Published in final edited form as:

Otol Neurotol. 2013 December ; 34(9): . doi:10.1097/MAO.0b013e31829e83ad.

Timing Discrepancies of Early Intervention Hearing Services in Urban and Rural Cochlear Implant Recipients

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Abstract

Objective—The purpose of this study was to examine the timing of early intervention diagnostic and therapeutic services in cochlear implant recipients from rural and urban areas.

Study design—Retrospective case series review

Setting—Tertiary referral center

Patients—Cochlear implant recipients from a single comprehensive hearing institute born with severe congenital sensorineural hearing loss were examined. Timing of diagnostic and therapeutic services was examined.

Intervention(s)—Diagnosis, amplification, and eventual cochlear implantation for all patients in the study

Main outcome measure(s)—Time points of definitive diagnosis, amplification, and cochlear implantation for children from urban and rural regions were examined. Correlation analysis of distance to testing center and timing of services was also assessed.

Results—40 children born with congenital hearing loss were included in the study and were diagnosed at a median age of 13 weeks after birth. Children from rural regions obtained amplification at a median age of 47.7 weeks after birth, while urban children were amplified at 26 weeks after birth. Cochlear implantation was performed at a median age of 182 weeks after birth in those from rural areas and at 104 weeks after birth in urban-dwelling patients. A linear relationship was identified between distance to the implant center and timing of hearing aid amplification ($r=0.5$, $p=0.033$) and cochlear implantation ($r=0.5$, $p=0.016$).

Conclusions—Children residing outside of metro areas may be at higher risk of delayed rehabilitative services and cochlear implantation than those residing in urban areas that may be closer in proximity to tertiary care centers.

Keywords

Cochlear implants; Congenital hearing loss; Rural healthcare

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Presented at American Otological Society, April 13, 2013, Orlando, FL

INTRODUCTION

Pediatric hearing loss is a common problem with an incidence of approximately 1 per 1000 births.¹ The sense of hearing is vital during the early years of life for the development of speech, language, and cognition and early identification and intervention can prevent adverse educational and social consequences. The consequences of delayed diagnosis and/or failure for appropriate intervention for infants with hearing loss can be significant delays in language, cognitive, and social development.²

Universal newborn hearing screening programs in hospitals have been implemented in most states and help in early identification and timely intervention for children born with hearing loss. The standards of care that have been recommended by the National Institutes of Health,³ Joint Committee on Infant Hearing (JCIH),⁴⁻⁷ and the American Academy of Pediatrics⁷ are that a diagnosis of hearing loss should be made before 3 months of age, rehabilitation with hearing aid amplification prior to 6 months of age, and if no progress is made cochlear implantation should occur at 12 months of age. The United States Preventive Services Task Force has recognized the relationship of hearing loss with communication skills, psychosocial development, and educational progress.⁸ Early identification of hearing loss leads to utilization of early intervention services.^{9,10} Initiation and utilization of early intervention services with hearing aids prior to 6 months of age has shown to improve language expression in the school setting.¹¹⁻¹⁴ Early cochlear implantation results in significant development within the cortical auditory system.¹⁵⁻¹⁷ Age of implantation has also been identified as the primary predictor of language development outcomes in children with hearing loss.^{18,19}

The screening tests and appropriate follow up for definitive diagnostic testing is vital; however, issues such as compliance, socioeconomic factors, and access to care remain major barriers to timely hearing healthcare. The presence of disparities in diagnostic and intervention services result in some socioeconomic groups being at a high risk of becoming lost to follow-up.²⁰⁻²² Patients in rural areas face additional access to care barriers that compound these concerns. These barriers include lower socioeconomic status, unemployment, and a shortage of healthcare. Pediatric cochlear implantation centers are sparse in many states with a largely rural population and travel distances can impede intervention. The timing of diagnostic and intervention services for children with severe congenital hearing loss in rural areas is largely unstudied and further investigation may identify disparities and delays in appropriate care. The purpose of this study is to assess for disparities in the timing of hearing loss diagnosis and intervention services in children from a major urban area and those from nearby rural counties.

