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Timing and Impact of Hearing Healthcare in Adult Cochlear Implant Recipients: A Rural-Urban Comparison

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Abstract

Objective—The purpose of this study is to compare the timing and impact of hearing healthcare of rural and urban adults with severe hearing loss who use cochlear implants (CI).

Study Design—Cross-sectional questionnaire study

Setting—Tertiary referral center

Patients—Adult cochlear implant recipients.

Main Outcome Measures—Data collected included county of residence, socioeconomic information, impact of hearing loss on education/employment, and timing of hearing loss treatment. The benefits obtained from cochlear implantation were also evaluated.

Results—There were 91 participants (32 from urban counties, 26 from moderately rural counties, and 33 for extremely rural counties). Rural participants have a longer commute time to the CI center ($p < 0.001$), lower income ($p < 0.001$) and higher percentage of Medicaid coverage ($p = 0.004$). Compared with urban-metro participants, rural participants with gradually progressive hearing loss had a greater time interval from the onset of hearing loss to obtaining hearing aid amplification (10 years versus 5 years, $p = 0.04$). There was also a greater time interval from onset of hearing loss to the time of cochlear implantation in rural participants ($p = 0.04$). Reported job loss was higher in rural participants than in urban participants ($p = 0.05$). Both groups reported comparable benefit from cochlear implantation.

Conclusions—Rural CI recipients differ from urban residents in socioeconomic characteristics and may be delayed in timely treatment of hearing loss. Further efforts to expand access to hearing healthcare services may benefit rural adult patients.

Keywords

Rural Health; Adult hearing loss; Cochlear implantation

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INTRODUCTION

Hearing loss in the adult population of the United States is a significant public health issue. The U.S. Department of Health and Human Services, as indicated in Healthy People 2020, included timely hearing screening with appropriate treatment referral as a priority achievement¹. The high prevalence of hearing loss has been reported in the literature as well, with over 30 million people age 12 and over experiencing some degree of hearing loss in both ears²⁻⁴. As the life expectancy in the U.S. continues to climb, the health burden of chronic disease would be expected to increase substantially, making prompt recognition and intervention essential.

Despite the high prevalence of adult hearing loss, treatment options are underutilized. According to the MarkeTrak VII online survey, less than 25% of adults with hearing loss own hearing aids². Delays to diagnosis and treatment exist, in part, because screening for hearing loss is not uniform and referrals for advanced testing are uncommon. Among adults who acknowledge hearing loss, acquiring hearing aids is commonly delayed after first detection³. Sensorineural hearing loss is primarily treated with hearing aids; however, when the degree of loss becomes severe cochlear implantation is the standard of care. In spite of highly rated hearing-related outcomes and quality of life for cochlear implant (CI) patients,⁴ this aspect of hearing healthcare is not widely accessed by those who may benefit. Despite an abundance of data to support their efficacy and FDA approval in the United States for 30 years, it is estimated that fewer than 6% of Americans who could benefit from CI have one⁵. To date, little research exists documenting timing of access of hearing healthcare and barriers to this care for an adult population.

The diagnostic and therapeutic process to obtain cochlear implantation rehabilitation may be complicated and time consuming. Additionally, a significant financial burden may be incurred due to travel, missed work and purchase of equipment such as hearing aids. There is evidence to suggest delays in diagnosis and treatment of hearing loss in children from rural communities⁶. Some rural residents have been documented to have poorer health in general related to a lack of necessary local health resources and significant geographic isolation⁷. The purpose of this study is to compare the timing and impact of hearing healthcare of rural and urban adults with severe hearing loss who use cochlear implants. The hypothesis of the study was that adult CI recipients from more rural counties are delayed in timing of access to hearing healthcare when compared with urban CI recipients.

METHODS

Institutional review board (protocol 14-0854-F1V) approval was obtained prior to initiation of the study. Inclusion criterion was adult (>18 years old) cochlear implant patients receiving active care at our institution from 1989 until present. Patients who received their cochlear implant before the age of 18 were excluded as the focus of this study was on adult cochlear implantation. Since this subject area has not been previously examined, a 29-item questionnaire was developed to assess patient demographics, timing to the initiation of audiological care, barriers to care and effect of hearing loss on quality of life. The 7-item

International Outcome Inventory for Hearing Aids (IOI) was utilized by adapting the questionnaire for cochlear implant patients and included to evaluate treatment efficacy. The multidisciplinary research team developed this questionnaire with input from literature review, patients and providers. The questionnaire was piloted with several patients before wide circulation and then modified to ensure clarity and ease of completion. Each mailing included an addressed stamped return envelope.

