NCHAM National Center for Hearing Assessment and Management Utah State University

JEHDI The Journal of Early Hearing Detection and Intervention

2019; 4(1): 36–42

Newborn Hearing Screenings for Babies Born at Home: Report from an Initiative in Michigan

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Abstract: Objective: Babies born in an out-of-hospital setting (e.g., homebirth) often do not receive a universal newborn hearing screening (UNHS). The purpose of this study was to evaluate the effect of providing training and equipment for newborn hearing screening to midwives who attend homebirths.

Study Design: Midwives from around the state of Michigan were invited to participate in a two-part UNHS training. Hearing screening data from all midwives who attended homebirths (N = 112) during the 2015 and 2016 calendar years were analyzed using a two-level multilevel model. Estimated odds of babies being screened were calculated based on midwife group.

Results: Having a midwife who hosted an Automated Auditory Brainstem Response (AABR) machine at her practice increased the odds of receiving a screening by 39.37 times. Having a midwife who had access to an AABR machine increased the odds of receiving a screening by 8.57 times. Having a midwife who received focused education about the importance of newborn hearing screening increased the odds of receiving a screening by 10.82 times.

Conclusion: Providing UNHS equipment and training to midwives significantly increases the odds that babies born at home will receive a hearing screening at birth. This is evidence for the continued outreach and inclusion of midwives in UNHS programs.

Key Words: newborn hearing screening, homebirth, midwifery

Acronyms: AABR = Automated Auditory Brainstem Response; EHDI = Early Hearing Detection and Intervention; SWOT = Strengths, Weaknesses, Opportunities, and Threats; UNHS = universal newborn hearing screening

Acknowledgements: The authors would like to acknowledge Dr. Brittny Burdick for her contributions to this project and her assistance with the midwives' training. The authors would also like to acknowledge Evan Withrow for his work in compiling the data for this analysis.

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Disclosures: This project was supported by a grant from the Carls Foundation, Bloomfield Hills, MI. Wendy Switalski was an employee and shareholder of Audiology Systems, Inc. at the time of the study, which was the distribution company from which the hearing screening equipment was purchased. The other authors have no conflicts of interest relevant to this article to disclose.

Having a homebirth is a choice that an increasing number of Americans are making (MacDorman, Declercq, & Mathews, 2013; MacDorman, Mathews, & Declercq, 2012). There has been a 39% increase in the overall proportion of out-of-hospital births in the United States from 2004–2010 (MacDorman et al., 2013). Unfortunately, in a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of Early Hearing Detection and Intervention (EHDI) programs across the country, homebirths were listed as the third most reported weakness (12% of respondents; Houston, Bradham, Muñoz, & Guigand, 2011). Concerns included lack of follow-up for homebirths and many EHDI coordinators reported that the majority of babies born at home did not receive a screening (Houston et al., 2011). Many families who choose to have a homebirth face financial, cultural, educational, or logistical barriers when trying to obtain a newborn hearing screening.

Most homebirths (70.1%) in the United States are attended by a midwife (MacDorman et al., 2013), and midwives have professional responsibilities in the newborn hearing screening process. The American College of Nurse Midwives Core Competencies (2012) indicates that the midwife independently manages and provides care for newborns up to 28 days of life. In addition, according to the Midwives Alliance of North America Core Competencies for Midwifery Practice (2014), the midwife provides postpartum care to the newborn as well as support and information to parents about screening tests and the applicable laws and regulations, including newborn hearing screening. In the state of Michigan (MI), for example, the state guidelines for newborn hearing screening state that, “Health professionals who provide birthing services outside of a hospital will ensure that a newborn hearing screening is completed within one month of the birth” (MI Early Hearing Detection and Intervention System, 2002). In Michigan, the term *health professional* is typically interpreted as a professional who holds a license in their health care field. Midwives are not currently licensed in Michigan, but an amendment to current legislation will require any midwife attending homebirth to be licensed beginning in 2019 (MI Public Health Code. Act 368 of 1978). Although the legal guidelines vary state to state, this specific example suggests that the responsibility is on the midwife attending an out-of-hospital birth to verify that the hearing screening is completed.

