# Supplemental Figures/Tables

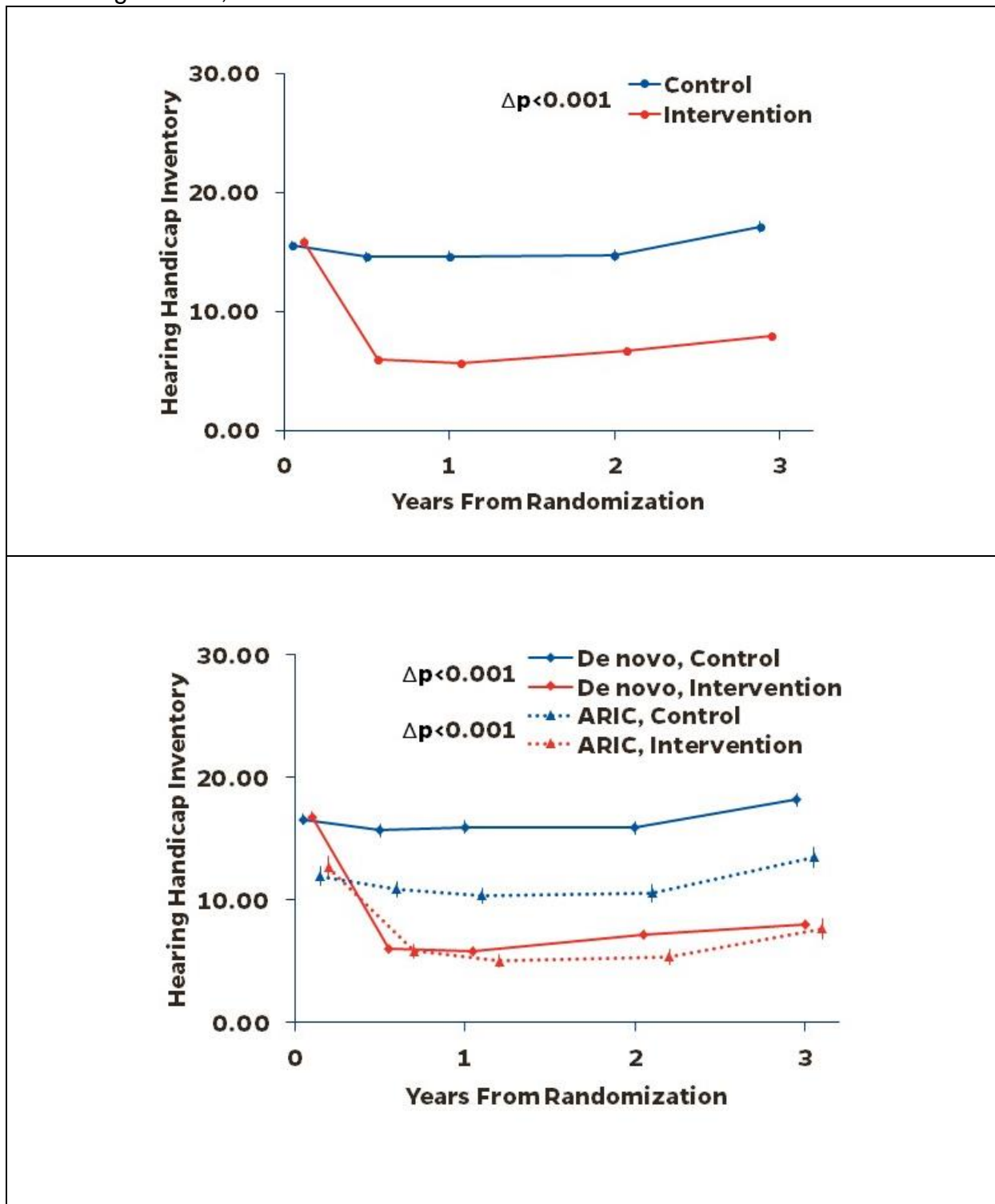## Table of Contents

Supplemental Figure S1A, S1B.