Question formats included fill in the blanks, open-ended semi-structured, multiple choice, yes/no and 6-point Likert-type scale questions. The first set of questions focused on demographic information, including participant's gender, race, age, marital status, education, employment, income, insurance status and side of implantation. County of residence and commute time to the participant's cochlear implant center were recorded. A timeline to hearing healthcare acquisition was developed by first asking respondents how many years ago a hearing loss was noticed. Subsequent questions inquired about the time interval after hearing loss onset that hearing loss interfered with daily activities and the time elapsed after hearing loss onset until medical/audiological care (including hearing aid fitting) and timing of cochlear implantation, was sought. The final question set concerned the impact of hearing loss on educational attainment and employment. The survey concluded with the IOI questionnaire.

Surveys were separated, based on patient-reported county of residence, to a urban/suburban group or a rural group based on the rural status of each county using the Beale codes of 2013 (US Department of Agriculture Rural-Urban Continuum Coding system)⁸. This numerical scale has nine 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 2,500 residents and not adjacent to a metro area. We compared data from participants in the urban/metro counties (Beale code 1–3) with those from rural counties (Beale code 4–9).

Returned questionnaires were analyzed by coding each item separately into the secure Research Electronic Data Capture database (REDCap) (Vanderbilt University, Nashville, TN). Descriptive statistical analysis included mean time interval from onset of hearing loss to access of hearing healthcare with hearing aids and mean time interval from onset of hearing loss to cochlear implantation. This was compared between urban versus rural groups across the entire dataset. Etiology of hearing loss may differ widely along with the rate of progression of hearing loss; therefore, primary analysis was performed on participants who experienced hearing loss for at least 10 years with gradually progressive hearing loss. Continuous variables were summarized by calculating means and categorical variables were described with counts and percentages. Multiple-choice and graded-scale question-answer frequencies were calculated. Survey data was managed using an Excel spreadsheet (Microsoft, Redmond, WA, USA) and statistical analysis was performed with SAS software (SAS Institute Inc., Cary, NC, USA). A p -value < 0.05 was considered to be statistically significant. Associations between measured variables were assessed using Chi-square tests for dichotomous variables, Student's t -test for normally distributed, continuous variables and Mann-Whitney U-test for ordinal variables and those with non-normal distributions. We used a log-rank test to examine differences in the distribution of timing of implantation from

onset of hearing loss between urban and rural participants. The corresponding Kaplan-Meier curves are also provided to visualize these distributional differences.

RESULTS

A summary of demographic and socioeconomic data is found in Table 1. Of the 267 questionnaires mailed to participants, 91 were returned (34% response rate), with 33 from extremely rural counties (Beale code 7–9), 26 from moderately rural counties (Beale code 4–6), and 32 from urban counties. The response rate was equal among rural and urban participants. Rural and urban participants were similar in distribution of age, gender and race. Regarding education, rural participants had a lower level of education with 39% pursuing post-high school education compared with 88% of the urban participants ($p=0.003$). Participants from rural counties had a significantly longer commute to the cochlear implant center than urban patients (108 min. v. 37 min. respectively, $p<0.001$). Additionally, rural participants had a lower average income distribution ($p<0.001$) and lower percentage with private insurance coverage with higher Medicaid coverage. Of note, 21% of rural participants reported an annual income below the poverty line for a single household ($< \$10,000/\text{year}$) compared with 4% of the urban participants ($p=0.028$).

A total of 64 participants with gradually progressive hearing loss of at least 10 years duration participated in the study and 27 participants who either did not report duration/progression of hearing loss or who had precipitous hearing loss of less than 10 years. Gradually progressive hearing loss is more commonly encountered in the adult population therefore the primary analysis for timing of hearing healthcare was assessed in this group of 64 participants. The time interval from onset of hearing loss to obtaining hearing aids was 10 years in the rural participants compared with 5.05 years in the urban participants ($p=0.04$). Furthermore, we compared the time interval between the onset of hearing loss to cochlear implantation in these patients. This group was aged matched and had confirmed hearing aid usage before cochlear implantation. This time interval was 36 years in rural participants compared to 29 years in urban-metro participants and the distribution of the timing to implantation was statistically significant between groups ($p=0.04$) (Fig 1).