Although midwives have a responsibility to provide information to their clients about newborn hearing screening, a survey of 518 practicing midwives showed that 92.9% reported having a lack of knowledge to guide families through the newborn hearing screening process (Goedert, Moeller, & White, 2011). Many midwifery education programs report including some information about newborn hearing screening as part of their curriculum, but this may not be sufficient for midwives to take an active role in a newborn hearing screening program (Palmer, Bednarz, Dilaj, & MacDonald, 2016). The purpose of this study is to determine if a training program, along with providing equipment, improved hearing screening rates for babies born in out-of-hospital settings. This included an analysis of newborn hearing screening data after implementation of this training program to see if babies born in an out-of-hospital setting were more likely to receive a newborn hearing screening based on their midwife’s participation in the training program and her access to an Automated Auditory Brainstem Response (AABR) screening machine.

Method

Training

In 2014, an initiative spearheaded by the Michigan Coalition for Deaf and Hard of Hearing People, a 501(c)3 organization, in partnership with the Michigan EDHI program and Central Michigan University provided hands-on training and distributed 15 AABR machines to midwives who attend homebirths. This effort was supported by a grant from the Carls Foundation, who only funds 501(c)3 agencies. All midwives in the state of Michigan were invited to participate in a training session. Invitations to participate were distributed through the Michigan Midwives Association, who supported this effort, and direct contact with midwives across the state. In order to participate in the hands-on training and receive access to an AABR machine, the midwives were required to first complete an online educational training. The online training was created by the Michigan EDHI program to train all healthcare professionals who will be doing newborn hearing screening. It consisted of ten modules covering topics such auditory anatomy, hearing screening methods, risk factors for hearing loss, communicating and reporting screening results, the hearing screening process, and a final assessment. This is the same online training completed by hospital staff. Each participant completed the online training and passed the final assessment with a score of 80% or better prior to attending a hands-on training session.

Hands-on training sessions were conducted in five different locations around Michigan over a four-month period in early 2014. The hands-on training sessions were conducted by a MI EHDI program consultant, a pediatric diagnostic audiologist, an audiology graduate student, and a representative of the equipment distribution company. The equipment representative provided step-by-step instruction and practice using the AABR equipment. The audiologist then led a discussion of the importance of hearing screening, how to communicate screening results to parents, and the process for follow-up after a baby refers on the screening. Challenges specific to homebirth families were addressed. The MI EHDI program consultant then reviewed the Coalition Agreement for using the equipment, the process and paperwork for reporting screening results, and diagnostic sites where families could be referred if additional testing was needed. Finally, each midwife completed a hearing screening using the Baby ISAO (Intelligent Hearing Systems) hearing loss simulator. The training sessions were about 2–3 hours each.

Midwives who participated in this training were either given an AABR machine to host in their practice or provided access to borrow a machine from a host location. The Coalition purchased an additional AABR machine, for a total of 16 and provided an additional hands-on training session in mid–2016. This was a refresher course for most participants who had extremely limited access to a machine, and recruited two new midwives into the program, with one hosting the new machine. The Coalition maintains ownership of the machines, purchases supplies, and arranges calibration and insurance for the equipment. The Coalition also works closely with EHDI and their data to determine best placement of machines on an annual basis. After the second year of the grant (Fall of 2015), midwives were assessed a minimal per baby screening fee, payable to the Coalition, to be able to continue to purchase and ship supplies, as well as provide calibration and insurance on the machines.

Participants

Data for this study were obtained from the state-wide hearing screening data reported to the EHDI program. Data included all midwives from the state of Michigan who reported attending a homebirth in the 2015 and 2016 calendar years and who did a metabolic blood spot screen ($N = 112$). Midwives belonged to four groups including those who hosted a machine for EDHI screening (*host midwives;* $n = 15$; 13.39%), those who had access to a machine (*access midwives;* $n = 25$; 22.32%), those who received educational resources through the free online training provided by EHDI but did not complete the hands-on training and therefore did not have access to a machine (*education midwives;* $n = 4$; 3.57%), and those who did not receive access to screening machines or to educational resources (*non-participants;* $n = 68$; 60.71%). There were no missing data.

