

Self-Reported Hearing Loss in Older Adults Is Associated With Higher Emergency Department Visits and Medical Costs

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Abstract

Hearing loss is common among older adults. Thus, it was of interest to explore differences in health care utilization and costs associated with hearing loss and hearing aid use. Hearing loss and hearing aid use were assessed through self-reports and included 5 categories: no hearing loss, aided mild, unaided mild, aided severe, and unaided severe hearing loss. Health care utilization and costs were obtained from medical claims. Those with aided mild or severe hearing loss were significantly more likely to have an emergency department visit. Conversely, those with aided severe hearing loss were about 15% less likely to be hospitalized. Individuals with unaided severe hearing loss had the highest annual medical costs (\$14349) compared with those with no hearing loss (\$12118, $P < .001$). In this study, those with unaided severe hearing loss had the highest medical costs. Further studies should attempt to better understand the relationship between hearing loss, hearing aid use, and medical costs.

Keywords

hearing loss, hearing aids, Medicare, health care costs, older adults, cross-sectional survey

What do we already know about this topic?

Hearing loss is associated with a number of chronic conditions, including dementia and an increased risk for falls.

How does your research contribute to the field?

Most previous studies of the costs associated with hearing loss do not take into account the use of hearing aids.

What are your research's implications toward theory, practice, or policy?

We found that the use of hearing aids was associated with lower medical costs among those with severe self-reported hearing loss.

Background

In the United States, hearing loss affects about 27% of adults age 60 to 69, 55% of those age 70 to 79, and 79% of those age 80 and older.¹ Individuals with hearing loss are more likely to be older, white, and male with lower education and income.² About 19% of individuals age 70 and older with hearing loss use hearing aids, including 3% of persons with mild hearing loss, 40% with moderate hearing loss, and 77% of those with severe hearing loss.³

An extensive body of literature exists regarding the association between hearing loss and poorer health, yet little is published regarding the associations between hearing loss and hearing aid use with health care utilization and medical costs. This area of study is important as Medicare accounts for about 15% of US federal spending, and is at risk of

depleting its hospital insurance trust fund by as early as 2026.⁴ Given the prevalence of hearing loss in a burgeoning older population, examining health care utilization and costs

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associated with aided and unaided hearing loss may provide information enabling improved Medicare stewardship.

What is known about the relationship between hearing loss and health care utilization comes from a small number of studies. Two of these studies used National Health and Nutrition Examination Survey (NHANES) data to identify individuals age 70 and older, both finding an increased risk for hospitalization among those with hearing impairment.^{2,5} Elsewhere, a prospective study using audiometry to identify hearing loss observed an increased risk of hospitalization among those with hearing impairment.⁶ Two other studies used data from the Medical Expenditure Panel Survey (MEPS). The first found an increased odds of emergency department (ED) visits among those with hearing loss.⁷ Meanwhile, the other study, which used a sample of 1336 individuals with serious difficulty hearing, reported decreased ED visits and hospitalizations among hearing aid users.⁸

As with health care utilization, little is known about potential associations between hearing loss, hearing aid use, and medical costs. One study using MEPS data found a positive association between hearing loss and higher total medical expenditures.⁷ Another study of more than 560 000 privately insured individuals age 55 to 64 reported that those with hearing loss who had not used hearing services had health care costs of \$14 165, followed by those with hearing loss who did use hearing services (\$13 767), and those with no hearing loss (\$10 629).⁹ More recently, a study of individuals age 65 and older compared medical costs among those self-reporting hearing loss and use or nonuse of hearing aids.⁸ This study found that individuals wearing hearing aids experienced higher annual health care costs, with increased average out-of-pocket spending of \$325 and total health care costs of \$1125, but with \$71 lower Medicare spending. Considering these findings, it appears that research on the relationships between hearing loss, hearing aid use, health care utilization, and medical costs has provided inconsistent results to date.

Statement of Purpose

Although hearing loss has been associated with increased hospitalizations and medical costs, there is less evidence and consistency regarding whether hearing loss and hearing aid use are associated with ED visits, hospitalizations, and medical costs among those age 65 and older. Therefore, our purpose was to further explore health care utilization and costs associated with several combinations of hearing loss severity and hearing aid use among older adults.

