Limited Health Literacy and Hearing Loss Among Older Adults

Timothy S. Wells, PhD; Steven R. Rush, MA, LP; Lorraine D. Nickels, BSN, MS; Lizi Wu, PhD; Gandhi R. Bhattarai, PhD; and Charlotte S. Yeh, MD

ABSTRACT

Background: Effective communications between health care providers and patients are critical for high-quality health care. **Objective:** This study sampled adults age 65 years and older to explore (1) characteristics associated with limited health literacy (LHL) and (2) medical costs and gaps in care based on health literacy, hearing loss, and hearing aid use status. **Methods:** The study included 19,223 adults age 65 years and older who completed a health survey that was linked to his or her medical claims that were generated after medical care provided in the year prior to survey completion. Health literacy, hearing loss, and hearing aid use were assessed through self-reports. Health literacy was coded as *limited* and *adequate*. Hearing loss and hearing aid use were coded into five categories: no hearing loss, unaided mild, aided mild, unaided severe, and aided severe hearing loss. **Key Results:** Seven percent reported LHL and 41% reported hearing loss. Hearing loss, especially unaided severe, was associated with LHL, as were memory loss, depression, loneliness, older age, and male gender. People with aided severe hearing loss and LHL had higher annual medical costs than those with adequate health literacy. Similarly, those with no hearing loss and LHL had higher annual medical costs than those with adequate health literacy. **Conclusions:** Unaided mild, aided severe, and unaided severe hearing loss were positively associated with LHL, although the association was reduced among hearing aid users. Specifically, aided mild or severe hearing loss had lower odds of LHL, compared to unaided mild or severe hearing loss, respectively. We also observed that people with both hearing loss and LHL were more likely to have higher medical costs. Continued focus on solutions to address both LHL and hearing loss remains warranted. **[*HLRP: Health Literacy Research and Practice*. 2020;4(2):e129-e137.]**

Plain Language Summary: Health survey and medical claims data were used for this study. Hearing loss, especially unaided severe, was associated with limited health literacy, as were memory loss, depression, loneliness, older age, and male gender. Those with both limited health literacy and hearing loss had the highest medical costs. Health literacy and hearing loss can affect health care communications, warranting further study.

Adults age 65 years and older are more likely to have limited health literacy (LHL) (Kutner, Greenberg, Jin, & Paulsen, 2006). Health literacy is defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (U.S. Department of Health and Human Services, 2009). Meanwhile, hearing loss remains a significant public health problem (National Academies of Sciences, Engineering, and Medicine, 2016). Health literacy and hearing loss can both affect health care communications. Therefore, we studied characteristics (i.e., traits) associated with LHL, and determined how combinations of LHL, hearing loss, and hearing aid use were associated with medical costs.

Characteristics associated with LHL include having less than a college education, being male, being an ethnic minority, and having poorer physical or mental health (MacLeod et al., 2017). Older adults with LHL are more likely to visit emergency departments (ED), be hospitalized, and have higher medical costs (MacLeod et al.,

2017). Other studies have positively associated LHL with poorer health outcomes, poorer use of health care services (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011), and lower self-rated health (Cutilli, Simko, Colbert, & Bennett, 2018).

In the United States, hearing loss disproportionately affects older adults, (Lin, Niparko, & Ferrucci, 2011) of whom about 19% use hearing aids (Lin, Thorpe, Gordon-Salant, & Ferrucci, 2011). People with hearing loss are also less satisfied with their health care communications and overall health care (Mick, Foley, & Lin, 2014), perceive more unmet health care needs (Mikkola et al., 2016), and have higher health care costs (Simpson, Simpson, & Dubno, 2016). Finally, a recent study found that adults age 65 years and older with unaided severe hearing loss were more likely to report poor to fair self-rated health and were less likely to exercise regularly (Wells et al., 2019).

Less is known about how the use of hearing aids affects health literacy. Even though hearing loss is associated with communication challenges in the health care setting and adverse outcomes (McKee, Stransky, & Reichard, 2018), we found no evidence of improved health literacy or health care use associated with hearing aid use. For example, one study found no improvement in health care communications with hearing aid use (Mick et al., 2014). Meanwhile, in another study, hearing aid use was not associated with unmet health care needs (Mikkola et al., 2016).

