maryland EHDI program database, within 48 hours.

Appendix B
Staff Training Plan

Learning objectives	**Content outline**	**Method of instruction**	**Time spent**	**Method of evaluation**
Understand the importance of early identification of hearing difficulties	• Impact of hearing on childhood development • Importance of early identification of hearing status • Describe state EHDI program efforts	Presentation/discussion	3 minutes	Teachback
Understand the services available to patients for free at UMD Hearing and Speech Clinic	• Explain background of collaboration between MDH, UMD • Explain services free services for infant audiological evaluation	Presentation/discussion	2 minutes	Teachback
Understand each individual role in arranging the referral appointment and communicating and reinforcing the appointment with families	• Describe individual roles in facilitating appointment, educating families, and reinforcing • Describe color card system utilized for education and appointments	Presentation/discussion	3 minutes	Teachback, return demonstration

Appendix C
Example handouts



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BABY'S NAME _____ BIRTH DATE _____

NEWBORN HEARING SCREENING

It is very important to determine your baby's hearing status in the first few months of life to prevent delays in language development.

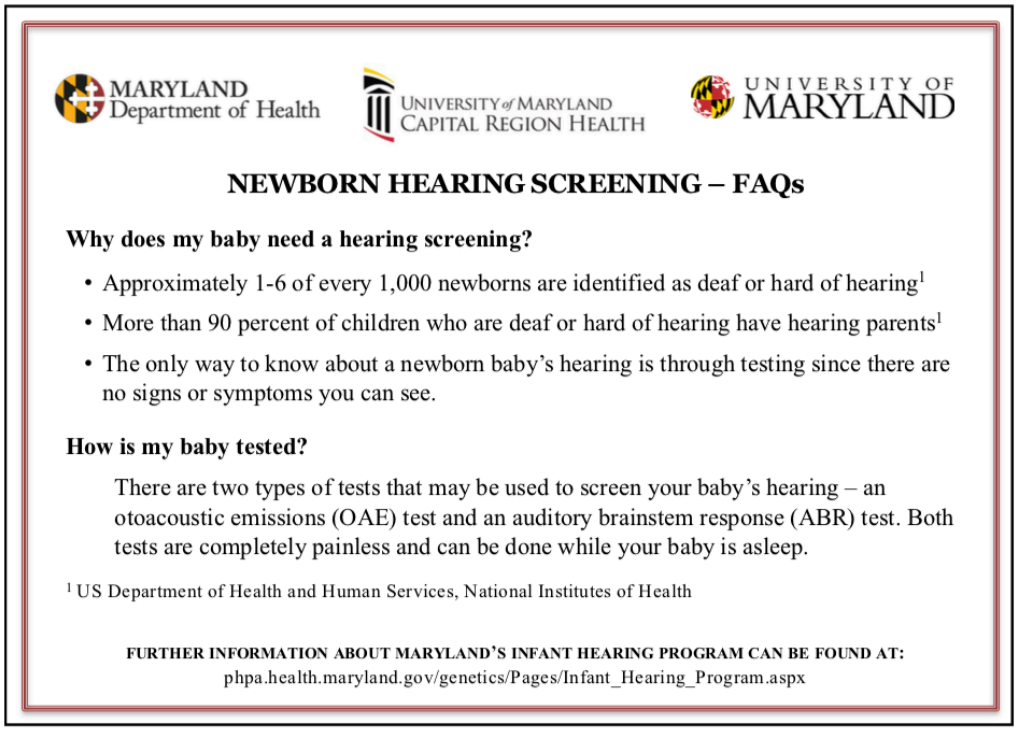
Your baby's newborn hearing screening result in one or both ears indicates that **another screening is needed**.

A FREE follow-up hearing screening for your child has been scheduled:

Date: _____

Time: _____ **a.m./p.m.**

Location: The University of Maryland Hearing & Speech Clinic
7251 Preinkert Drive, 0110 LeFrak Hall
College Park, MD 20742
301-405-4218



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NEWBORN HEARING SCREENING – FAQs

Why does my baby need a hearing screening?