Data regarding impact of hearing loss on employment and education is recorded in Table 2. Positively, this self-reported data indicates that the majority (over 50%) of adult CI recipients found that their hearing loss did not prevent hiring nor experienced discrimination in the workplace related to their hearing loss. Additionally, the majority of participants were not prevented from completing education due to their hearing loss. Negative impacts of hearing loss was also identified, in that, nearly 80% of both rural and urban participants reported that hearing loss caused difficulty with performing their job and 30% of all participants reported loss of a job due to their hearing loss. Although employment and termination are likely related to multiple factors, a higher percentage of rural participants reported loss of a job related to their hearing loss compared with urban participants (40% versus 12%, $p=0.05$). Approximately 44% of all participants reported that they felt that their hearing loss prevented them from completing education and 58% had a desire to complete higher education, which was limited by hearing loss. There were no statistically significant differences in responses between rural and urban and participants in the other employment

and education questions. Data from the adapted IOI questionnaire indicated at least a moderate benefit in all 7 categories for each group, demonstrating consistent use, acceptability, utility and improved quality of life achieved with cochlear implantation (Figure 2). A non-significant trend toward more consistent CI use (>8 hours per day) ($p=0.061$) and with higher satisfaction with the CI ($p=0.069$) was seen in the rural recipients when compared with the urban CI recipients. There was no statistically significant difference between rural and urban participants for the other 5 IOI questions which relate respectively to overall benefit, residual activity limitations, residual participation restrictions, impact of hearing loss on relationship with others, and overall quality of life.

DISCUSSION

This study demonstrates a delay in the timing of access to hearing healthcare in adult cochlear implant recipients. The impact of the delay on auditory outcomes and quality of life is unknown and the key determinants in timely access to care are undefined. Nevertheless, the rural population of the United States represents a significant proportion of the overall population with unique limitations with respect to access to healthcare. Approximately 20% of the U.S. population resides in rural areas⁹, and the effect of rural residence, socioeconomics and geographical factors on auditory rehabilitation has not been evaluated in adult patients. This study was conducted in a state with a rural population of 1.8 million out of a total population of 4.2 million and where 85 of the 120 counties are considered rural¹⁰. Complicating access to care is the fact that cochlear implantation services are only available in two urban areas. Demographic data in this study demonstrate socioeconomic disadvantages for the rural cochlear implant population in the form of lower overall income distribution with 41% of rural participants earning a household income of less than \$20,000 a year. This accurately reflects epidemiologic data from the region which has shown that the majority of rural residents in the Appalachian region are distressed and the median household income is \$24,609¹¹. The socioeconomic disparity in this sample of cochlear implant recipients may seem intuitive; however, objective evidence characterizing rural and urban patients is important in formulating specific strategies for improving access to care in the future. In addition, rural patients are traveling an average of over 1.5 hours to obtain hearing healthcare and this geographical gap has the potential to delay the receipt of advanced care. This distance disparity could lead to missed appointments and unwillingness to travel due to lack of travel funds and lack of consistent transportation. The use of hearing aids is the key initial step in treatment after the development of hearing loss and there appears to be a delay in access to this care in rural CI recipients compared with those in urban areas. Timing of receipt of a cochlear implant may be directly related to the rate of decline of hearing loss since only those with more severe forms of hearing loss are candidates for implantation; however, it is possible that delays in the initial treatment of hearing loss may play a role in the timing of implantation. Additionally, the urban-rural regional differences in the knowledge, attitudes, and behaviors of adults with hearing loss are largely unknown, yet it is possible that those individuals from rural regions may have different cultural perceptions regarding the impact of hearing loss, diagnosis and treatment than urban residents. Further efforts are needed to investigate these regional differences.

Paramount to the justification of resource allocation in expanding access to care for a particular intervention is proving its need and efficacy in this particular population. Studies have demonstrated that adults with hearing loss are more than twice as likely to be unemployed or partly unemployed (2.2 adjusted odds ratio) and experience a 25% decrease in wages compared to those without hearing loss (\$23,481 versus \$31,272)¹². Hearing impairment in adults is also associated with an increase in depression by at least 50% compared to adults with excellent hearing¹³. Hearing loss can thus contribute significantly to financial hardship and prevent upward mobility, and those patients residing in rural areas are particularly vulnerable. Our study reflected similar findings in that essentially half of the respondents indicated their hearing loss prevented achievement of higher levels of education and difficulty performing their job. Benefit from cochlear implantation is not isolated to urban residents, but rather, our data indicates that adults with severe hearing loss who receive cochlear implants receive significant benefit whether they live in urban or rural areas.

Considering all participants involved in this study, there was an average time gap of approximately 30 years between the time of onset of hearing loss and cochlear implantation. Obviously, the nature and the rate of hearing loss may vary widely and may affect timing of cochlear implantation; however, it is compelling to consider that adult patients with hearing loss may experience a 30 year journey of hearing loss before receiving a CI. Despite this large time interval, cochlear implantation continues to be a successful treatment modality for both rural and urban patients. The IOI-HA originally described by Cox et al¹⁴ was adapted to pertain to cochlear implants to measure efficacy of the implant in this study. The majority of participants reported using their device(s) for >8 hours a day. In addition, they reported high satisfaction with the implant and overall improvement in quality of life. The rural participants reported receiving at least equal, if not more benefit from cochlear implantation than their urban counterparts. Hypothetically, a selection bias may account for this finding, in that, rural adults that are delayed in access could have more severe hearing loss at the time of implantation and even modest improvement of hearing function could translate into high satisfaction. Additionally, rural adults that are motivated enough to overcome barriers to actually access care and receive a cochlear implant are perhaps more compliant with the rehabilitation following implantation which could potentially impact outcomes and patient satisfaction.