Finally, both LHL and hearing loss have been positively associated with increased medical costs. One study found $487 to $1,267 higher annual medical costs for those with LHL (MacLeod et al., 2017). Similarly, a systematic review reported that LHL was associated with higher annual medical costs of $143 to $7,798 (Eichler, Wieser, & Brugger, 2009). Elsewhere, medical costs in one study were $1,551 higher for those with LHL, but the significance was marginal (p = .08) (Howard, Gazmararian, & Parker, 2005). Similarly, people with hearing loss averaged $3,168 higher health care costs over a 1.5-year period than those without hearing loss (Simpson et al., 2016). Finally, hearing aid use has been associated with reduced Medicare costs, but increased total and out-of-pocket health care spending (Mahmoudi, Zazove, Meade, & McKee, 2018).

Although studies have described the characteristics of those with either LHL or hearing loss, little is published on whether those with hearing loss or hearing aid use are more likely to have LHL. It is also known that those with either LHL or hearing loss have higher medical costs, but the effect of both factors together on medical costs has not been extensively studied. Thus, this study was designed to help fill existing knowledge gaps regarding LHL, hearing loss, and hearing aid use and how these factors are associated with medical costs among older adults.

METHODS

Study Population

The study included people with an AARP® Medicare Supplement plan insured by UnitedHealthcare Insurance Company (for New York certificate holders, UnitedHealthcare In-

Timothy S. Wells, PhD, is the Associate Director of Research, Research for Aging Populations, Optum. Steven R. Rush, MA, LP, is the Director, UnitedHealth Group Health Literacy Innovations Program. Lorraine D. Nickels, BSN, MS, is the Director, Clinical Services Healthcare Transformation, UnitedHealth Group Alliances. Lizi Wu, PhD, is a Data Analyst, Research for Aging Populations, Optum. Gandhi R. Bhattarai, PhD, is the Director of Research, Research for Aging Populations, Optum. Charlotte S. Yeh, MD, is the Chief Medical Officer, AARP Services.

Address correspondence to Timothy S. Wells, PhD, Research for Aging Populations, Optum, 315 E. Eisenhower Parkway, Suite 305, Ann Arbor, MI 48108; email: Tim.Wells@optum.com.

Grant: This work was funded by the Medicare Supplement Health Insurance Program.

Disclaimer: Compensation for Timothy S. Wells, Steven R. Rush, Lorraine D. Nickels, Lizi Wu, and Gandhi R. Bhattarai as UnitedHealth Group employees was not dependent upon research results and full independence has been retained in the conduct of this research. Compensation for Charlotte S. Yeh as an AARP employee was not dependent upon research results and full independence has been retained in the conduct of this research.

Disclosure: Timothy S. Wells, Steven R. Rush, Lorraine D. Nickels, Lizi Wu, and Gandhi R. Bhattarai all own stock in UnitedHealth Group.

Acknowledgment: The authors thank Stephanie J. MacLeod, MS, and Jessica Belt, BA, both of UnitedHealth Group, for editorial assistance and critical review of the manuscript; and Michael McKee, MD, MPH (University of Michigan) for his review of the manuscript.

Received: November 28, 2018; Accepted: June 5, 2019

doi: 10.3928/24748307-20200511-01

surance Company of New York). These plans are offered in all 50 states, Washington, DC, and various U.S. territories. Eligible study participants were age 65 years and older, had completed a telephone survey as described below, and had at least 12 months of continuous plan coverage in the year prior to survey completion.

Telephone Survey

As described in a previous publication (Wells et al., 2019), this study used self-reported health literacy, hearing loss, and hearing aid use data from a survey administered using telephonic interactive voice response (IVR). The survey was conducted in the latter part of 2015 and first part of 2016 among a random sample of 150,000 residents of New Jersey, Missouri, Texas, and Washington, selected to support the implementation of a new population health initiative in these states.

In the questionnaire, the hearing loss question was "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 the National Health and Nutrition Examination Survey (NHANES) by omitting or *are you deaf* as a possible response. The hearing aid 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*.

Hearing Loss Definitions

Five combinations of hearing loss and hearing aid use were created (Wells et al., 2019) **(Table 1)**. *Excellent* or *good* hearing and no reported hearing aid use were combined into a no hearing loss group and used as the reference category in regression modeling. Those who answered that they had *a little trouble* hearing were considered to have mild hearing loss, while those who answered they had *moderate* or *a lot of trouble* hearing were considered to have severe hearing loss. Both mild and severe hearing loss were further divided into those with (i.e., aided) and without (i.e., unaided) hearing aid use.