- Approximately 1-6 of every 1,000 newborns are identified as deaf or hard of hearing[1]
- More than 90 percent of children who are deaf or hard of hearing have hearing parents[1]
- The only way to know about a newborn baby's hearing is through testing since there are no signs or symptoms you can see.

How is my baby tested?

There are two types of tests that may be used to screen your baby's hearing – an otoacoustic emissions (OAE) test and an auditory brainstem response (ABR) test. Both tests are completely painless and can be done while your baby is asleep.

[1] US Department of Health and Human Services, National Institutes of Health

FURTHER INFORMATION ABOUT MARYLAND'S INFANT HEARING PROGRAM CAN BE FOUND AT:
phpa.health.maryland.gov/genetics/Pages/Infant_Hearing_Program.aspx

Appendix D
Screening Results Summary by Project Phase

Weeks	Screening results
Weeks 1-3 (no cards available)	• 72 babies born • 71 screened (1 in NICU unable to screen) • 4 babies did not pass initially, passed on inpatient rescreen
Weeks 4-6	• 68 babies born • 67 babies screened (1 baby deceased) • 3 babies did not pass initially, passed on inpatient rescreen
Weeks 7-9	• 76 babies born • 76 screened • 5 babies did not pass initially, later passed on inpatient rescreen

Appendix E

Evidence relating to newborn hearing screening follow-up: interventions and root cause analysis

Author, Year	Study objective/ intervention/ exposures	Design	Sample (N)	Outcomes studied/ measured	Results	Level and quality rating
Hunter, L. L., Meinzen-Derr, J., Wiley, S., Horvath, C. L., Kothari, R., & Wexelblatt, S. (2016)	The objectives of this study were to decrease newborns lost to hearing screening follow-up by providing rescreening appointments at a local WIC program in conjunction with participants' WIC appointments.	Non-randomized controlled trial	260 WIC-eligible infants received the intervention compared to 1,233 infants who did not receive the intervention.	Lost to follow-up (LTF) rate of infants who failed initial screen; average age of hearing confirmation	Babies in intervention arm had LTF rate of 9.7% compared to 28.7% in non-intervention groups ($p<0.001$) and control hospitals 18.1%, ($p=0.02$). Average age of hearing confirmation in intervention group was 34.8 days compared to 63.6 dates in the control ($p<0.001$).	Level III, Grade A quality evidence
Ravi R, Gunjawate D, Yerraguntla K, Lewis L, Driscoll C, Rajashekhar B (2016)	This meta synthesis examined global studies that identified causes for lost-to-follow-up rates in early newborn hearing screening programs	Systematic review	53 articles were reviewed among single- and multi-center studies across the globe	Causes identified for LTF rates in early newborn hearing screening programs and most common strategies for overcoming these problems	Overall LTF rates were 20% in single-center and 21% in multi-center studies. Educational disparity and lack of knowledge among parents were most strongly associated with loss to follow-up. Most common strategy to overcome LTF was a data-management system, followed by increased parental education.	Level V. grade B quality evidence