METHODS

Institutional review board approval was obtained prior to initiation of the study. Clinical and demographic data from the records of children (<18 years old) with cochlear implants from a single non-profit comprehensive cochlear implantation institution were examined. This center serves as one of only a few cochlear implant centers within the state and provides cochlear implant services for a large geographic area. The implant center is located within a large metro area that encompasses a population of over 1 million people and includes 8 counties of central Kentucky and 4 in southern Indiana.²³ This Louisville metro area is includes both urban and suburban areas. The region outside this metro area is largely rural. Children that were included in the study had failed newborn hearing and follow-up audiological testing confirmed severe sensorineural hearing loss. These children were fit with hearing aids and subsequently received cochlear implantation. Diagnostic and intervention services were provided for some children outside the implant center; however,

all children underwent cochlear implant assessment and rehabilitation at this single center. Children with acquired causes of hearing loss or progressive were excluded from the study. We collected demographic data including date of birth, county or origin at time of birth based on ZIP code, date of diagnosis of hearing loss, date of hearing aid amplification, and date of cochlear implantation. All dates were recorded in weeks after birth. Children were separated into two groups based on county of origin to the urban region (within one of the twelve Louisville-metro counties) or rural region (counties outside this metro area). The status of bilateral and unilateral cochlear implantation was also recorded. The rural status of each county of origin was determined using the Beale codes of 2003 United States Department of Agriculture Rural-Urban Continuum Coding system²⁴ and was recorded. This numerical scale has 9 classifications with the most urban county being 1 with a metro population of 1 million or more and 9 being the most rural code indicating that the county is completely rural or less than 2500 urban population and not adjacent to a metro area. Differences in these variables in urban versus rural patients was examined using the two-sample Wilcoxon rank-sum test and Chi square analysis. Distance from the ZIP code of origin to the diagnostic/CI center was also recorded. Pearson's correlation coefficient analysis was performed on this data to determine the relationship of distance to the timing of amplification and cochlear implantation. Data were managed using an Excel spreadsheet (Microsoft, Redmond, WA, USA), and statistical analyses were performed with Stata (StataCorp, College Station, TX, USA).

RESULTS

We identified 40 cochlear implant recipients who met inclusion criteria. These children were implanted between 1993 and 2011 and 35 of the children were implanted after 2000, when mandatory newborn hearing screening was implemented. All of the children failed newborn hearing screening and were subsequently found to have severe sensorineural hearing loss. Diagnostic testing and amplification throughout the urban and rural regions include state-sponsored clinics through the Cabinet for Health and Family Services, academic and private Audiology and Otolaryngology practices, and the Heuser Hearing Institute. All children in the study had cochlear implant evaluation and post-implantation rehabilitative services performed at the Heuser Hearing Institute and most of the subjects had diagnostic testing and amplification services performed as well at this institution. Gender was equally balanced with 21 female children and 20 males. There were 28 children from the Louisville-metro counties (the Beale code for all these counties is 1 indicating a dense urban area). The average distance of travel for children from the urban region to the Heuser Hearing Institute (which is in the metro area) was 15.5 miles (range of 1–37 miles). There were 12 children from adjacent and regional counties outside this metro area in and these counties have Beale codes ranging from 1–8 with an average code of 5 (indicating rural status). Only 1 child was from a Beale code county of 1, which is an adjacent county to the Louisville metro area. The average distance of travel for children in the rural region was 97.8 miles (range of 40–164 miles).

ABR was the primary means of diagnostic evaluation after failed newborn hearing screening and we found no significant difference in the age of diagnosis of hearing loss in children from urban and rural areas. The median age of diagnosis was 13 weeks after birth for both urban and rural regions ($p=0.861$). We identified a trend toward amplification disparity as children from rural regions were fit with hearing aids at a median age of 47.7 weeks after birth while urban children were fit at a median age of 26 weeks ($p=0.205$) (Figure 1). We also identified a trend in delayed cochlear implantation in rural region children as they were implanted at a median age of 182 weeks after birth while urban children were implanted at a median age of 104 weeks after birth ($p=0.050$) (Figure 2). Using a Chi square analysis, we also found that there were a greater percentage of children from rural regions with bilateral

cochlear implants (58%) than those from the urban area (25%) ($p=0.043$) (Figure 3). A linear relationship was identified between distance to the implant center and timing of hearing aid amplification ($r=0.5$, $p=0.033$) and cochlear implantation ($r=0.5$, $p=0.016$) (Figure 4). The average distance of travel for those in urban counties was 13.5 miles and 96 miles for those in rural counties.