Health Literacy

Health literacy was assessed using the question "How confident are you filling out medical forms by yourself?" (Wallace, Rogers, Roskos, Holiday, & Weiss, 2006). Responses of *a little bit* and *not at all* were categorized as LHL, whereas *extremely*, *quite a bit*, and *somewhat* were categorized as adequate health literacy (Wallace et al., 2006).

TABLE 1

Categorization of Hearing Loss and Hearing Aid Use

Hearing loss status from survey	Reported hearing aid use from survey	Study category
Excellent or good	No	No hearing loss
A little trouble	No	Unaided mild hearing loss
	Yes	Aided mild hearing loss
Moderate or a lot of trouble	No	Unaided severe hearing loss
	Yes	Aided severe hearing loss

Other Characteristics from the Telephone Survey

Variables for loneliness, depression, physical exercise, and memory loss were derived from the survey. Loneliness and depression were measured using the Three-Item Revised University of California, Los Angeles Loneliness Scale (Hughes, Waite, Hawkley, & Cacioppo, 2004), and Patient Health Questionnaire (PHQ-2) (Kroenke, Spitzer, & Williams, 2003). Meanwhile, 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, the number of prescription drugs taken per day was determined from the survey by asking "How many different prescription drugs do you take each day?"

Characteristics from Claims Data

Demographic variables included age and gender. For race/ethnicity and income, zip code-level correlates were assigned based on the zip code of residence (U.S. Census Bureau, 2015).

Health status was additionally characterized using variables from claims data, including the Hierarchical Condition Category (HCC) score (Centers for Medicare & Medicaid Services, 2014). Next, variables were created for several disease conditions including respiratory disease (i.e., asthma or chronic obstructive pulmonary disease), diabetes, and stroke. Finally, people with an injurious fall or hip fracture were identified from suggested Healthcare

Effectiveness Data and Information Set diagnosis codes (National Committee for Quality Assurance, 2016). More information regarding how these variables were created can be found in a previous publication (Wells et al., 2019).

Statistical Analyses

Descriptive statistics were calculated to test for the significant differences between those with LHL and those with adequate health literacy. Chi-square tests were used to illustrate statistically significant differences in categorical variables. However, because this study included over 19,000 people, many statistically significant differences were quite small and a difference of 5% was considered meaningful.

Many variables came from the survey; thus, those who responded may have differed from those selected but chose not to participate. As a result, respondents may not be representative of the intended study population. To minimize the effect of nonresponse on study findings, propensity-weighted adjustment techniques (Little, 1986) were applied in the logistic regression analyses.

Logistic regression modeling was performed to estimate characteristics associated with LHL. In this model, LHL was the dependent variable, and the five hearing loss/hearing aid use groups (no hearing loss, unaided mild hearing loss, aided mild hearing loss, unaided severe hearing loss, and aided severe hearing loss) were explanatory variables, along with the variables previously described. Next, a generalized linear model (GLM) was used to estimate annual medical costs for combinations of health literacy and the five hearing loss and hearing aid use groups. The method proposed by Nooghabi et al. (2010) was used to identify 128 extreme values that were removed from the cost analysis using a cutoff value of 0.005.

Analyses were also performed to determine if combinations of health literacy and the five hearing loss and hearing aid use groups were associated with gaps in medical care. First, we assessed differences in ED visits and hospitalizations. Next, we used principles of evidence-based medicine (EBM) (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996) to develop metrics for adhering to both clinical and pharmacotherapy standards of care. For example, one EBM clinical metric would recommend that a patient with heart disease should see a cardiologist on a regular basis. Meanwhile, an example of a pharmacotherapy metric is adhering to a drug regimen as prescribed. For this analysis, Separate Cochran-Mantel-Haenszel Chi-square tests for stratified tables (Cody & Smith, 1997) were performed to evaluate the association between LHL and the four gaps in care measures described above, while adjusting for the five combinations of hearing loss and hearing aid use groups.

RESULTS

Among those contacted, 24,893 people (18%) completed the survey. Nonrespondents were more likely to live in Texas, or in a zip code characterized as being high income or with a moderate percentage of ethnic minority residents. After data cleaning and removing exclusions, 19,223 survey participants were included in this study. Among included participants, 7% had LHL, 41% had self-reported hearing loss, and 15% used hearing aids **(Table 2)**.