Methods

The main analysis used survey data to identify those who self-reported hearing loss and hearing aid use. In addition, a sensitivity analysis of the association between hearing loss

and medical costs was performed using claims data to identify individuals with a hearing loss diagnosis or claims evidence of hearing aid use. Methods for the sensitivity analysis are discussed following a description of methods for the survey-based analysis.

Survey-Based Analysis

Study population. This study included individuals with an AARP® Medicare Supplement plan insured by UnitedHealthcare Insurance Company (for New York certificate holders, UnitedHealthcare Insurance Company of New York). These plans are offered in all 50 states, Washington DC, and various US territories. Study participants completed a telephone survey and had at least 12-month continuous plan coverage between January 1, 2014 and March 30, 2017. Exclusions included those with less than 12 months of continuous plan coverage, negative medical costs, missing values of interest, or who reported good to excellent hearing but also hearing aid use. In addition, a method described elsewhere¹⁰ was used to identify and exclude individuals with extreme medical costs from analyses, using a cutoff value of 0.005.

Telephone survey. The survey was administered using automated telephone interactive voice response (IVR) technology, conducted in the latter part of 2015 and the first part of 2016 among a random sample of 150 000 residents of New Jersey, Missouri, Texas, and Washington. These states were chosen to support local population health initiatives. The survey included questions about the perceived extent of hearing loss and hearing aid use. The hearing loss question is a modified version of one found in the NHANES and asked, “Which statement best describes your hearing without a hearing aid? Would you say your hearing is: excellent, good, that you have a little trouble, moderate trouble, or a lot of trouble?” This question differs from that in NHANES by omitting “or are you/is s/he deaf?” as a possible response. The hearing aid use question was identical to the one in NHANES, which asks, “In the past 12 months, have you worn a hearing aid at least 5 hours a week?” with possible responses of “Yes” or “No.”

Other variables determined from the survey. Several variables were derived from the survey and used in multivariate modeling, including self-reported symptoms of depression, memory loss, prescription drug use, loneliness, lack of social support, and physical exercise. Depression was assessed with the 2-item Patient Health Questionnaire (PHQ-2).¹¹ Loneliness was measured using the Three-Item Loneliness Scale, adapted by Hughes et al,¹² from the Revised University of California, Los Angeles (R-UCLA) Loneliness Scale. Physical exercise and memory loss were determined by asking “How many days per week do you get 30 minutes or more of light to moderate physical activity?” and “Are you

being treated for serious memory loss or have you been told you have serious memory loss?” Finally, prescription drug use was determined by asking “How many different prescription drugs do you take each day?” and lack of social support was determined with the question “How often can you count on members of your family or your friends for support?”

Data determined from claims. Demographic variables available in claims data included age and sex. Although the data lacked individual information on race/ethnicity, zip code-level correlates were assigned based on the zip code of residence. Using data from the 2010 US Census, we coded for the percentage of minority individuals living in each zip code.¹³ Binary indicators were created based on this ratio to account for the impact of living in low (<15%) or medium-high ($\geq 15\%$) minority areas. State of residence and urbanicity (ie, metropolitan, micropolitan, other) were included in the cost modeling, as medical costs are known to vary by geographic location.¹⁴ Finally, to characterize the use of various AARP Medicare Supplement plans, we divided them into 2 groups to proxy member copayment cost sharing: first-dollar coverage plans (plans C and F, which have minimal copayment/coinsurance requirement), with all other plans (A, K, L, B, D, E, G, H, I, and N, which require some level of copayment/coinsurance responsibility to be paid by the patient) combined into the reference group.

Data from other sources. The supply of health care services where an individual lives is known to influence health care utilization and expenditures.¹⁵ Thus, we derived the number of primary care providers and hospital beds per 100 000 in the Hospital Service Area from the Dartmouth Atlas of Health Care.¹⁶ Hospital Service Area information was transferred to zip code level by the crosswalk supplied with the data. The number of primary care providers was based on being above the 70th percentile for provider density, whereas the number of hospital beds was based on being in the bottom 20th percentile for hospital bed density.

Statistical analyses. To provide granularity, 5 combinations of hearing loss and hearing aid use were created. “Excellent” or “Good” self-reported hearing and no reported hearing aid use were combined into a “no hearing loss” group and used as the reference category in modeling. Those who answered that they had “A Little Trouble” hearing were considered to have “mild hearing loss,” whereas those who answered that they had “Moderate” or “A Lot of Trouble” hearing were considered to have “severe hearing loss.” The moderate and severe hearing loss categories were further divided into those with (ie, aided) and without (ie, unaided) hearing aid use.