**Figure S1A, S1B.** Blue represents the control intervention while red represents the hearing intervention group. In the top panel (S1A), Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) score for each group is shown at Baseline (0 Years from Randomization) and at 6 months and years 1-3 (1, 2, 3 Years from Randomization). Bottom panel (S1B) shows De novo and ARIC recruitment sources separated out. De novo is represented in solid line (blue control, red intervention) and ARIC is represented with dashed line (blue control, red intervention). Clinical scaling of the HHIE-S is the following: *No Handicap* (0-8), *Mild-Moderate* (10-24) and *Severe* (26-40).

Supplemental Table S1. Baseline characteristics of analytic sample by recruitment type.

| | Total | ARIC | De Novo | p-value |
|---|---|---|---|---|
| Number of participants (% of total N) | 923 | 216 (23.4) | 707 (76.6) | |
| **Demographics** | | | | |
| **Age**, years. Mean (SD) | 76.7 (4.0) | 78.85 (2.9) | 76.09 (4.0) | <0.001 |
| **Sex,** N (%) | | | | 0.01 |
|   Male | 434 (47.0) | 84 (38.9) | 350 (49.5) | |
|   Female | 489 (53.0) | 132 (61.1) | 357 (50.5) | |
| **Race,** N (%) | | | | <0.001 |
|   White | 811 (87.9) | 152 (70.4) | 659 (93.2) | |
|   Black | 105 (11.4) | 63 (29.2) | 42 (5.9) | |
|   Other | 7 (0.8) | 1 (0.5) | 6 (0.8) | |
| **Education,** N (%) | | | | <0.001 |
|   Less than HS | 36 (3.9) | 21 (9.7) | 15 (2.1) | |
|   HS or some college | 398 (43.1) | 86 (39.8) | 312 (44.1) | |
|   College or more | 489 (53.0) | 109 (50.5) | 380 (53.8) | |
| **Marital status,** N (%) | | | | 0.09 |
|   Married | 571 (61.9) | 123 (57.0) | 448 (63.4) | |
|   Not married | 352 (38.1) | 93 (43.1) | 259 (36.6) | |
| **Living alone,** N (%) | 279 (30.2) | 80 (37.0) | 199 (28.2) | 0.01 |
| **Household Income,** N (%) | | | | <0.001 |
|   <$25k | 143 (15.5) | 58 (26.9) | 85 (12.0) | |
|   $25k-$50k | 275 (29.8) | 73 (33.8) | 202 (28.6) | |
|   $50k-$75k | 207 (22.4) | 47 (21.8) | 160 (22.6) | |
|   $75k-$100k | 137 (14.8) | 19 (8.8) | 118 (16.7) | |
|   >$100k | 161 (17.4) | 19 (8.8) | 142 (20.1) | |
| | | | | |
| **Recruitment Route Descriptions** | | | | |
| **Field center,** N (%) | | | | 0.03 |
|   Forsyth County, NC | 221 (23.9) | 51 (23.6) | 170 (24.1) | |
|   Jackson, MS | 235 (25.5) | 62 (28.7) | 173 (24.5) | |
|   Minneapolis suburbs, MN | 215 (23.3) | 35 (16.2) | 180 (25.5) | |
|   Washington County, MD | 252 (27.3) | 68 (31.5) | 184 (26.0) | |
| **Participant part of a spousal pair,** N (%) | 86 (9.3) | 23 (10.7) | 63 (8.9) | 0.44 |
| | | | | |
| **Baseline Functional & Clinical Characteristics** | | | | |
| **Hypertension[1],** N (%) | 530 (57.4) | 139 (64.4) | 391 (55.3) | 0.02 |
| **Diabetes[2],** N (%) | 183 (19.8) | 60 (27.8) | 123 (17.4) | <0.001 |
| **Drinking status,** N (%) | | | | 0.01 |
|   Current | 524 (56.8) | 103 (47.7) | 421 (59.6) | |
|   Former | 230 (24.9) | 61 (28.2) | 169 (23.9) | |
|   Never | 169 (18.3) | 52 (24.1) | 117 (16.6) | |
| **Cigarette smoking,** N (%) | | | | 0.12 |