Many characteristics were associated with LHL in unadjusted comparisons **(Table 2)**. In logistic regression modeling **(Table 3)**, self-reported memory loss was most strongly associated with LHL, followed by PHQ-2 depression. Meanwhile, those with unaided severe hearing loss were 80% more likely to report LHL, followed by those with unaided mild hearing loss (46%), and aided severe hearing loss (41%), respectively, while those with aided mild hearing loss were not at increased risk for LHL. In addition, many other characteristics were also positively associated with LHL, as shown in **Table 3**.

In the GLM cost models **(Table 4)**, significant differences by health literacy status were observed for those with aided severe hearing loss and those with no hearing loss. More specifically, across each hearing loss and hearing aid use category, those with LHL had higher medical costs. In comparison, those with LHL and aided severe hearing loss had the highest annual medical costs ($15,999), whereas those with adequate health literacy and no hearing loss had the lowest annual medicals costs ($10,484).

Finally, in the gaps in care analysis, the positive associations for ED visits and hospitalizations remained after adjusting for the five hearing loss and hearing aid use groups ($p < .05$), whereas no associations remained for the EBM metrics after adjustment ($p > .05$). Furthermore, in all four gaps in care models, the Breslow-Day test for homogeneity was not significant, indicating no differences in the LHL and the four gaps in care associations created by the five hearing loss and hearing aid use groups.

DISCUSSION

To our knowledge, this is the first study to find a positive association between LHL and aided or unaided severe hearing loss and unaided mild hearing loss. Among those with mild and severe hearing loss, self-reported use of hearing aids was associated with a lower risk for LHL. If this finding is accurate, it suggests that the use of hearing aids may be one way to improve health literacy. For example, if the LHL is caused more by the inability to hear what is being said by the health care provider (i.e., ability to obtain

TABLE 2

Unweighted Descriptive Comparisons for Adequate and Limited Health Literacy

	Adequate health literacy ($n = 17,873$)	Limited health literacy ($n = 1,350$)	
Characteristic	%		***p* Value**
Age			
65-74	36.8	24.1	
75-84	44.7	42.7	<.001
≥85	18.6	33.2	
Female	65.7	55.6	<.001
HCC score			
<0.8	58.6	39.2	
0.8-2	32.8	41.2	<.001
>2	8.6	19.6	
Income[a]			
Low	12.7	17.9	
Medium	37.3	41.9	<.001
High	49.9	40.1	
Minority[a]			
Low	58.7	59	
Medium	39.1	38.6	.826
High	2.2	2.4	
Prescription drugs			
0-4 per day	49.5	66.9	<.001
≥5 per day	50.5	33.1	
Injurious fall or hip fracture	3.8	7.8	<.001
Respiratory disease[b]	13.9	21.2	<.001
Diabetes	19.9	28.3	<.001
Stroke	5.4	10.4	<.001
Loneliness			
Low	71.3	47	
Medium	20.6	31	<.001
High	8.1	22	
Exercise (days/week)			
0	9.3	24.5	
1-3	36.2	39.9	<.001
4-7	54.5	35.6	
Self-reported memory loss	1.1	12.6	<.001
PHQ-2 depression	5.1	23.6	<.001
Hearing loss status			
No hearing loss	60.3	41	
Aided mild hearing loss	17.4	22.2	
Unaided mild hearing loss	3.5	3	
Aided severe hearing loss	8	17.1	<.001
Unaided severe hearing loss	10.9	16.7	

Note. HCC = hierarchical condition category; PHQ = Patient Health Questionnaire. [a]Based upon U.S. Census data for zip code of residence. [b]Includes asthma and chronic obstructive pulmonary disease.

health information) than the ability to process what is being said, then the use of hearing aids may improve health literacy among these people. Alternatively, it may be that people with LHL are less proficient at obtaining and using hearing aids, which could contribute to the positive association between LHL and aided or unaided severe hearing loss and unaided mild hearing loss (Convery, Hickson, Meyer, & Keidser, 2019).

We also identified several previously reported characteristics associated with LHL. For example, studies have identified women as typically having higher health literacy than men, and that older adults and those with lower incomes are more likely to have LHL (Kutner et al., 2006). Others have also previously identified LHL associated with poorer cognitive function or cognitive decline (Geboers et al., 2018), history of a stroke (MacLeod et al., 2017), lower likelihood to exercise (Fernandez, Larson, & Zikmund-Fisher, 2016; Geboers, Reijneveld, Jansen, & de Winter, 2016), and increased loneliness (Geboers et al., 2016).

