ARIC Manuscript Proposal #4230

PC Reviewed: 4/11/23	**Status: _____**	**Priority: 2**
SC Reviewed: _____	**Status: _____**	**Priority: ____**

1.a. Full Title: Association of Hearing Loss with Perceived Physical Ability and Functional Limitations: Results from the Atherosclerosis Risk in Communities Study

b. Abbreviated Title (Length 26 characters): Hearing and physical function

2. Writing Group

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I, the first author, confirm that all the coauthors have given their approval for this manuscript proposal. SA **[please confirm with your initials electronically or in writing]**

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3. Timeline: Analyses and manuscript to be completed within 1 year

4. Rationale:

Physical function, or the capacity to perform physical tasks, declines with aging[1] and is essential to maintain independence in older adults.[2,3] Hearing loss is highly prevalent in older ages, affecting in the US nearly two-third of adults older than 60 years of age.[4] Previous studies have found mixed results when examining the association between hearing loss and physical function. Older adults with hearing loss have been found to report more difficulty performing activities of daily life (ADLS), instrumental ADLs (IADLS) and more demanding physical tasks (e.g., walking ¼ block, walking 2 km, lifting 10-pound objects).[5,6] There is also evidence that hearing loss is associated with poor lower-extremity physical function measured with performance-based tests.[7–9] However, a separate study found no association between hearing and ADLS, IADLS, and mobility.[10] Additional research is needed to understand the relationship between hearing loss and physical function, and whether hearing aid users perceive less difficulty performing ADL, IADL, and mobility tasks than non-users.

At visit 6 (2016-2017) of the Atherosclerosis Risk in Communities (ARIC) study, objective audiometry hearing assessments were conducted. In addition, a physical ability questionnaire was introduced to assess the perceived difficulty level in performing activities, including ADLs, IADLS, and heavier physical tasks (e.g., walking a specific distance or lifting heavy objects). Given this rich source of information, our first aim is to assess the cross-sectional association between objective hearing loss and the level of perceived physical ability at visit 6. Furthermore, using data from the functional status assessment included in semi-annual ARIC follow-up interviews, our second aim is to study the cross-sectional association of objective hearing loss at visit 6 with perceived functional status in the 2016 follow-up interview (GNE). Our third aim is to study the longitudinal association of objective hearing loss at visit 6 with change in functional status over 3-4 years using semi-annual follow-up interviews in 2017 (GNF) and 2020 (GNG). Lastly, given that hearing loss may be addressed using hearing devices such as hearing aids, we will investigate the effect modification by hearing aid use of the three aforementioned outcomes/aims among participants with hearing loss.

5. Main Hypothesis/Study Questions:

Aim 1: To study the cross-sectional association of hearing loss and hearing aid use with perceived physical ability with ADLs, IADLs, and heavier physical tasks among older adults at visit 6 of ARIC.

Aim 1A: To study the cross-sectional association of hearing loss with perceived physical ability with ADLs, IADLs, and heavier physical tasks among older adults at visit 6 of ARIC.

Hypothesis: Older adults with hearing loss will perceive more difficulty in performing ADLs, IADLs, and heavier physical tasks compared to those with no hearing loss. Specifically, we hypothesize perceived difficulties will be more strongly driven by IADLs and heavier physical tasks than ADLs.

Aim 1B: To study the cross-sectional association of hearing aid use with perceived physical ability with ADLs, IADLs, and heavier physical tasks among older adults with hearing loss at visit 6 of ARIC.

Hypothesis: Hearing aid users perceive better physical ability with ADLs, IADLs, and heavier physical tasks compared to nonusers. Specifically, we hypothesize that the association with IADLs and heavier physical tasks will be stronger than that with ADLs.

Aim 2: To study the cross-sectional association of hearing loss and hearing aid use at visit 6 (2016-2017) with perceived functional status (using the GNE interview, 2016).

Aim 2A: To study the cross-sectional association of hearing loss at visit 6 of ARIC with perceived functional status.

Hypothesis: Older adults with hearing loss will perceive more functional difficulties compared to those with no hearing loss.

Aim 2B: To study the cross-sectional association of hearing aid use among participants with hearing loss at visit 6 of ARIC with perceived functional status.

Hypothesis: Hearing aid users will perceive fewer functional difficulties compared to nonusers.

Aim 3: To study the longitudinal association of hearing loss and hearing aid use at visit 6 (2016-2017) with change in functional status over a follow-up period of 3-4 years.