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[1] Hypertension was defined as measured systolic blood pressure ≥ 140, diastolic blood pressure ≥ 90, or self-reported medication use for lowering blood pressure.
[2] Diabetes was defined as measured fasting blood glucose ≥ 126 mg/dL, non-fasting level ≥ 200 mg/dL, self-reported diagnosis of diabetes by a physician, or self-reported medication use for diabetes.

| | | | | |
|---|---|---|---|---|
| Current | 24 (2.6) | 9 (4.2) | 15 (2.1) | |
| Former | 421 (45.6) | 89 (41.2) | 332 (47.0) | |
| Never | 478 (51.8) | 118 (54.6) | 360 (50.9) | |
| **CES-Depression score[3],** mean (SD) | 2.5 (2.5) | 2.57 (2.7) | 2.44 (2.5) | 0.48 |
| **UCLA Loneliness score,** mean (SD) | 32.8 (8.5) | 32.37 (8.2) | 32.88 (8.6) | 0.43 |
| **Prorated MMSE score[4],** mean (SD) | 28.2 (1.6) | 27.97 (1.8) | 28.27 (1.6) | 0.02 |
| **Better-hearing ear PTA[5],** mean (SD) | 39.4 (6.9) | 39.1 (6.7) | 39.6 (6.9) | 0.39 |
| **Baseline HHIE-S score (continuous),** mean (SD) | 15.4 (9.8) | 12.09 (9.7) | 16.44 (9.6) | <0.001 |
| **Baseline HHIE-S score (categorical)[6],** N (%) | | | | <0.001 |
| No Hearing Handicap (HHIE-S<10) | 287 (31.1) | 98 (45.4) | 189 (26.7) | |
| Mild or greater Handicap (HHIE-S≥10) | 636 (68.9) | 118 (54.6) | 518 (73.3) | |
| **Hearing aid usage[7],** mean (SD) | 6.6 (4.5) | 6.30 (4.5) | 6.72 (4.5) | 0.46 |
| Abbreviations: SD = standard deviation; UCLA = university of California, los angles; NC = North Carolina; MS = Mississippi; MN = Minnesota (MN); MD = Maryland; ARIC = Atherosclerosis Risk in Communities (ARIC) Study. | | | | |

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[3] Depression was defined with the 11-item Center for Epidemiologic Studies Depression (CES-D) Scale which measures frequency of depressive symptoms in the past week. No depressive symptomology: score range: 0-9; Depressive symptomology: score range: > 9

[4] Mini-Mental State Examination [MMSE] was used to measure baseline cognition.  A MMSE score ≥23 for participants with a high school degree or less, ≥25 for participants with some college education or more was used to define normal cognition.

[5] Hearing was measured audiometrically and summarized with a 4-frequency pure tone average (0.5, 1, 2, and 4 kHz; pure-tone average [PTA]) for the better-hearing ear.

[6] HHIE-S  = Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores have the following clinical scaling *No Handicap* (0-8), *Mild-Moderate* (10-24) and *Severe* (26-40).

[7] Hearing aid usage was defined by a time-weighted average of datalogging of the hearing aid use per day between baseline and Year 3. A total of 392 participants had information for average number of hearing aid use between baseline and Year 3.

Supplemental Table S2. Proportion of Study Participants with No Handicap (HHIE-S ≤8) and Mild or worse Hearing Handicap (HHIE-S ≥10) by Randomization Group.

| | Hearing Intervention | | Control | | p-value[1] |
|---|---|---|---|---|---|
| | No Handicap N (%) | Mild or Worse Handicap N (%) | No Handicap N (%) | Mild or Worse Handicap N (%) | |
| Baseline | 124 (30.8) | 319 (69.2) | 145 (31.4) | 317 (68.6) | <0.001 |
| 6 months | 345 (77.7) | 99 (22.3) | 151 (35.0) | 281 (65.0) | <0.001 |
| Year 1 | 348 (78.0) | 98 (22.0) | 154 (35.2) | 284 (64.8) | <0.001 |
| Year 2 | 319 (74.2) | 111 (25.8) | 158 (37.5) | 263 (62.5) | <0.001 |
| Year 3 | 269 (65.8) | 140 (34.2) | 104 (25.2) | 308 (74.8) | <0.001 |

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[1] p-value for a two-sample test of proportions.