In our study, people with depression were over 2.5 times more likely to have LHL, which contrasts with two studies that found no association between depression and LHL once

TABLE 3

Adjusted Characteristics Associated with Limited Health Literacy

Characteristic	Limited health literacy OR [95% CI]
Age	
65-74	1.00[a]
75-84	1.24 [1.07, 1.43]
≥85	1.82 [1.54, 2.15]
Female	0.70 [0.62, 0.79]
HCC score	
<0.8	1.00[a]
0.8-2	1.13 [0.98, 1.31]
>2	1.66 [1.37, 2.01]
Income[b]	
High	1.00[a]
Medium	1.39 [1.22, 1.58]
Low	1.75 [1.48, 2.08]
Low (for ethnic/racial minorities)[b]	1.06 [0.94, 1.20]
Prescription drugs (per day)	
0-4	1.00[a]
≥5	1.22 [1.07, 1.39]
Injurious fall or hip fracture	1.35 [1.06, 1.71]
Respiratory disease[c]	1.19 [1.02, 1.39]
Diabetes	1.06 [0.92, 1.23]
Stroke	1.35 [1.10, 1.64]
Medium-high loneliness	1.74 [1.54, 1.97]
Exercise 4-7 days/week	0.67 [0.59, 0.76]
Self-reported memory loss	7.53 [5.96, 9.52]
PHQ-2 depression	2.67 [2.27, 3.15]
Aided mild hearing loss	0.94 [0.67, 1.33]
Unaided mild hearing loss	1.46 [1.25, 1.71]
Aided severe hearing loss	1.41 [1.19, 1.69]
Unaided severe hearing loss	1.80 [1.51, 2.15]

Note. CI = confidence interval; HCC = hierarchical condition category; OR = odds ratio; PHQ = Patient Health Questionnaire.
[a]Reference category. [b]Based upon U.S. Census data for zip code of residence. [c]Includes asthma and chronic obstructive pulmonary disease.

confounders were considered. The first study found that depression was positively associated with LHL until models were adjusted for cognitive abilities (Serper et al., 2014). Meanwhile, in another study, those with LHL were 2.7 times more likely to be depressed, until models were adjusted for health status, including medical conditions, activities of daily living, and self-reported health (Gazmararian, Baker, Parker, & Blazer, 2000). In contrast, the association between LHL and depression remained in our model, after adjusting for self-reported memory loss, respiratory disease, diabetes, or stroke. Clearly the association between depression and LHL is sensitive to study design issues and requires further study.

We found no previous reports of positive relationships between LHL and either higher HCC scores, respiratory conditions, injurious falls/hip fractures, or taking five or more medications per day. However, a body of literature exists on associations between LHL and higher health care use. Therefore, it seems plausible that people with LHL will have more encounters with the health care system that increase the likelihood of medical claims related to either an asthma or chronic obstructive pulmonary disease diagnosis, both of which are included in the respiratory disease category. In addition, those with higher health care use are more likely to have higher HCC scores. Similarly, we did not find any evidence in the literature of a positive association between injurious falls, hip fractures, or increased prescription drug use with LHL. However, two possible explanations may shed light on these associations. As previously discussed, people with LHL are less likely to exercise, and older adults who do not exercise are more likely to fall (Guirguis-Blake, Michael, Perdue, Coppola, & Beil, 2018). Next, LHL was positively associated with increased prescription drug use, and certain prescription drugs (i.e., high falls risk drugs) are associated with an increased risk of falls/hip fractures (Musich, Wang, Ruiz, Hawkins, & Wicker, 2017).

We also observed that those with LHL had higher annual medical costs when compared to those with adequate health literacy within each category of hearing loss and hearing aid use. However, these differences were only statistically significant for those with no hearing loss and those with aided severe hearing loss. The significant cost difference for those with limited versus adequate health literacy among those without hearing loss likely represents the increased medical costs associated with LHL among those with normal hearing. At least two studies have found increased medical costs associated with LHL (Eichler et al., 2009; Howard et al., 2005), supporting other findings that those with LHL are less likely to use preventive medicine services, but more likely to use EDs and to be hospitalized (MacLeod et al., 2017). Additionally, the gaps in care analysis supported this previous finding that people with LHL are more likely to use EDs and to be hospitalized. An unexpected finding was that those with LHL and aided severe hearing loss had the highest medical costs, rather than those with unaided severe hearing loss.