Aim 3A: To study the longitudinal association of hearing loss at visit 6 of ARIC with change in perceived functional status over a follow-up period of 3-4 years.

Hypothesis: Older adults with hearing loss will be more likely to develop functional difficulties over time compared to those with no hearing loss.

Aim 3B: To investigate the association between hearing aid use among participants with hearing loss at visit 6 of ARIC and onset of functional difficulties over a follow-up period of 3-4 years.

Hypothesis: Hearing aid users will be less likely to develop functional difficulties over time compared to nonusers.

6. Design and analysis (study design, inclusion/exclusion, outcome and other variables of interest with specific reference to the time of their collection, summary of data analysis, and any anticipated methodologic limitations or challenges if present).

Study design: Cross-sectional (at visit 6, 2016-2017) and longitudinal analyses (baseline: visit 6, follow-up duration of 3-4 years, end of follow-up: semi-annual follow-up general interview questions (GNG) in 2020).

Inclusion:
For aim 1:
Participants with audiometric hearing assessments at visit 6 (exposure of interest) who completed the physical ability questionnaire (outcome of interest) and have data on the included covariates.
Additional criteria for aim 1B:
Participants with mild or greater hearing loss measured on audiometry at visit 6.

For aim 2:
Participants with audiometric hearing assessments and data on hearing aid use at visit 6 (exposure of interest) who completed the functional status section in the semi-annual follow-up general interview questions in 2016 (GNE) (outcome of interest) and have data on the included covariates.
Additional criteria for aim 2B:
Participants with mild or greater hearing loss measured on audiometry at visit 6.

For aim 3:
Participants with audiometric hearing assessments and data on hearing aid use at visit 6 (exposure of interest) who completed the functional status section in the semi-annual follow-up general interview questions in 2016 (GNE) and at least one of the subsequent ones (GNF in 2017 and/or GNG in 2020) (outcome of interest) and have data on the included covariates.
Additional criteria for aim 3B:
Participants with mild or greater hearing loss measured on audiometry at visit 6.

Exclusion: Participants who are non-Black and non-White.

Outcome assessment:

Physical ability

The physical ability questionnaire included in visit 6 of ARIC contains 12 items that evaluate the participant's perceived level of difficulty to perform some activities (no difficulty, little difficulty, much difficulty, unable to do). The 12 items can be divided into 3 main categories: 1) activities of daily living [ADL] (dressing, eating, walking from one room to another in the house, and getting in and out of bed, standing up from an armless chair), 2) instrumental activities of daily living [IADL] (performing household chores, meal preparation, and managing finances), and 3) heavier physical tasks (walking ¼ mile; walking up 10 steps without resting; stooping, crouching, or kneeling; lifting 10-pound objects). For primary analyses, we will dichotomize the answers for each item into a binary variable of no difficulty (No=0) and any difficulty/inability to do (Yes=1). We will group the items into the domains described above (ADLs, IADLs, and heavier physical tasks) and within we will consider that participants have difficulties within a domain if they report any difficulty/inability to do for at least one of the items of the respective domain. In addition, we will create a physical ability difficulty score that is equal to the sum of items for which participants reported any difficulty/inability to do and analyze that score as our outcome (range: 0-12).

Functional status

Self-reported functional status was measured annually from 2016-2020 during semiannual follow-up general interview questions (GNE, GNF, GNG). Participants reported their ability to perform various activities via four questions to which they answered yes or no. These included:
1) doing usual activities, such as work around the house or recreation,
2) walking half a mile (about 8 ordinary blocks) without help,
3) walking up and down the stairs without help, and
4) doing heavy work around the house, like shoveling snow or washing windows, walls, or floors, without help.

Perceived ability for each question was treated as a binary variable (Yes/able=1, No/unable=0). A functional status score ranging from 0-4 will be derived by summing the responses to the four questions, where 0 indicates poor functional status and 4 indicates optimal functional status.[11] We will use this score as a continuous outcome and will additionally dichotomize into a binary variable of 0=no functional difficulties and ≥1=functional difficulties.