Supplemental Table S3. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores Under the Intention to Treat Principle Stratified by Recruitment Type.

| | ARIC (N=216) | | De Novo (N=707) | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **6 Months Difference** | | | | |
| Control | -2.0 (-5.7, 1.8) | | -0.6 (-1.8, 0.6) | |
| Hearing Intervention | -7.9 (-11.8, -4.1) | | -10.5 (-11.8, -9.3) | |
| Between Groups | -6.0 (-8.8, -3.1) | <0.001 | -9.9 (-11.6, -8.3) | <0.001 |
| | | | | |
| **1 Year Difference** | | | | |
| Control | -0.8 (-4.4, 2.7) | | 0.2 (-1.1, 1.4) | |
| Hearing Intervention | -7.1 (-10.7, -3.5) | | -10.2 (-11.5, -8.9) | |
| Between Groups | -6.3 (-9.1, -3.4) | <0.001 | -10.3 (-12.0, -8.7) | <0.001 |
| | | | | |
| **2 Year Difference** | | | | |
| Control | -1.9 (-5.8, 2.0) | | 1.0 (-0.5, 2.5) | |
| Hearing Intervention | -8.2 (-12.2, -4.2) | | -8.0 (-9.5, -6.4) | |
| Between Groups | -6.3 (-9.2, -3.4) | <0.001 | -8.9 (-10.6, -7.2) | <0.001 |
| | | | | |
| **3 Year Difference** | | | | |
| Control | 2.1 (-1.8, 5.9) | | 1.8 (0.6, 3.0) | |
| Hearing Intervention | -4.4 (-8.3, -0.4) | | -8.5 (-9.8, -7.3) | |
| Between Groups | -6.4 (-9.7, -3.2) | <0.001 | -10.3 (-12.0, -8.6) | <0.001 |

NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at each assessment points and the difference from baseline and between the groups is reported after randomization (6 months and years 1-3). The clinical scaling of the HHIE-S is *No Handicap* (0-8), *Mild-Moderate* (10-24) and *Severe* (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates.

Supplemental Table S4. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores Analysis Restricted to Participants who Completed their Assigned Interventions (Per-protocol Analyses). (N=775)

| | Unadjusted Model | | Fully Adjusted Model | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **6 Months Difference** | | | | |
| Control | 0.2 (-1.0, 1.4) | | 0.1 (-1.0, 1.2) | |
| Hearing Intervention | -10.2 (-11.3, -9.1) | | -10.1 (-11.1, -9.0) | |
| Between Groups | -10.4 (-12.1, -8.8) | <0.001 | -10.2 (-11.7, -8.6) | <0.001 |
| | | | | |
| **1 Year Difference** | | | | |
| Control | 0.1 (-1.1, 1.3) | | 0.2 (-0.9, 1.3) | |
| Hearing Intervention | -10.5 (-11.6, -9.4) | | -10.2 (-11.3, -9.2) | |
| Between Groups | -10.6 (-12.2, -8.9) | <0.001 | -10.5 (-12.0, -8.9) | <0.001 |
| | | | | |
| **2 Year Difference** | | | | |
| Control | 0.4 (-0.8, 1.6) | | 0.9 (-0.4, 2.3) | |
| Hearing Intervention | -9.4 (-10.5, -8.3) | | -8.8 (-10.1, -7.4) | |
| Between Groups | -9.8 (-11.4, -8.1) | <0.001 | -9.7 (-11.2, -8.1) | <0.001 |
| | | | | |
| **3 Year Difference** | | | | |
| Control | 2.7 (1.5, 4.0) | | 2.9 (1.7, 4.0) | |
| Hearing Intervention | -8.1 (-9.3, -7.0) | | -8.1 (-9.1, -7.0) | |
| Between Groups | -10.9 (-12.6, -9.2) | <0.001 | -10.9 (-12.5, -9.3) | <0.001 |

NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at each assessment points and the difference from baseline and between the groups is reported after randomization (6 months and years 1-3). The clinical scaling of the HHIE-S is No Handicap (0-8), Mild-Moderate (10-24) and Severe (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global cognition factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates.