TABLE 4

Adjusted Annual Medical Costs for Hearing Loss, Hearing Aid Use, and Limited Health Literacy

	Number		Adjusted annual medical costs			
Hearing category	Limited health literacy	Adequate health literacy	Limited health literacy ($)	Adequate health literacy ($)	Cost difference ($)	*p* Value
No HL	549	10,705	13,055	10,484	2,571	.031
Unaided mild HL	296	3,083	13,504	11,171	2,333	.465
Aided mild HL	39	619	13,037	12,383	654	1.000
Unaided severe HL	228	1,417	13,680	13,014	666	1.000
Aided severe HL	222	1,937	15,999	11,511	4,487	.012

Note. HL = hearing loss.

As previously described, both LHL and hearing loss have been associated with higher medical costs, leading to the speculation that people with unaided severe hearing loss would have the highest medical costs. However, at least one recent study has proposed that some of those with hearing loss may have such impaired communication that they avoid seeking medical care, and therefore have lower health care use (Mikkola et al., 2016). This seems especially relevant to those with both LHL and severe hearing loss; not only are these people likely having difficulty hearing their health care providers, but also difficulty understanding what they are being told. As a result, these people may be more likely to be dissatisfied with their health care and less likely to use health care services.

STUDY LIMITATIONS

There are limitations to consider. The health literacy, hearing loss, and hearing aid use data came from a cross-sectional IVR survey with a low response rate. To mitigate the effects of survey nonresponse, propensity score weighting techniques were used. Next, the percent that reported LHL was lower than expected. The use of a single question for LHL is likely to underreport LHL compared to multiquestion validated measures (Chew, Bradley, & Boyko, 2004). Underreporting LHL would most likely drive results toward not observing significant associations, yet the characteristics that we found associated with LHL are consistent with existing literature. Using a telephone-administered survey may have made it difficult for those with severe hearing loss to participate. Although 20% of respondents were classified as having severe hearing loss, this is lower than other published estimates (National Institutes of Health, 2016). As with LHL, underreporting of hearing loss would most likely drive results toward not observing significant associations. Strengths of this study include a relatively large sample of over 19,000 people, and the ability to simultaneously explore the relations between LHL, hearing loss, and hearing aid use.

CONCLUSIONS

In this study, we observed that LHL was associated with older age, male gender, lower income, a number of health conditions, and hearing loss, especially among those who did not use hearing aids. Additionally, we observed how those with both LHL and hearing loss have higher medical costs. The existing literature offers ways that LHL can be improved and confirms that the detrimental effects of hearing loss can be mitigated. With regards to LHL, the National Action Plan to Improve Health Literacy (U.S. Department of Health and Human Services, 2010) suggests placing more emphasis on teaching health literacy skills as part of one's formal education, as well as making community-based efforts to improve the health literacy of adults. The Plan also suggests several ways that health care communications can be improved, such as by revising healthcare-related materials and teaching health care providers how to better communicate with those with LHL. Meanwhile, the National Academies of Sciences, Engineering, and Medicine (2016) has recommended efforts to enable easier access to hearing health care; improve quality of hearing health care; increase the affordability of hearing health care and hearing aids; encourage primary care physicians to become more involved in hearing health care; and

increase the amount of publicly available, evidence-based information on hearing loss and treatment options. Clearly, much can be done to improve health literacy and mitigate the adverse effects of hearing loss. Finding higher medical costs among those with LHL and hearing loss suggests a savings opportunity associated with making these changes.

REFERENCES

Berkman, N. D., Sheridan, S. L., Donahue, K. E., Halpern, D. J., & Crotty, K. (2011). Low health literacy and health outcomes: An updated systematic review. *Annals of Internal Medicine, 155*(2), 97-107. https://doi.org/10.7326/0003-4819-155-2-201107190-00005 PMID:21768583

Centers for Medicare and Medicaid Services. (2014). *Medicare managed care manual. Chapter 7 – Risk adjustment*. Retrieved from https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/mc86c07.pdf

Chew, L. D., Bradley, K. A., & Boyko, E. J. (2004). Brief questions to identify patients with inadequate health literacy. *Family Medicine, 36*(8), 588-594. PMID:15343421

Cody, R. P., & Smith, J. K. (1997). *Applied statistics and the SAS programming language* (4th ed.). Prentice-Hall.