Limitations of this questionnaire study are inherent and may include sampling bias as well as recall bias from the participants. There is a smaller cohort of rural participants compared with the urban group; however, this is a representative percentage of our overall implant patient base as the response rate was similar between rural and urban participants. We have observed that many of the rural implant patients in our practice may not be seen as frequently as the urban patients and it is possible that inaccurate address information could limit the number of rural patients who actually received a survey. Additionally, those with low literacy may not complete written questionnaires. Data is also representative of patients with hearing loss who have succeeded in obtaining cochlear implants, thus disparities in hearing healthcare and impact to quality of life is unmeasured in the undiagnosed and those failing to navigate the healthcare system. The nature of the survey introduces the possibility of recall bias as a contributing factor in result interpretation as well. The pathway to adult

cochlear implantation may occur over a few decades, thus is subject to a large variety of complicating factors. The etiology of hearing loss was not investigated in this study but is not widely known for the majority of these patients. Lastly, the findings of this study may not be able to be generalized to other regions. Future studies are indicated to explore strategies for improving access to care in vulnerable populations, such as those from rural regions. Provision of remote services (either through satellite clinics or telemedicine) and penetration of hearing healthcare specialists into rural areas may be able to mitigate regional differences in timing of healthcare. While provider density is relatively fixed, remote audiological diagnostic testing and cochlear implant programming could serve to expand the reach of specialized providers from tertiary care medical centers. Additional education should also be provided for community primary care physicians and local health departments to inquire about hearing loss in adult patients and initiate appropriate referrals.

CONCLUSION

This study compares socioeconomic and demographic aspects of rural and urban cochlear implant recipients and assesses the timing of access of hearing healthcare along with the impact of hearing loss and the benefit from cochlear implantation. The rural cochlear implant recipients in this study have a lower level of education and lower household income and a greater travel distance to the cochlear implant center compared with urban participants. Those from rural regions have a delay to initiation of hearing loss treatment with hearing aids when compared with urban counterparts. Both rural and urban groups reported occupational and educational difficulties related to their hearing impairment and both groups reported benefit from cochlear implantation. Future studies are needed to address improving access to hearing healthcare in rural regions.

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Figure 1. Kaplan-Meier estimate for time to cochlear implantation from onset of hearing loss for rural and urban study participants ($p=0.04$).

Figure 2.
Comparison of hearing outcomes in rural and urban adult cochlear implant patients via the IOI instrument.

Table 1

Demographic data of Rural And Urban Cochlear Implant Patients

<i>Characteristic</i>	Urban	Rural	p-value
Population Size	32	59	
Mean age (years)	62.4	61.6	0.821
Mean commute time to CI center (min)	37	108	< 0.001
Male sex (%)	44%	47%	0.798
Race			
White	97%	98%	1.000
African American	3%	0%	0.356
Native American	0%	2%	1.000
Education (%)			0.003
No degree	3%	17%	0.089
High school or equivalent	9%	43%	0.001
Post-secondary education	34%	10%	0.010
College graduate	41%	10%	0.001
Graduate degree	13%	19%	0.560
Income (%)			< 0.001
Less than \$10,000	4%	21%	0.028
\$10,000–20,000	7%	20%	0.126
\$20,000–30,000	21%	21%	1.000
\$30,000–60,000	14%	29%	0.119
More than \$60,000	54%	9%	<0.001
Insurance (%)			
Medicaid	9%	31%	0.021
Medicare	47%	59%	0.284
Private	56%	31%	0.019
Other	28%	19%	0.317
Cochlear Implant Use (%)			0.164
Unilateral	72%	84%	
Bilateral	28%	16%	

Table 2

Self-Reported Impact of Hearing Loss on Employment & Education

(% Agree or Strongly Agree)	Total Sample	Urban	Rural	p-value
Difficulty performing job	78%	77%	79%	0.91
Prevent Hiring	49%	40%	54%	0.31
Causing Loss of Job	30%	12%	40%	0.05
Prevent Promotion	56%	67%	50%	0.25
Cause Discrimination in Workplace	40%	43%	38%	0.73
Desire to complete higher education	58%	57%	58%	0.94
Prevented from completing education in past	44%	35%	49%	0.27