Although all midwives in the state were encouraged to participate in the training program, midwives self-selected whether they were interested in the training or not. Any midwife who completed both the online and hands-on training were included as access midwives (excluding those chosen as host midwives). Host midwives were chosen based on geographic location and birth volume to have a distribution across that state that met the needs of the region. Midwives who submitted a metabolic bloodspot screen but did not participate in any part of the training program were included in the non-participant group.

Data Analysis

The purpose of this study was to determine the odds of an infant undergoing hearing screening based on a midwife's access to and experience with AABR screening machines, as well as the total number of homebirths the midwife has attended. Because infants who were delivered by the same midwife do not have independent outcomes from one another (i.e., infants are "clustered" or "nested" within midwives), a two-level multilevel model was used to account for the non-independence of observations (McCoach & Adelson, 2010) and to use a midwife-level variable (treatment group) to explain variability in our outcome (hearing screening status; McCoach, 2010). The outcome of interest was an indicator of whether or not the infant had been screened (SCREENED; 0 = *no*, 1 = *yes*). The level-one, or infant-level, model controlled for YEAR the baby was born (0 = *2015*, 1 = *2016*). The level-two, or midwife-level, variable of interest was their treatment status, represented by three dummy-coded group variables (HOST, ACCESS, and EDUCATE, with NONE as the reference group) At this level we controlled for the total number of births the midwife attended in 2015 and 2016 combined (TOTBIRTH), which we grand-mean centered so that it would have a meaningful 0 (Enders & Tofighi, 2007).

Given that our outcome (whether an infant was screened) was binary, we specified our model using a Bernoulli distribution, a binomial level-1 sampling model that provides the probability or odds of the desired outcome. Full maximum likelihood (FIML) and EM Laplace iterations were used to produce population-average models. Compared to unit-specific models, "population average models generally will be more useful when the desired inferences focus on the group-level variables, rather than the varying effects of individual level covariates" (O'Connell & McCoach, 2008, p. 218). Additionally, with the population model, random effects are not held constant (O'Connell & McCoach, 2008).

We used a model-building approach, as recommended by Raudenbush and Bryk (2002). First, we used the HLM 7.03 software to estimate an unconditional model with SCREENED as the outcome variable to estimate the average probability that an infant was screened for hearing loss: $\exp(-0.65) / 1+\exp(-0.65) = 0.52/(1+0.52) = 0.34$. Next, we added the level-one control variable, YEAR, to determine if its slope should be allowed to randomly vary in subsequent models. Although the differential for 2015 and 2016 was not statistically significant ($p = .055$), the slope ($\gamma_{10} = 0.04$) did statistically significantly vary between midwives ($\tau_{11} = 0.13$, $\chi^2_{(91)} = 176.54$, $p < .001$). Based on model fit comparisons ($\chi^2\Delta_{(2)} = 12.59$, $p = 0.002$; AICΔ = 8.58; BIC(n)Δ =-3.13; BIC(j)Δ = 3.15), we chose to allow the slope to randomly vary and to retain the variable as a covariate in the model. This indicates that although the probability of being screened did not differ on average based on the year of birth, that differential varied across midwives; in other words, babies were more likely to be screened in 2015 for some midwives, more likely to be screened in 2016 for other midwives, and yet for other midwives there was no difference. Next, we added the level-two control variable, TOTBIRTH, as a predictor of the intercept. Although the total number of births a midwife attended did not predict whether an infant was screened ($\gamma_{01} = -0.0001$, $p = .99$), because our model is relatively simple and we identified this as a potential covariate a priori, we opted to leave it in the model. Finally, we added the three dummy-coded group variables of interest, HOST, ACCESS, and EDUCATE, to the intercept. This resulted in our final model:

$SCREENED_{ij} = \gamma_{00} + \gamma_{01}*TOTBIRTH_j + \gamma_{02}*HOST_j + \gamma_{03}*ACCESS_j + \gamma_{04}*EDUCATE_j + \gamma_{10}*YEAR_{ij} + u_{0j} + u_{1j}*YEAR_{ij}$

where the outcome is whether infant i whose birth was attended by midwife j was screened and γ_{02}, γ_{03}, and γ_{04} represent the differential in the log-odds of being screened when the attending midwife had hosted a machine, had access to a machine, or were provided with educational resources, respectively, compared to midwives who did not participate in the project at all, after controlling for the year of birth and the total number of births the midwife attended.