Convery, E., Hickson, L., Meyer, C., & Keidser, G. (2019). Predictors of hearing loss self-management in older adults. *Disability and Rehabilitation, 41*(17),2026-2035. https://doi.org/10.1080/09638288.2018.1457091 PMID:29587551

Cutilli, C. C., Simko, L. C., Colbert, A. M., & Bennett, I. M. (2018). Health literacy, health disparities, and sources of health information in U.S. Older Adults. *Orthopedic Nursing, 37*(1), 54-65. https://doi.org/10.1097/NOR.0000000000000418 PMID:29369135

Eichler, K., Wieser, S., & Brügger, U. (2009). The costs of limited health literacy: A systematic review. *International Journal of Public Health, 54*(5), 313-324. https://doi.org/10.1007/s00038-009-0058-2 PMID:19644651

Fernandez, D. M., Larson, J. L., & Zikmund-Fisher, B. J. (2016). Associations between health literacy and preventive health behaviors among older adults: Findings from the health and retirement study. *BMC Public Health, 16*, 596. https://doi.org/10.1186/s12889-016-3267-7 PMID:27430477

Gazmararian, J., Baker, D., Parker, R., & Blazer, D. G. (2000). A multivariate analysis of factors associated with depression: Evaluating the role of health literacy as a potential contributor. *Archives of Internal Medicine, 160*(21), 3307-3314. https://doi.org/10.1001/archinte.160.21.3307 PMID:11088094

Geboers, B., Reijneveld, S. A., Jansen, C. J., & de Winter, A. F. (2016). Health literacy is associated with health behaviors and social factors among older adults: Results from the LifeLines cohort study. *Journal of Health Communication*, *21*(Suppl. 2), 45-53. doi:10.1080/10810730.2016.1201174

Geboers, B., Uiters, E., Reijneveld, S. A., Jansen, C. J. M., Almansa, J., Nooyens, A. C. J., Verschuren, W. M. M., de Winter, A. F., & Picavet, H. S. J. (2018). Health literacy among older adults is associated with their 10-years' cognitive functioning and decline - the Doetinchem Cohort Study. *BMC Geriatrics, 18*(1), 77. https://doi.org/10.1186/s12877-018-0766-7 PMID:29558890

Guirguis-Blake, J. M., Michael, Y. L., Perdue, L. A., Coppola, E. L., & Beil, T. L. (2018). Interventions to prevent falls in older adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *Journal of the American Medical Association, 319*(16), 1705-1716. https://doi.org/10.1001/jama.2017.21962 PMID:29710140

Howard, D. H., Gazmararian, J., & Parker, R. M. (2005). The impact of low health literacy on the medical costs of Medicare managed care enrollees. *The American Journal of Medicine, 118*(4), 371-377. https://doi.org/10.1016/j.amjmed.2005.01.010 PMID:15808134

Hughes, M. E., Waite, L. J., Hawkley, L. C., & Cacioppo, J. T. (2004). A short scale for measuring loneliness in large surveys: Results from two population-based studies. *Research on Aging, 26*(6), 655-672. https://doi.org/10.1177/0164027504268574 PMID:18504506

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2003). The Patient Health Questionnaire-2: Validity of a two-item depression screener. *Medical Care, 41*(11), 1284-1292. https://doi.org/10.1097/01.MLR.0000093487.78664.3C PMID:14583691

Kutner, M., Greenberg, E., Jin, Y., & Paulsen, C. (2006). The health literacy of America's adults: Results from the 2003 National Assessment of Adult Literacy (NCES 2006–483). U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2006/2006483.pdf

Lin, F. R., Niparko, J. K., & Ferrucci, L. (2011). Hearing loss prevalence in the United States. *Archives of Internal Medicine, 171*(20), 1851–1852. https://doi.org/10.1001/archinternmed.2011.506 PMID:22083573

Lin, F. R., Thorpe, R., Gordon-Salant, S., & Ferrucci, L. (2011). Hearing loss prevalence and risk factors among older adults in the United States. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences, 66*(5), 582-590. https://doi.org/10.1093/gerona/glr002 PMID:21357188

Little, R. J. A. (1986). Survey nonresponse adjustments for estimates of means. *International Statistical Review, 54*(2), 139-157. https://doi.org/10.2307/1403140

MacLeod, S., Musich, S., Gulyas, S., Cheng, Y., Tkatch, R., Cempellin, D., . . . Yeh, C. S. (2017). The impact of inadequate health literacy on patient satisfaction, healthcare utilization, and expenditures among older adults. *Geriatric Nursing, 38*(4), 334-341. https://doi.org/10.1016/j.gerinurse.2016.12.003 PMID:28089217