Descriptive statistics were calculated to test for significant differences between the 5 hearing loss/hearing aid use categories. Although chi-square tests were used to illustrate statistically significant differences in categorical variables,

many of these differences were of small magnitude and likely do not indicate a meaningful difference. Therefore, we focused on those with at least 5 percentage points difference, as this magnitude (or greater) is more likely to be meaningful. In addition, several variables had a small amount (<5%) of missing data; when this occurred in subsequent multivariate modeling, those with missing data were excluded from the model.

As previously noted, several variables used in this study came from the survey, with respondents who may have differed in important ways compared with those selected to participate but who chose not to do so. As a result, respondents may not be representative of the study population. To help minimize the effect of nonresponse on study findings, propensity-weighted adjustment techniques¹⁷ were applied in the logistic regression analyses for differences in ED visits and hospitalizations.

In addition to descriptive analyses, adjusted logistic regression models were performed to estimate the association between hearing loss/hearing aid use and ED visits or hospitalizations. These models included the 5 categories of hearing loss/hearing aid use as the main predictor variable with those categorized as having no hearing loss as the reference category. These models were additionally adjusted for all of the variables listed in Table 1 with the exception of state and location. Meanwhile, a generalized linear model (GLM) was used to estimate medical cost differences. In this model, the 5 different hearing loss/hearing aid use categories were the main predictor variables. The model was also adjusted for age, sex, first-dollar coverage Medicare Supplement plans, zip-coded minority status, state, location, supply of physicians and hospital beds, loneliness, memory loss, and likelihood to exercise at least 4 days per week.

Sensitivity Analysis Using Hearing Loss Diagnostic Codes

Analytic population. The study population for the sensitivity analysis included individuals with an AARP Medicare Supplement plan who were continuously enrolled from July 2014 to December 2016. Excluded were those who were less than 65 years of age, those with zero or negative medical costs, or those who could not be reasonably matched to the comparison group using propensity scores.¹⁸ Using a method described elsewhere,¹⁰ 4226 individuals with extreme medical cost values were identified and removed from the analysis using a cut-off value of 0.005. Finally, 3544 individuals who self-reported having hearing loss or hearing aid use on the survey, but no evidence of either in the claims data, were excluded.

Hearing loss. Hearing loss diagnoses as well as evidence of hearing aid use were identified between July 2014 and June 2015 using *International Classification of Diseases*, Ninth Revision, Clinical Modification (ICD-9-CM) and *International Classification of Diseases*, Tenth Revision, Clinical

Table 1. Unweighted Descriptive Comparisons by Hearing Loss and Hearing Aid Use With Self-Reported Hearing Loss Data.

Characteristic	No hearing loss n = 11852 (%)	Unaided mild hearing loss n = 3551 (%)	Aided mild hearing loss n = 693 (%)	Unaided severe hearing loss n = 1746 (%)	Aided severe hearing loss n = 2268 (%)	P value
Claims-based variables						
Age						<.001
65-74	41.1	34.6	17.9	29.5	20.2	
75-84	43.7	45.4	48.9	45.8	44.4	
≥85	15.2	20.0	33.2	24.7	35.4	
Sex—female	72.2	59.1	47.8	55.2	49.5	<.001
First-dollar coverage plan	77.4	76.1	78.4	75.9	77.6	.309
Income ^a						<.001
Low	12.6	14.1	12.7	15.7	12.5	
Medium	37.0	39.4	35.4	39.4	39.2	
High	50.4	46.6	51.9	44.9	48.3	
Low minority ^a	59.0	56.9	60.8	60.9	58.0	.035
Location						<.001
Metropolitan	79.9	78.4	79.8	74.7	78.5	
Micropolitan	11.0	11.7	12.7	12.7	12.6	
Other	9.1	9.9	7.5	12.6	8.9	
Hierarchical condition category score						<.001
<0.8	62.3	54.4	53.4	45.1	47.5	
0.8-2.0	30.0	35.9	37.7	40.9	41.1	
>2.0	7.7	9.7	8.9	14.0	11.4	
Local medical services ^b						
High density of primary care physicians	23.7	25.0	27.8	24.9	25.4	.049
Diabetes	18.1	22.9	18.9	28.3	22.8	<.001
Respiratory disease ^c	13.0	15.5	11.3	19.0	17.0	<.001
Stroke	5.1	5.8	7.2	7.3	7.5	<.001
Survey-based variables						
2-item Patient Health Questionnaire—Depression	4.8	7.8	4.3	13.7	8.8	<.001
Memory loss	1.3	1.8	2.0	4.1	3.5	<.001
≥5 prescription drugs per day	29.6	38.4	33.9	47.1	41.0	<.001
Medium/high loneliness	25.9	35.5	34.5	40.1	38.5	<.001
Lack of social support	6.2	7.7	8.8	10.4	9.7	<.001
Exercises 4+ days/week	55.9	50.2	58.2	42.0	50.4	<.001