Supplemental Table S5. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores using Complier Average Causal Effect. Two-Stage Least Squares (N=923).

| | Unadjusted Model | | Fully Adjusted Model | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **6 Months Difference** | | | | |
| Control | -1.0 (-2.1, 0.1) | | -0.7 (-1.8, 0.3) | |
| Hearing Intervention | -10.8 (-12.1, -9.6) | | -10.5 (-11.7, -9.4) | |
| Between Groups | -9.9 (-11.6, -8.1) | <0.001 | -9.8 (-11.4, -8.2) | <0.001 |
| | | | | |
| **1 Year Difference** | | | | |
| Control | -0.9 (-2.0, 0.3) | | -0.3 (-1.4, 0.8) | |
| Hearing Intervention | -11.1 (-12.3, -9.8) | | -10.5 (-11.7, -9.4) | |
| Between Groups | -10.2 (-12.0, -8.4) | <0.001 | -10.2 (-11.8, -8.6) | <0.001 |
| | | | | |
| **2 Year Difference** | | | | |
| Control | -0.8 (-2.0, 0.3) | | 0.3 (-1.0, 1.5) | |
| Hearing Intervention | -9.8 (-11.1, -8.6) | | -8.6 (-10.0, -7.3) | |
| Between Groups | -9.0 (-10.8, -7.2) | <0.001 | -8.9 (-10.5, -7.3) | <0.001 |
| | | | | |
| **3 Year Difference** | | | | |
| Control | 1.3 (0.1, 2.4) | | 1.7 (0.6, 2.7) | |
| Hearing Intervention | -8.6 (-9.9, -7.4) | | -8.4 (-9.5, -7.2) | |
| Between Groups | -9.9 (-11.7, -8.1) | <0.001 | -10.0 (-11.7, -8.4) | <0.001 |

NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at each assessment points and the difference from baseline and between the groups is reported after randomization (6 months and years 1-3). The clinical scaling of the HHIE-S is No Handicap (0-8), Mild-Moderate (10-24) and Severe (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global cognition factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates.

Supplemental Table S6. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores using two-level mixed effect linear model. Multiple Imputation Analyses (N=977).

| | Unadjusted Model | | Fully Adjusted Model | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **6 Months Difference** | | | | |
| Control | -0.5 (-1.2, 0.2) | | -0.5 (-1.8, 0.8) | |
| Hearing Intervention | -9.8 (-10.5, -9.1) | | -9.8 (-11.0, -8.5) | |
| Between Groups | -9.3 (-10.3, -8.3) | <0.001 | -9.3 (-10.3, -8.3) | <0.001 |
| | | | | |
| **1 Year Difference** | | | | |
| Control | -0.5 (-1.2, 0.2) | | 0.6 (-0.7, 1.9) | |
| Hearing Intervention | -10.0 (-10.7, -9.3) | | -8.8 (-10.0, -7.5) | |
| Between Groups | -9.5 (-10.4, -8.5) | <0.001 | -9.4 (-10.4, -8.4) | <0.001 |
| | | | | |
| **2 Year Difference** | | | | |
| Control | -0.4 (-1.2, 0.3) | | 1.8 (0.3, 3.2) | |
| Hearing Intervention | -8.8 (-9.5, -8.1) | | -6.5 (-8.0, -5.1) | |
| Between Groups | -8.4 (-9.4, -7.4) | <0.001 | -8.3 (-9.3, -7.3) | <0.001 |
| | | | | |
| **3 Year Difference** | | | | |
| Control | 1.6 (0.9, 2.3) | | 2.4 (1.1, 3.7) | |
| Hearing Intervention | -7.6 (-8.3, -6.9) | | -6.9 (-8.3, -5.6) | |
| Between Groups | -9.2 (-10.2, -8.2) | <0.001 | -9.3 (-10.3, -8.3) | <0.001 |

NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at each assessment points and the difference from baseline and between the groups is reported after randomization (6 months and years 1-3). The clinical scaling of the HHIE-S is No Handicap (0-8), Mild-Moderate (10-24) and Severe (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global cognition factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates.