Exposure assessment:

Pure tone audiometry was done in a sound-proof booth using insert earphones (EARTone 3a; 3M) and the Interacoustics AD629 audiometer (Interacoustics A/S, Assens, Denmark). Air conduction was completed at standard octaves from 500-8000 Hz. The hearing threshold was measured at each one of the four sound frequencies (.5, 1.0, 2.0 and 4.0 kHz) and the four-frequency pure-tone average (PTA) is calculated for each ear. In our primary analyses, we will use the better-hearing ear PTA (BPTA) as both a continuous measure, scaled per 10 dB, and as a

categorial measure, with categories being normal hearing (BPTA ≤25 decibels hearing level [dB HL]), mild hearing loss (BPTA 26-40 dB HL), moderate hearing loss (BPTA 41-60 dB HL), and severe or greater hearing loss (BPTA > 60 dB HL), to study the association with perceived physical ability.

Other variables of interest:
Age at study visit and demographic information (collected at Visit 1) including: sex (male, female), field center/race, and educational level (categorized as <12 years of education, high school/high school equivalent or vocational training, any college).
Health status factors (from Visit 6) including: smoking status (never, former, or current smoker), diabetes (fasting blood glucose >126mg/dl, non-fasting blood glucose ≥200 mg/dl, or use of diabetes medication), hypertension (systolic BP ≥140mmHg or diastolic BP ≥90mmHg; or use of antihypertensive medication), and body mass index (in kg/m^2, categorized as normal [<25], overweight [25-30], obese [>30]).
Hearing aid use was self-reported at Visit 6 (yes, no) and we included it in secondary analyses. In these analyses, we additionally adjusted for household income to account for socioeconomic differences between hearing aid users and nonusers.

Data analysis: For descriptive analysis, we will compare sociodemographic and health status factors across hearing loss categories. Continuous variables will be summarized with means and standard deviations (SD), or medians and interquartile range (IQR), and compared using ANOVA tests. Categorical variables will be summarized with frequencies and proportions and compared using chi-squared tests.

Aim 1A: To study the cross-sectional association of hearing loss with perceived physical ability with ADLs, IADLs, and heavier physical tasks among older adults at visit 6 of ARIC.

We will use multivariable regression analyses to compare the relative differences in perceived physical ability across hearing categories and with increasing BPTA (by 10 dB increments).
First, we will use a logistic regression model to study the odds of reporting physical ability difficulties within each domain (ADLs, IADLs, heavier physical tasks) by hearing loss categories and per 10 dB higher BPTA.
Second, we will use a linear regression or tobit regression model (depending on the distribution of the score) to evaluate differences in the physical ability difficulty score (sum of items for which at least some difficulty was reported) by hearing loss categories and per 10 dB higher BPTA.
For each regression model, we will present estimates adjusted for sociodemographic factors (age, sex, race/field center, education), and estimates adjusted for sociodemographic and health-related factors (smoking status, diabetes, hypertension, BMI).

Aim 1B: To study the cross-sectional association of hearing aid use with perceived physical ability with ADLs, IADLs, and heavier physical tasks among older adults with hearing loss at visit 6 of ARIC.

Using the same analytic approach and models described above, we will assess effect modification by hearing aid use in a sample restricted to participants with mild or greater hearing loss.
We will investigate whether hearing aid users have lower odds of perceiving physical ability difficulties within each domain (ADLs, IADLs, and heavier physical tasks) and a lower physical ability difficulty score compared to nonusers. Because hearing aid users and non-users may differ in socioeconomic factors, we will additionally include income levels in the sociodemographic factors adjusted for in the models.

Aim 2A: To study the cross-sectional association of hearing loss at visit 6 of ARIC with perceived functional status (using the GNE interview, 2016).

We will use a linear regression model to evaluate the functional status score using GNE (2016) by hearing loss categories and per 10 dB higher BPTA.
We will use a logistic regression model to estimate the odds of having functional difficulties by hearing loss categories and per 10 dB higher BPTA.
For each regression model, we will present estimates adjusted for sociodemographic factors (age, sex, race/field center, education), and estimates adjusted for sociodemographic and health-related factors (smoking status, diabetes, hypertension, BMI).

Aim 2B: To study the cross-sectional association of hearing aid use among participants with hearing loss at visit 6 of ARIC with perceived functional status.

Using the same analytic approach and models described above, we will assess effect modification by hearing aid use in a sample restricted to participants with mild or greater hearing loss.
We will investigate whether hearing aid users have better functional status scores and lower odds of having functional difficulties relative to nonusers. Similarly, because hearing aid users and non-users may differ in socioeconomic factors, we will additionally include income levels in the sociodemographic factors adjusted for in the models.

Aim 3A: To study the longitudinal association of hearing loss at visit 6 of ARIC with change in perceived functional status over a follow-up period of 3-4 years.