DISCUSSION

Expediting the diagnosis and intervention of congenital hearing loss is vital and this study sought to identify differences in hearing healthcare timing for those from a rural region that surrounds an urban area. Approximately 20% of the U.S. population resides in rural areas²⁵ and the effect of rural residence and distance from rehabilitation services has not been widely evaluated in cochlear implant recipients. The state of Kentucky is largely a rural state as 85 of the 120 counties are considered rural and 1.8 million people live in rural region out of a total state population of 4.2 million people.²⁶ This state has implemented newborn hearing screening throughout and has diagnostic services available throughout the state; however, cochlear implantation services are only available in 2 urban areas (Louisville and Lexington) for the entire state. Many other states have cochlear implantation centers that are faced with this rural-urban disparity and access to services can be challenging for patients. Perhaps as a result of a mature newborn hearing-screening program, we found that hearing loss in children from rural regions can be diagnosed in a timely manner as both urban and rural had a median age of diagnosis within the JCIH⁴⁻⁷ recommended 3 months of age time frame. Children from the metro region also were within the recommend time frame of amplification (median age of 6 months) and were implanted in a timely fashion (median age of 2 years of age). This urban region, for the purposes of this study, was referred to as urban based on USDA population Beale county code determinations; however, this region is diverse in terms of insurance status, socioeconomic status, and race/ethnicity and further investigation is indicated to characterize differences within urban populations in access to care. Regardless of the diversity, the children within this metro area were within close proximity to necessary services and were an average distance of 13.5 miles away from the comprehensive hearing healthcare system and were treated within the recommended time frame.

The children from the rural areas also have diverse backgrounds but all children had significant distances to travel to obtain timely care. These children resided, on average, 96 miles from the implant center. We identified a trend that indicated that the children from the rural counties were delayed in obtaining therapeutic services. Specifically, children from rural regions received their first cochlear implant around 3.5 years of age. Although there is no universally accepted age of implantation, it is accepted that earlier implantation result in better language development.^{18,19} If we examine age 2 as a target age in cochlear implantation, as used in a recent study,²⁷ we see that only 33% of those from the rural region were implanted before age 2 while 54% of children from the urban region were implanted before age 2. Interestingly, we also found that a higher percentage of children from rural regions had bilateral cochlear implants. This may seem counterintuitive, as it might be expected that children from areas of hearing healthcare disparity may have limited resources and may not be able to or willing to undergo the rehabilitative process necessary for bilateral cochlear implant recipients. A potential theory for this finding, grounded in our clinical experience, proposes that this phenomenon is based simply on the age of the 1st implant and is not a function of the rural residence. Further investigation needs to be performed to examine this finding; however, anecdotally, we have found that children who have significant language developmental delays due to delays in either diagnosis or initiation of therapeutic services are often likely to receive bilateral implants. It has been our observation that when children “fall through the cracks” but eventually receive appropriate

services at an older age there is a trend to maximize medical and surgical treatment. For example, if children from rural regions are implanted with their first implant at 3 years of age there is often a dramatic speech delay compared with their normal hearing peers and a heightened level of concern for their development is often a driving force to seek a second implant. At 12–24 months of age, the contrast in language differences between hearing impaired children and normal hearing children may not seem as drastic and a unilateral cochlear implant recipient may make satisfactory progress and the concern for a second implant may not be as compelling. We intend to investigate further factors that may be involved in parent-decision making regarding unilateral versus bilateral cochlear implantation in this population.

This study is limited by a small sample size and may account for the modest differences in the timing of therapeutic services between the rural and urban regions. The small number of subjects has also limited the types of analyses that can be performed to assess causality of delayed intervention. These data serve as the basis to implement a prospective study involving multiple institutions to assess differences in treatment timing and language outcomes in rural versus urban populations. The reasons for delay in intervention in children from rural areas are likely multiple and complex in their relationship to each other. Certainly there are vast regional differences that exist in urban regions throughout the US, as well as, differences between rural regions as well. Delineations as arbitrary as “urban” versus “rural” based on population as the USDA classification uses may be oversimplified and not accurately reflect fundamental differences in populations that lie at the heart of hearing healthcare disparity. It is imperative to apply population health research methods to investigate disparities in rural areas by assessing factors that influence health behaviors and may make the conclusions more generalizable.²⁸ Race may also be a factor that may play a significant role in affected hearing healthcare timing but was not investigated in this study. The rural region in this study is predominately white while the metro area is more racially heterogeneous and the affect on race on intervention timing also needs further investigation in future prospective studies.