^aBased on US Census data for zip code of residence.

^bBased on Dartmouth Atlas of Health Care.

^cIncludes asthma and chronic obstructive pulmonary disease.

Modification (ICD-10-CM) codes. Using these codes, a dichotomous (Yes/No) variable was created for which anyone with claims evidence of hearing loss or hearing aid use was coded as Yes, whereas the rest were coded as No.

Statistical analysis of medical costs. Because this analysis used propensity score matching of those with hearing loss to those without, descriptive statistics were limited to ensure that the matching was effective in minimizing case-mix differences between the 2 groups. Although a GLM model was used for the main cost analysis, an analysis of variance (ANOVA)

model provided better fit for these data. Again, hearing loss was the main predictor variable; the model was additionally adjusted for age, sex, first-dollar Medicare Supplement plans, state, location, zip-coded minority status, and density of primary care physicians.

Results

Among those contacted, 24 893 individuals (18%) completed the survey. After cleaning the data and removing exclusions, 20 110 survey participants were included in this study, of

Table 2. Descriptive Comparisons Using Hearing Loss Diagnostic Codes.

Characteristic	No hearing loss n = 499 788 (%)	Hearing loss n = 499 927 (%)	P value
Age			<.001
65-74	34.0	33.3	
75-84	38.6	37.9	
≥85	27.4	28.9	
Sex—female	55.2	55.7	<.001
First-dollar Medigap coverage	74.4	74.2	.022
Minority status ^a			.043
Low	51.6	51.5	
Medium	45.1	45.3	
High	3.3	3.2	
Division			<.001
Northeast Central	13.7	13.9	
Southeast Central	3.7	4.0	
Mid-Atlantic	21.3	19.1	
Mountain	7.6	7.9	
New England	5.8	5.9	
Pacific	11.8	12.6	
South Atlantic	25.7	25.5	
Northwest Central	3.4	3.7	
Southwest Central	6.9	7.5	
Location			<.001
Metropolitan	85.1	83.7	
Micropolitan	9.1	9.6	
Other	5.8	6.7	
Local medical services ^b			<.001
Primary Care Physicians			
Low	32.0	31.3	
Medium	46.9	47.4	
High	21.1	21.3	

^aBased on US Census data for zip code of residence.

^bBased on Dartmouth Atlas of Health Care.

which 41% (8258) had self-reported hearing loss. Among those with self-reported hearing loss, 77% with “A Lot of Trouble” hearing used hearing aids, followed by 50% of those with “Moderate Trouble” and 16% of those with “A Little Trouble” (data not shown). Finally, when categorized into the possible combinations of hearing loss and hearing aid use, 18% (3551) had unaided mild hearing loss, 3% (693) had aided mild hearing loss, 9% (1746) had unaided severe hearing loss, 11% (2268) had aided severe hearing loss, and 59% (11 852) had no hearing loss.

In unweighted descriptive analyses using a difference of 5 percentage points as likely to be meaningful, notable differences when comparing those with and those without hearing loss included that those with hearing loss were more likely to be older, men, with lower income, and sicker (Table 1). In the descriptive table for the sensitivity analysis, most *P* values remained statistically significant, although the actual differences were minimal (Table 2). This suggests that the propensity score weighting did an adequate job of balancing

case-mix differences between those with hearing loss and those with no hearing loss.

In the multivariable logistic regression model for ED visits, those with aided mild hearing loss were 23% more likely to have an ED visit (adjusted odds ratio [OR] = 1.23; 95% confidence interval [CI], 1.03-1.46), whereas those with aided severe hearing loss were 28% more likely to have an ED visit (OR = 1.28; 95% CI, 1.16-1.42) (Figure 1). Meanwhile, in the logistic regression model for hospitalizations, the only significant finding was that those with aided severe hearing loss were about 16% less likely to be hospitalized (OR = 0.84; 95% CI, 0.73-0.96), compared with the no hearing loss group.