Results

For each group of midwives, we examined the number of births and the number of infants who were screened for hearing loss in 2015 and 2016. (The average number of births/infants screened per midwife for each group is provided in parentheses throughout the current paragraph.) The total number of births (2015–2016) for host midwives was 571 ($M = 38.07$, $SD = 29.64$) with 453 infants screened (79.33%; $M = 30.20$, $SD = 23.82$). Access midwives attended 513 births ($M = 20.52$, $SD = 13.66$) and screened 243 infants (47.37%; $M = 9.72$, $SD = 7.57$). Education midwives assisted with 140 births ($M = 35.00$, SD = 12.46) and screened 83 infants (59.29%; $M = 20.75$, $SD = 7.14$). Finally, our largest group, non-participants, assisted with 1,356 births ($M = 19.94$, $SD = 37.03$) and screened 87 infants (6.42%; $M = 1.28$, $SD = 2.53$). The average number of births, infants screened, and percentage of infants screened for each midwife group are provided in Table 1. In comparison with data from the MI EHDI database from 2013, prior to the implementation of the training program, the proportion of babies screened increased in all groups except the non-participant group. In 2013, only 14.2% of babies born at home received a hearing screening.

Table 2 reports the results for the final model. Total births ($\gamma_{01} = -0.01$; $p = .04$), host ($\gamma_{02} = 3.67$; $p < .001$), access ($\gamma_{03} = 2.15$; $p < .001$), and educate ($\gamma_{04} = 2.38$; $p < .001$) were statistically significant predictors of being screened. The intercept, $\gamma_{00} = -2.14$ ($p < .001$), represents the expected log odds of an infant being screened for hearing loss in 2015 when the midwife did not participate in the hearing screening project, after controlling for number of births she attended. Thus, the estimated odds (or *referent odds*) of being screened for a child with these characteristics is 0.12. Total Births had a negative effect on the log-odds of infant screening ($\gamma_{01} = -0.01$; $p = .04$) when controlling for midwife group and year. The odds of being screened is expected to be lowered by 0.99 as total births increases by one (holding other variables constant). There was not a statistically significant difference in the log-odds of an infant being screened when born in 2015 or 2016 ($\gamma_{10} = 0.22$; $p = .12$).

Table 1

Average Number of Births, Infants Screened, and Percentage of Infants Screened Per Midwife for Each Midwife Group 2015–2016

	Average Number of Births		Average Number of Infants Screened		Average Percentage of Infants Screened
	N	Mean (*SD*)	*N*	Mean (*SD*)	Mean (*SD*)
Host Midwives	571	38.07 (29.64)	453	30.20 (23.82)	82.08 (18.39)
Access Midwives	513	20.52 (13.66)	243	9.72 (7.57)	51.56 (29.68)
Education Midwives	140	35.00 (12.46)	83	20.75 (7.14)	59.86 (7.95)
Non-Participants	1,356	19.94 (37.03)	87	1.28 (2.53)	14.28 (27.27)

Note. Host Midwives: $n = 15$; Access Midwives: $n = 25$; Education Midwives: $n = 4$; Non-Participants: $n = 68$.