Supplemental Table S7. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores. Two-level mixed effect linear model. Analyses including COVID-19 timing related covariates (N=923)

| | Unadjusted Model | | Fully Adjusted Model | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **6 Months Difference** | | | | |
| Control | -1.0 (-2.1, 0.2) | | -0.7 (-1.7, 0.3) | |
| Hearing Intervention | -10.0 (-11.1, -8.9) | | -9.7 (-10.7, -8.7) | |
| Between Groups | -9.0 (-10.6, -7.4) | <0.001 | -9.0 (-10.4, -7.5) | <0.001 |
| | | | | |
| **1 Year Difference** | | | | |
| Control | -0.9 (-2.0, 0.3) | | -0.2 (-1.3, 0.8) | |
| Hearing Intervention | -10.1 (-11.3, -9.0) | | -9.5 (-10.6, -8.4) | |
| Between Groups | -9.3 (-10.8, -7.7) | <0.001 | -9.3 (-10.7, -7.8) | <0.001 |
| | | | | |
| **2 Year Difference** | | | | |
| Control | -1.0 (-2.4, 0.5) | | 0.1 (-1.2, 1.5) | |
| Hearing Intervention | -9.4 (-10.8, -8.0) | | -8.2 (-9.5, -6.8) | |
| Between Groups | -8.4 (-10.0, -6.8) | <0.001 | -8.3 (-9.8, -6.8) | <0.001 |
| | | | | |
| **3 Year Difference** | | | | |
| Control | 1.1 (-0.4, 2.6) | | 1.0 (-1.4, 3.4) | |
| Hearing Intervention | -8.3 (-9.8, -6.8) | | -8.5 (-10.9, -6.1) | |
| Between Groups | -9.4 (-11.0, -7.7) | <0.001 | -9.5 (-11.0, -8.0) | <0.001 |

NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at each assessment points and the difference from baseline and between the groups is reported after randomization (6 months and years 1-3). The clinical scaling of the HHIE-S is No Handicap (0-8), Mild-Moderate (10-24) and Severe (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global cognition factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates.

Supplemental Table S8. Estimated Effect of the ACHIEVE Intervention on HHIE-S Scores. Two-level mixed effect linear model. Analyses restricting our sample to only baseline and Year 3 measures, all of which took place in-person. (N=923)

| | Unadjusted Model | | Fully Adjusted Model | |
|---|---|---|---|---|
| | Coefficient (95% CI) | P-Value | Coefficient (95% CI) | P-Value |
| **3 Year Difference** | | | | |
| Control | 1.3 (0.5, 2.5) | | 1.7 (0.6, 2.8) | |
| Hearing Intervention | -8.1 (-9.3, -6.8) | | -7.8 (-8.9, -6.7) | |
| Between Groups | -9.4 (-11.1, -7.6) | <0.001 | -9.5 (-11.1, -7.9) | <0.001 |
| NOTE: Hearing Handicap Inventory for the Elderly – Screening version (HHIE-S) scores (means and 95% CI) for each group (Control vs. Hearing Intervention) is reported at Year 3 assessment point and the difference from baseline and between the groups is reported after randomization (Year 3). The clinical scaling of the HHIE-S is No Handicap (0-8), Mild-Moderate (10-24) and Severe (26-40), thus, a reduction from baseline or between groups indicates reduced impairment. The unadjusted model included a binary variable for the intervention (hearing intervention vs. health education control) and the interaction of time with the intervention group variable. The fully adjusted model additionally included baseline age, race, sex, education, marital status, living arrangements, income, recruitment route, being part of a recruited spousal pair, hypertension, diabetes, smoking and drinking status, depression, loneliness, global cognition factor score, better-ear pure tone average, whether the outcome was assessed over the phone or in person, and the interaction between study visit and all additional covariates. | | | | |