Cunningham, M., Thomson, V., McKiever, E., Dickinson, L. M., Furniss, A., & Allison, M. A. (2017)	This retrospective analysis examined the characteristics of newborns who failed their initial hearing screen in-hospital	Retrospective case-control cohort study	13,904 Colorado newborns did not pass the newborn admission hearing screening from 2007 to 2012, and 2,482 did not have a documented follow-up	Characteristics of infants were analyzed, including maternal age, race, insurance status, maternal education level, maternal substance use, residence, birth order, time living in US, gestational age, genetic abnormalities, cleft lip.	Maternal age, education, smoking, and birth country; and payer, race, birth order, and population density were associated with completion of follow-up hearing screening. Low-income, rural, and minority infants are at risk for loss to follow-up, as were babies with history of maternal smoking, lower family education level, and multiple siblings. Foreign-born mothers were more likely to complete outpatient rescreenings.	Level IV evidence, grade A
Russ, S. A., Hanna, D., DesGeorges, J., & Forsman, I. (2010)	This qualitative study used a learning collaborative "Model for Improvement" to decrease infants lost to follow-up for hearing screens. Interventions included linking EHDI program with a medical home, expanding family options to communicate, providing "roadmap" education, trying to reduce audiology appointment bottleneck, and increasing early intervention program enrollment	Case series study (mostly qualitative)	Early Hearing Detection and Intervention (EHDI) programs in eight states and the infants they serve	Rates of LTF infants at three months, parent feedback and staff feedback about the program cycle improvement process	Only one program site out of eight sustained a decrease in LTF infants by three months old. Feedback from families was positive as engagement increased. Staff feedback was also positive and singled small-level "promising changes" meriting broader implementation and data follow-up	Level VI evidence, grade C quality
Bhatia, P., Mintz, S., Hecht, B. F., Deavenport,	7 federally qualified health centers (FQHCs) implemented a periodic, objective infant-toddler	Case series study	Infant patients at 7 FQHC sites. 1965 hearing	Rates of screenings conducted, fail rates, rates of	1696 patients received hearing screenings, 205 (10%) failed in at least one ear, seven patients	Level IV, quality B evidence

A., & Kuo, A. A. (2013).	hearing screening program during well-child visits		screenings were performed for 1696 unique patients	patients who failed who received audiology follow-up	met criteria for being followed by audiology, and five patients were identified as having had hearing loss. No statistical analysis was conducted; the site showed satisfaction with the process of screening and prompt intervention.	
Krishnan, L. A., & Van Hyfte, S. (2014).	This study examined the effects of a policy change requiring an audiology appointment to be made prior to hospital discharge of infants who failed the initial screen	Case control study	111 infants who failed initial hearing screening and required diagnostic follow-up	Follow-up rates, rates of infants diagnosed with hearing loss. Rates were compared to a previous 2009 study of a similar population from prior to the policy change	22 infants were identified as having some variety of hearing loss requiring further assessment (with 6 having sensorineural hearing loss) and 8 infants (7%) were lost to follow-up (from 18% in the 2009 study). Time of identification went from 7 to 4.8 weeks, time of hearing loss confirmation went from 18.7 weeks to 7 weeks, and hearing aid fitting went from 11 months to 6 months.	Level IV, grade B
Cockfield, C. M., Garner, G. D., & Borders, J. C. (2012).	This case series study used scripted NP education and an appointment card for hearing screen was provided to families of infants who failed their initial screens	Case series study	17 newborns who failed initial hearing screening at two different sites	Infants who failed initial screen who attended audiology appointments within three months	14/17 newborns had audiology appointments within three months, 3 newborns were lost to follow-up. Hospital A had a statistically significant (P=0.01) improvement. Hospital B rates went from 70% to 40% but data analysis was not	Level IV, grade B quality

					conducted due to small sample size.	
Tran, T. Schindelar, L. Ibieta, T. Webb, J. Jumonville, W. Peat, M. & Berry, S. (2017)	This study examined the relationship between audiology appointments scheduled prior to discharge and lost to follow-up rates and diagnosis times in Louisiana	Case control study	4598 children in Louisiana who failed initial hearing screen	Loss to follow-up, initiation of follow-up time to completion of audiological diagnosis.	56.1% were scheduled for a hospital appointment prior to discharge; the lost to follow-up rate was 32% for those without an appointment schedule before discharge vs 20.9% for those with an appointment schedule before discharge ($p<0.001$). There was no association of early diagnosis with hospital scheduled appointment (83.6% no appointment vs 90.8% with appointment, $p=.362$)	Level IV evidence, grade A quality