Having a midwife who hosted a machine for AABR screening had a positive effect on the log-odds of infant screening ($\gamma_{02} = 3.67$; $p < .001$) when controlling for total births, midwife group, and year. The odds of an infant with a midwife hosting a machine being screened was 39.37 times greater compared to an infant with a midwife in the non-participant group (holding other variables constant). Having a midwife who had access to an AABR machine had a positive effect on the log-odds of infant screening ($\gamma_{03} = 2.15$; $p < .001$) when controlling for total births, midwife group, and year. For infants with midwives in this group, the odds of being screened was 8.57 times greater compared to infants with a midwife in the non-participant group (holding other variables constant). Finally, having a midwife who was provided with educational resources had a positive effect on the log-odds of infant screening ($\gamma_{04} = 2.38$; $p < .001$) when controlling for total births, midwife group, and year. For infants with these midwives, the odds of being screened was 10.82 times greater compared to an infant with a midwife in the non-participant group (holding other variables constant).

Table 2
Fixed Effects from the Final Model of Infant Screening

Fixed Effect	Coefficient	*SE*	*t*(df)	*p*
Model for SCREENED outcome ($ß_0$)				
Intercept (γ_{00})	-2.14	0.22	-9.78 (107)	<.001
Total Births (γ_{01})	-0.01	0.004	-2.10 (107)	.04
Host (γ_{02})	3.67	0.39	9.37 (107)	<.001
Access (γ_{03})	2.15	0.33	6.46 (107)	<.001
Educate (γ_{04})	2.38	0.65	3.68 (107)	<.001
Model for YEAR slope ($ß_1$)				
Intercept (γ_{10})	0.22	0.14	1.56 9111)	.12

Fixed Effect	Coefficient	Odds Ratio	Confidence Interval
Model for SCREENED outcome ($ß_0$)			
Intercept (γ_{00})	-2.14	0.12	(0.08, 0.18)
Total Births (γ_{01})	-0.01	0.99	(0.98, 1.00)
Host (γ_{02})	3.67	39.37	(18.10, 85.64)
Access (γ_{03})	2.15	8.57	(4.34, 16.58)
Educate (γ_{04})	2.38	10.82	(3.00, 39.06)
Model for YEAR slope ($ß_1$)			
Intercept (γ_{10})	0.22	1.25	(0.94, 1.65)

Discussion

The likelihood that an infant would receive a universal newborn hearing screening differed significantly depending on midwives' access to AABR machines and the educational resources that they were provided during their initial trainings. Providing midwives with training and access to newborn hearing screening equipment had a positive effect on the number of babies who received a hearing screening. However, the likelihood that an infant would be screened decreased as the total number of births the midwife attended increased. These results support the need for continued national efforts to include midwives in the universal newborn hearing screening process.

Many practicing midwives do not think that participating in newborn hearing screening is part of their job or feel unprepared to participate in a newborn hearing screening program (Goedert et al., 2011). However, during their care for infants, midwives are expected to develop a plan for care, which includes national and local screening guidelines (ACNM, 2012). This includes newborn hearing screening. By training midwives and providing them access to newborn hearing screening equipment, the rate of newborn screenings increased. Although the number of midwives receiving education only was small ($n = 4$), there was an increase in the odds of screening even for those midwives who only received focused education about the importance and process of newborn hearing screening. This suggests that even if implementing a full screening program for midwives is not financially or logistically feasible, increasing educational outreach to midwives and identifying local community locations where they can refer their families to have the baby's hearing screened can have a significant positive effect on newborn hearing screening rates. Further research on this as an intervention needs to be conducted.

To date, this is the first study to present outcome data from a program to train midwives to conduct newborn hearing screenings. In a study of the implementation of universal newborn screening in the state of Wisconsin, Kerschner et al. (2004) mentioned that a group of midwives purchased hearing screening equipment and provided screening services for their homebirth clients. Although the midwives who participated had 79% screening rate, there were only three groups of midwives who participated in this program as of 2002 and the efforts were focused on a small geographical region of the state (Kerschner et al., 2004). Although there may be some initial resistance, from either midwives or state agencies, to training midwives, both the midwives in Wisconsin (Kerschner et al., 2004) and the midwives in Michigan who participated in these programs have been supportive of these efforts.