Some of these factors that are germane to this study include insurance status, level of education, socioeconomic status, distance from the hearing healthcare center; however, these factors may not only causative factors but may also serve as confounding variables. Insurance status and type of coverage may also play a significant role in timing of implantation but this varies widely regionally and nationally. The effect of presence or type of insurance coverage on intervention timing was not investigated in this study due to the small number of subjects. Uninsured children in this region are eligible to obtain Medicaid and all children are able to receive services at the Heuser Hearing Institute regardless of insurance status. All children in this particular study had some type of insurance coverage. Lester and colleagues²⁷ identified that children with Medicaid are at a 21% higher risk of being implanted after the age of 2 when compared to those with private insurance. The insurance coverage varies widely within this region and, according to 2005 statistics available for both the Louisville metro and the rural areas, the uninsured rate for African Americans in the Louisville metro area was 23%,³⁰ while 13% for White Louisville residents.³⁰ The rural region in this study has an average uninsured rate 15.92%.²⁶ Certainly, further investigation is warranted to investigate the effect of insurance coverage on hearing healthcare timing in the urban African American population, as well as, the rural population. There is also a concern for the educational status of residents within rural areas as a lack of parental education may contribute to delayed healthcare. A recent report of educational status that contrasts the differences between the rural and urban regions (including the Louisville metro area) of this area of the country found that the average percentage of rural residents in this region of the country with no high school diploma is 33% compared with 20% for those residing in urban regions.²⁶ Certainly, the education level of residents in the

Louisville metro area is not homogenous and further investigation within the urban area may reveal similarities in educational disparities in urban minorities and rural residents, similar to the insurance status concerns.

The socioeconomic status and distance from the testing may play a significant role for hearing healthcare timing for rural residents. In our study we did identify linear relationship between timing of therapeutic intervention and distance from the hearing healthcare center. Most families were faced with a distance of over 90 miles to hearing rehabilitation services and the condition of the roads and highway systems in rural regions may exacerbate the travel difficulties for parents of young children. This may be somewhat intuitive; however, this issue has not been investigated previously in this field. Although further investigation is indicated, these results are relevant to other regions of the country as many implant centers in other states have families that have to travel great distances from rural regions to obtain appropriate care and we feel that these findings are clinically relevant. Furthermore, the average income in this rural region is \$29,847 and the unemployment rate is 46% compared to the this region's urban average income of \$42,148 and unemployment rate of 36%.²⁶ Financial hardship may significantly limit travel for hearing healthcare. There is evidence of a disparity in family income levels in those families with children with hearing loss and they are more likely to live closer to the poverty level. In addition, those families are less likely to seek medical care.²⁹ Further studies will prospectively investigate the economic status of families with children with hearing loss to characterize this urban-rural disparity. This may also serve as justification to develop programs, such as telemedicine, to bring timely hearing healthcare to those with limited means who may live great distances from treatment centers.

Research in healthcare disparities and access to care inequities is a vital, yet under-investigated, topic. Children from rural regions need to be closely monitored following failed newborn hearing screening as they may be at a higher risk of delay in receiving hearing amplification and cochlear implantation. Interventions need to be developed that facilitate timely care for children in these regions who may reside far from a hearing rehabilitation center. Implementation of telemedicine within rural areas may be able to deliver needed services to such areas. Further study is warranted to examine a larger group of children with hearing loss from rural regions to determine causative factors in hearing healthcare delivery delays.

Acknowledgments

This work was supported by University of Kentucky Center for Clinical and Translational Science (MLB), National Institute of Health (8 KL2 TR000116-02) (MLB), National Institutes of Health Loan Repayment Program (MLB), and National Institute of Deafness and Other Communication Disorders (1U24-DC012079-01)(MLB). The project described was supported by the National Center for Research Resources, UL1RR033173, and is now at the National Center for Advancing Translational Sciences.

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Figure 1.
Timing of Hearing Aid Amplification (weeks after birth) for Urban and Rural Regions.

Figure 2.
Timing of Cochlear Implantation (weeks after birth) for Urban and Rural Regions.

Figure 3.
Percentage of Children with Bilateral Cochlear Implants.

Otol Neurotol. Author manuscript; available in PMC 2014 December 01.