In the main analysis using survey data to identify those with hearing loss, and comparing with those with no hearing loss (Table 3), individuals with unaided severe hearing loss had the highest annual medical costs (\$14 349; *P* < .001). This group was followed by those with aided mild hearing loss (\$13 867; *P* = .082), aided severe hearing loss (\$13 437;

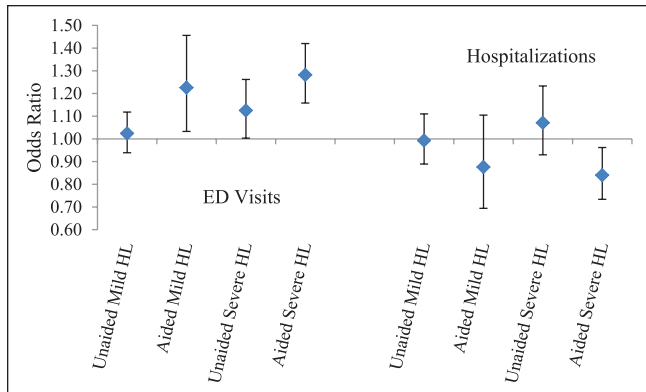


Figure 1. Adjusted odds ratios and 95% confidence intervals for emergency department (ED) visits and hospitalizations for the 4 categories of hearing loss (HL) with no HL as the reference category.

$P = .012$), and unaided mild hearing loss (\$12 890; $P = .149$). Similarly, in the sensitivity analysis, individuals with hearing loss had annual medical costs of \$18 548, which were 18% higher than those with no hearing loss ($P < .001$).

Discussion

In this study, we observed that individuals with unaided severe hearing loss had the highest medical costs, as well as increased odds for ED visits or hospitalizations, although the ORs for ED visits and hospitalizations were not statistically significant. Previous analyses using these data have shown that this group was more likely to include older men with lower income, and those with diabetes, respiratory disease, or taking more prescription drugs.¹⁹ Therefore, it makes sense that they had the highest medical costs. Conversely, it was surprising that the observed increased risks for ED visits and hospitalizations were not statistically significant, as ED visits and hospitalizations contribute significantly to health care spending.^{20,21} However, finding insignificant increased risk for ED visits and hospitalizations may be due to competing factors. For instance, there is evidence that those with hearing loss are more likely to have ED visits and to be hospitalized, as previously described. However, evidence also suggests that individuals who struggle to communicate with their health care providers, such as those with severe hearing loss and who do not use hearing aids, are less likely to seek health care, suggesting lower health care utilization.²² Perhaps, the interaction between these 2 competing factors counteracts each other such that we observe increased ED visits and hospitalization risks that fall short of statistical significance.

Next, we observed that those with aided mild or severe hearing loss had intermediate health care costs and were more likely to have 1 or more ED visits but less likely to be hospitalized, although the difference in hospitalizations was only statistically significant for those with aided severe hearing

loss. Notably, using ED services is the patient's choice, whereas physicians determine who to hospitalize. In addition, purchasing hearing aids is a costly out-of-pocket expense, suggesting that those who use them have higher incomes compared with those who do not. These individuals, or their caregivers, may be less inclined to defer what they perceive to be urgent or emergent medical care due to cost, which could lead to higher utilization of ED services. Meanwhile, the decrease in hospitalizations among those with aided hearing loss was unexpected, although supported by studies elsewhere. For instance, one study found a decrease in hospitalizations among hearing aid users,⁸ whereas another reported increased hospitalizations among those who did not use hearing aids.²³ A possible explanation may be that those who wear hearing aids are in overall better health. This may be related to positive health benefits associated with hearing aid use,²⁴ or the observations could be indirect, influenced by socioeconomic circumstances often associated with higher income, or by an association with other proactive, health-seeking behaviors seen to lesser degrees in those with unaided hearing loss. Finally, it is also possible that this finding is due to unmeasured confounding. For example, in 2010, 6.0% of the US population was age 75 and older,¹⁶ yet comprised 8.7% of all ED visits.²⁵ Although we adjusted for age in these analyses, similar associations may exist that we have not identified, or for which we were unable to adjust, yet may have influenced our ED and hospitalization findings. Finally and as expected, individuals with mild unaided hearing loss appeared most similar to those with no hearing loss with respect to health care costs, ED visits, and hospitalizations.