Two populations that traditionally choose homebirth and often are served by midwives are the Amish and Mennonite communities. With the increased likelihood of genetic and congenital conditions in these closed communities, effective newborn screening is extremely important (Morton et al., 2008). In a study of opinions about newborn screening in Amish and Mennonite communities in Wisconsin, Sieren et al. (2016) found that most families reported a positive view of newborn screening but cited lack of knowledge at the time or lack of access as reasons for not having their children screened. Sieren et al.'s (2016) questions focused on the newborn screening program as a whole, not specifically newborn hearing screening. However, the newborn hearing screening is considered a standard part of the newborn screening process. These data suggest that if midwives serving these communities are able to offer newborn hearing screening as part of their services, the Amish and Mennonite communities would be amenable to increasing their screening rate.

Limitations of this study include the timeframe of data collection, self-report nature of the hearing screening data, and difference in group sizes. Screening rates for this study were only analyzed for the first two years following implementation of this program. Continued training and support may result in further change in screening rates. Therefore, additional analysis over a longer timeframe would be beneficial.

The data for this study was taken from the MI EHDI database for all reported hearing screenings. However, it is possible that there are practicing midwives who chose to not report any screening data or were unable to be tracked with the Michigan data system. This information is not included in this analysis. At the time of this study, Michigan used Perkin & Elmer software to track hearing screenings and they can only be tracked if the baby also has a metabolic blood card screening as well. Midwives who performed hearing screenings, but not the metabolic screenings are not included in this study.

Looking at the size of each subject group, there was a much smaller number for midwives in the education only group ($n = 4$) compared to the other groups. The midwives in this group completed the online training modules but did not attend a hands-on training session. Most of the midwifes of the education-only group were recent transplants to the state and learned about the program immediately after all the hands-on training took place. Those midwives worked with the EHDI program consultant to take the on-line training and identify local community resources to direct their families. One of these midwives was from an Amish community. Even with such a small group there was a significant difference between the screening rates of babies born to midwives in this group compared to the non-participant group. Having seen an effect with such a small group could indicate the importance of additional education for midwives.

Distribution of the equipment was a limiting factor for this program. There were certain areas of the state that had higher homebirth rates than other areas, requiring an uneven distribution of the AABR equipment to account for the busier midwifery practices in those areas. Requiring midwives to share equipment was often challenging because several practices may have had conflicting schedules or needs. This necessitated a re-evaluation of the host sites and locations of the equipment annually. Continual monitoring of the birth and screening rates in different regions of the state have been vital to the maintenance of the program.

Recognizing that homebirth attendants have a powerful influence and provide guidance among parents who choose homebirth, it is important for EHDI programs to include this population when considering outreach programs. For programs considering embarking on a similar project, it is important to consider multiple training dates due to the nature of the work of midwives to be on call to deliver babies. In every training session, there was at least one and up to four fewer midwives attending than signed up, due to their unpredictable schedules. Offering multiple trainings in different locations ensures midwives had a chance to attend a later training if circumstances prevent them from attending a training session.

In Michigan EHDI's own homebirth analysis, covering the years 2014–2016, rates of babies identified with hearing loss within this population was statistically larger than expected, which was a revelation. The potential of early identification of babies who are deaf or hard of hearing and ensuring timely intervention services is the ultimate goal of all EHDI programs. Without this program, these babies were unlikely to be diagnosed until they were much older.

Conclusion

Providing midwives with training and education about newborn hearing screening as well as access to equipment increases the odds of a baby receiving a newborn hearing screening. Although midwives who had constant access to screening equipment had the highest odds of screening babies, providing access to equipment, even if not constant, and providing additional education and community resources, but not access to equipment also had a positive effect on the odds of babies being screened. The logistics of completing the trainings, distributing equipment across the state, maintaining equipment, and obtaining insurance for equipment are complicated; however, the outcomes have demonstrated the success of this type of program. Indeed, the results of this study, feedback from the midwives and the EHDI analysis has spurred The Coalition to seek additional funds and extend the partnerships to expand this project to increase the number of AABR machines available for Michigan midwives to be able to offer hearing screenings for their families.

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