Mahmoudi, E., Zazove, P., Meade, M., & McKee, M. M. (2018). Association between hearing aid use and health care use and cost among older adults with hearing loss. *JAMA Otolaryngology-Head & Neck Surgery, 144*(6), 498-505. https://doi.org/10.1001/jamaoto.2018.0273 PMID:29710214

McKee, M. M., Stransky, M. L., & Reichard, A. (2018). Hearing loss and associated medical conditions among individuals 65 years and older. *Disability and Health Journal, 11*(1), 122-125. https://doi.org/10.1016/j.dhjo.2017.05.007 PMID:28596096

Mick, P., Foley, D. M., & Lin, F. R. (2014). Hearing loss is associated with poorer ratings of patient-physician communication and healthcare quality. *Journal of the American Geriatrics Society, 62*(11), 2207-2209. https://doi.org/10.1111/jgs.13113 PMID:25413192

Mikkola, T. M., Polku, H., Sainio, P., Koponen, P., Koskinen, S., & Viljanen, A. (2016). Hearing loss and use of health services: A population-based cross-sectional study among Finnish older adults. *BMC Geriatrics, 16*(1), 182. https://doi.org/10.1186/s12877-016-0356-5 PMID:27821075

Musich, S., Wang, S. S., Ruiz, J., Hawkins, K., & Wicker, E. (2017). Falls-related drug use and risk of falls among older adults: A study in a US medicare population. *Drugs & Aging, 34*(7), 555-565. https://doi.org/10.1007/s40266-017-0470-x PMID:28580498

National Academies of Sciences, Engineering, and Medicine. (2016). *Hearing health care for adults: Priorities for improving access and affordability*. https://www.nap.edu/catalog/23446/hearing-health-

care-for-adults-priorities-for-improving-access-and

National Committee for Quality Assurance. (2016). *HEDIS measures and technical resources*. Retrieved May 11, 2020, from http://www.ncqa.org/hedis-quality-measurement/hedis-measures/hedis-2016

National Institutes of Health. (2016). *Quick statistics about hearing.* Retrieved May 11, 2020, from https://www.nidcd.nih.gov/health/statistics/quick-statistics-hearing

Nooghabi, M. J., Nooghabi, H. J., & Nasiri, P. (2010). Detecting outliers in gamma distribution. *Communications in Statistics. Theory and Methods, 39*(4), 698-706. https://doi.org/10.1080/03610920902783856

Sackett, D. L., Rosenberg, W. M., Gray, J. A., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: What it is and what it isn't. *BMJ (Clinical Research Ed.), 312*(7023), 71-72. https://doi.org/10.1136/bmj.312.7023.71 PMID:8555924

Serper, M., Patzer, R. E., Curtis, L. M., Smith, S. G., O'Conor, R., Baker, D. W., & Wolf, M. S. (2014). Health literacy, cognitive ability, and functional health status among older adults. *Health Services Research, 49*(4), 1249-1267. https://doi.org/10.1111/1475-6773.12154 PMID:24476068

Simpson, A. N., Simpson, K. N., & Dubno, J. R. (2016). Higher health care costs in middle-aged us adults with hearing loss. *JAMA Otolaryngology-Head & Neck Surgery, 142*(6), 607-609. https://doi.org/10.1001/jamaoto.2016.0188 PMID:27054903

U.S. Census Bureau. (2015). *2010 census urban and rural classification and urban area criteria*. Retrieved April 8, 2014, from https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html

U.S. Department of Health and Human Services. (2009). *Improving health literacy for older adults. Expert panel report 2009*. https://www.cdc.gov/healthliteracy/pdf/olderadults-508.pdf

U.S. Department of Health and Human Services. (2010). *National action plan to improve health literacy*. Retrieved May 11, 2020, from https://health.gov/our-work/health-literacy/national-action-plan-improve-health-literacy

Wallace, L. S., Rogers, E. S., Roskos, S. E., Holiday, D. B., & Weiss, B. D. (2006). Brief report: Screening items to identify patients with limited health literacy skills. *Journal of General Internal Medicine, 21*(8), 874-877. https://doi.org/10.1111/j.1525-1497.2006.00532.x PMID:16881950

Wells, T. S., Nickels, L. D., Rush, S. R., Musich, S. A., Wu, L., Bhattarai, G. R., & Yeh, C. S. (2019). Characteristics and health outcomes associated with hearing loss and hearing aid use among older adults. *Journal of Aging and Health.* Advance online publication. https://doi.org/10.1177/0898264319848866 PMID:31092107