Strengths and Limitations

Strengths of this study include the large sample of adults age 65 and older and the inclusion of hearing aid use data. This allowed the creation and analysis of 5 hearing loss/hearing aid use categories, which can be difficult to do with smaller samples. This study also explored the associations of aided and unaided hearing loss with health care utilization and costs; furthermore, the use of survey data allowed for adjustment for potential influential variables that are traditionally unavailable from claims data. In addition, the survey was conducted using telephone IVR technology, a limitation that could possibly restrict participation among individuals with hearing loss, and a lower prevalence was observed compared with a previous study.¹ It remains unclear whether this was due to nonresponder bias associated with the survey design, the fact that older individuals are more likely to underreport hearing loss,²⁶ a combination of both, or perhaps other factors. If the lower prevalence of hearing loss in this study is due to underreporting, this most likely would tend to bias the magnitude of any positive or negative associations toward the null. In addition, to make the results more representative, propensity score weighting was used to account for survey nonresponse. Finally, because we used self-reported hearing loss, this may not be sufficiently accurate to discriminate mild

Table 3. Medical Costs.

Group	Adjusted annual medical costs (\$)	P value
Survey analysis (n = 20 110)		
No hearing loss (n = 11 852)	12 118	not applicable
Aided mild hearing loss (n = 693)	13 867	.082 ^a
Unaided mild hearing loss (n = 3551)	12 890	.149 ^a
Aided severe hearing loss (n = 2268)	13 437	.012 ^a
Unaided severe hearing loss (n = 1746)	14 349	<.001 ^a
Claims analysis (n = 999 715)		
No hearing loss (n = 499 788)	15 707	not applicable
Hearing loss (n = 499 927)	18 548	<.001 ^a

^aCompared with the no hearing loss group.

from severe hearing loss. The only evidence that this categorization worked is a previous study which reported that hearing aid use increases with hearing loss severity.³ In their study, 3.4% of those with mild hearing loss used hearing aids, whereas 40% and 77% of those with moderate and severe hearing loss, respectively, used hearing aids. Meanwhile, in our data, hearing aid use showed a similar trend: 2% of those with “Good” hearing, 16% of those with “A Little Trouble” hearing, 50% of those with “Moderate Trouble,” and 77% of those with “A Lot of Trouble.”

Conclusions

In this study, those with aided mild or severe hearing loss were more likely to visit an ED, whereas only those with aided severe hearing loss were less likely to be hospitalized. In addition, those with aided or unaided severe hearing loss had medical costs that were significantly higher than those without hearing loss. Further studies should attempt to better understand the relationship between hearing loss, hearing aid use, and medical costs. For example, studying the source of medical expenses that are associated with unaided hearing loss should be considered, as well as the factors that drive or inhibit hearing aid-seeking behavior. Both of these may help efforts to test the effectiveness and return on investment for interventions to increase hearing treatment.

Ethics Approval and Consent to Participate

The conduct of this study has been approved by the New England Independent Review Board (NEIRB#: 16-093).

Consent for Publication

Consent for publication is not applicable, as this manuscript does not contain any individual person’s data in any form.

Availability of Data and Materials

The data sets generated and/or analyzed during the current study are not publicly available, as doing so would violate existing data use agreements.

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Author Contributions

T.S.W., L.D.N., S.R.R., and C.S.Y. conceived and designed the study. L.W. and G.R.B. performed the acquisition and analysis of data. T.S.W., L.D.N., S.R.R., L.W., G.R.B., and C.S.Y. interpreted the data. T.S.W. drafted the manuscript. L.D.N., S.R.R., and C.S.Y. revised the manuscript for important intellectual content. T.S.W., L.D.N., S.R.R., L.W., G.R.B., and C.S.Y. approved the final version to be published.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: T.S.W., L.D.N., S.R.R., L.W., and G.R.B. are all employed by UnitedHealth Group and have stock with UnitedHealth Group. C.S.Y. is employed by AARP Services, Inc. However, their compensation was not dependent upon the results obtained in this research, and the investigators retained full independence in the conduct of this research.

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