For these analyses, we will consider the functional status data from the semi-annual follow-up general interview questions in 2016 (GNE) as the baseline functional status as it roughly corresponds to the same period of hearing assessment in ARIC at visit 6 (2016-2017).
Among participants without functional difficulties at the 2016 (GNE) questionnaire, we will use a multivariable logistic regression model to estimate the odds of developing functional difficulties in subsequent semi-annual follow-up general interview questions (GNF, 2017 and/or GNG, 2020) across hearing loss categories and per 10 dB higher BPTA. Among all participants, we will additionally assess if there are differences in the change in functional status from GNF to GNG by hearing loss measures.
We will similarly present estimates adjusted for sociodemographic factors (age, sex, race/field center, education), and estimates adjusted for sociodemographic and health-related factors (smoking status, diabetes, hypertension, BMI).

Aim 3B: To investigate the association between hearing aid use among participants with hearing loss at visit 6 of ARIC and onset of functional difficulties over a follow-up period of 3-4 years.

Using the same model described above, we will investigate whether hearing aid users have lower odds of developing functional difficulties over a follow-up period of 3-4 years assessed in subsequent semi-annual follow-up general interview questions (GNF, 2017 and GNG, 2020). Similarly, because hearing aid users and non-users may differ in socioeconomic factors, we will additionally include income levels in the sociodemographic factors adjusted for in the models.

Anticipated challenges:

For our analyses, residual confounding is a main concern, and this may be especially relevant when comparing hearing aid users and nonusers. We will consider using propensity score matching to try to minimize it even further than with covariate adjustment. Differential attrition is a concern as those with hearing loss may be more likely to be lost to follow-up than those without hearing loss. In sensitivity analysis, we will use the inverse probability of attrition weights to address this potential source of bias.

7.a. Will the data be used for non-ARIC analysis or by a for-profit organization in this manuscript? ____ Yes _X__ No

b. If Yes, is the author aware that the current derived consent file ICTDER05 must be used to exclude persons with a value RES_OTH and/or RES_DNA = "ARIC only" and/or "Not for Profit" ? ____ Yes ____ No

(The file ICTDER has been distributed to ARIC PIs, and contains the responses to consent updates related to stored sample use for research.)

8.a. Will the DNA data be used in this manuscript? ____ Yes _X__ No

8.b. If yes, is the author aware that either DNA data distributed by the Coordinating Center must be used, or the current derived consent file ICTDER05 must be used to exclude those with value RES_DNA = "No use/storage DNA"? ____ Yes ____ No

9. The lead author of this manuscript proposal has reviewed the list of existing ARIC Study manuscript proposals and has found no overlap between this proposal and previously approved manuscript proposals either published or still in active status. ARIC Investigators have access to the publications lists under the Study Members Area of the web site at: http://www.cscc.unc.edu/aric/mantrack/maintain/search/dtSearch.html

__X___ Yes _____ No

10. What are the most related manuscript proposals in ARIC (authors are encouraged to contact lead authors of these proposals for comments on the new proposal or collaboration)?

MP#3553 Martinez-Amezcua et al. The Association Between Hearing Impairment and Physical Function in the Atherosclerosis Risk in Communities (ARIC) Study
MP#2418 Deal et al. Hearing Impairment and Physical Function in the Atherosclerosis Risk in Communities (ARIC) Hearing Pilot Study

11.a. Is this manuscript proposal associated with any ARIC ancillary studies or use any ancillary study data? __X__ Yes ____ No

11.b. If yes, is the proposal

_X_ A. primarily the result of an ancillary study (list number* ARIC NCS study 2008.06)

___ B. primarily based on ARIC data with ancillary data playing a minor role (usually control variables; list number(s)* _____ _____ _____)

*ancillary studies are listed by number https://sites.cscc.unc.edu/aric/approved-ancillary-studies

12a. Manuscript preparation is expected to be completed in one to three years. If a manuscript is not submitted for ARIC review at the end of the 3-years from the date of the approval, the manuscript proposal will expire.

12b. The NIH instituted a Public Access Policy in April, 2008 which ensures that the public has access to the published results of NIH funded research. It is **your responsibility to upload manuscripts to PubMed Central** whenever the journal does not and be in compliance with this policy. Four files about the public access policy from http://publicaccess.nih.gov/ are posted in http://www.cscc.unc.edu/aric/index.php, under Publications, Policies & Forms. http://publicaccess.nih.gov/submit_process_journals.htm shows you which journals automatically upload articles to PubMed central.

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