JSLHR

Research Article

Economic Impact of Hearing Loss and Reduction of Noise-Induced Hearing Loss in the United States

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Purpose: Hearing loss (HL) is pervasive and debilitating, and noise-induced HL is preventable by reducing environmental noise. Lack of economic analyses of HL impacts means that prevention and treatment remain a low priority for public health and environmental investment.
Method: This article estimates the costs of HL on productivity by building on established estimates for HL prevalence and wage and employment differentials between those with and without HL.
Results: We estimate that HL affects more than 13% of the working population. Not all HL can be prevented or treated, but if the 20% of HL resulting from excessive noise exposure were prevented, the economic benefit would be substantial—we estimate a range of $58 billion to $152 billion annually, with a core estimate of $123 billion. We believe this is a conservative estimate, because consideration of additional costs of HL, including health care and special education, would likely further increase the benefits associated with HL prevention.
Conclusion: HL is costly and warrants additional emphasis in public and environmental health programs. This study represents an important first step in valuing HL prevention —in particular, prevention of noise-induced HL—where new policies and technologies appear promising.

Hearing loss (HL) is a pervasive and costly condition in the United States, yet its economic and social impacts are difficult to estimate. Compared with other health conditions that are common in the United States—for example, cardiovascular disease—relatively little is known about the public health burden associated with HL, and HL commonly goes untreated and underreported (Sataloff, 2012).

Data on HL available in the United States vary considerably. Different measures are used, including quantitative audiometric test results, qualitative measures such as self-reported hearing loss (e.g., mild or severe), and self-reported functional status (e.g., "difficulty hearing whispers" or "difficulty hearing shouting near the ear"; Blanchfield, Feldman, Dunbar, & Gardner, 2001). Audiometric test results are considered the gold standard for HL identification, but studies with these data tend to have smaller samples than those that are based on self-report. The definition of HL or hearing impairment also varies. HL may be defined as unilateral or bilateral, identified via HL diagnostic code in medical records, or categorized in binary terms as a speech-frequency pure-tone audiometric average above or below 25 dB HL in both ears (World Health Organization [WHO], 2000), with a value > 25 dBHL indicating the potential for degraded communication and function in daily life (a WHO standard; WHO Regional Office for Europe, 2011).

As a result of the variability in identifying HL, estimates of the prevalence of bilateral HL in the United States vary widely, from 7.3% (Agrawal, Platz, & Niparko, 2008) to 26% (Basner et al., 2014) of the U.S. population. Lin et al. (2011) used the 2001–2008 National Health and Nutrition Examination Survey (NHANES) to estimate that 12.7% of the population age 12 years and older has bilateral HL exceeding the WHO limit of 25 db HL, rising to 20.3% when unilateral HL is added in. Jung and Bhattacharyya (2012), assessing diagnosis codes in data from the 2006 and 2008 Medical Expenditure Panel Survey, estimated that 0.5% of patients ages 18–64 years had recorded bilateral or unilateral HL. This is a substantially different estimate from that of Lin et al., even when the Lin et al. estimate (of bilateral and unilateral HL) is restricted to subjects under the age of 65, which results in an estimated 13% prevalence. Schoenborn and Heyman (2008) used self-reported hearing measures in the 2000–2006 National

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Editor: Nancy Tye-Murray
Associate Editor: Kathleen Cienkowski
Received October 23, 2015
Revision received April 19, 2016
Accepted June 13, 2016
DOI: 10.1044/2016_JSLHR-H-15-0365

Disclosure: The authors have declared that no competing interests existed at the time of publication.

Health Interview Survey to estimate that 16% of those age 18 years and over have trouble hearing (in one or both ears).

This variation makes it difficult to estimate the costs of HL to those who are affected by it and to society more broadly. The WHO has identified the lack of economic analyses of hearing and other sensory disabilities as a global issue resulting in low prioritization of prevention and treatment of these disabilities (WHO, 2000), and this certainly is the case in the United States. Even estimating the impact of a single form of HL with a distinct cause—noise-induced HL (NIHL)—presents substantial data challenges (Dobie, 2008; Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). Poor data, combined with the relatively invisible, slowly accumulating health effects of noise, help explain the low public and environmental health priority historically placed on HL.

In recent years, evidence has been accumulating on the impacts of HL—including declines in employment and productivity (Jung & Bhattacharyya, 2012; Kochkin, 2007; Sataloff, 2012; Yankaskas, 2013), need for special education (Dalton et al., 2003; Ruben, 1999), stress (Hasson, Theorell, Wallén, Leineweber, & Canlon, 2011; Kramer, Kapteyn, & Houtgast, 2006), reduced quality of life (Dalton et al., 2003; Opitz & Zbaracki, 2006), and secondary impacts on caregivers (Opitz & Zbaracki, 2006)—creating the opportunity to estimate the value of these impacts. In this article we estimate the costs of HL in the United States from lost productivity. Our approach builds on previous estimates by combining unemployment and wage variation by HL and providing estimates for the impacts of reduction in HL illustrative of feasible reductions in the most preventable form of HL, NIHL. This represents an important step to estimating the full costs of HL and is essential for assessing the potential value of policies and investments that could potentially reduce HL. For example, a national emphasis on reduction of motor-vehicle traffic noise could substantially reduce NIHL, which is completely preventable given sufficient exposure reductions, and analyses such as ours can suggest whether or not this may be a cost-effective strategy to improve public health. To better illustrate the ramifications of our analyses, we frame our results in terms of potential economic benefits associated with the substantial fraction of HL that could be prevented through reductions in noise exposure.

Method

Causes and Attribution of HL

The causes and sources of HL are discussed in detail elsewhere (Dobie, 2008; Nelson et al., 2005; Phaneuf & Hétu, 1990). In brief, genetics, noise exposure (NIHL), and aging are considered the primary causes of HL among adults, though it has been suggested that age-related HL may in many cases be unrecognized NIHL resulting from a lifetime of chronic exposure to noise (Rosenhall & Pedersen, 1995). Age-related HL and NIHL can be difficult to distinguish clinically, with primary differentiation often occurring only through patient history (Fransen, Lemkens, Van Laer, & Van Camp, 2003). Regardless of the chief cause, age-related HL and NIHL with similar audiometric configurations can be expected to have essentially the same impact on communication and function in daily life, and therefore virtually indistinguishable economic impacts. NIHL (either environmental or occupational) is considered the only completely preventable type of HL.

Estimating HL Prevalence

We have already described three estimates of the prevalence of HL: 20.3% by Lin et al. (2011), derived from audiometric data collected from 7,490 individuals in the NHANES; 0.5% by Jung and Bhattacharyya (2012), from medical diagnoses in Medical Expenditure Panel Survey data collected from 40,000 individuals; and 16% by Schoenborn and Heyman (2008), from self-reported HL measures collected from about 87,000 individuals in the National Health Interview Survey. Each of these estimates has notable limitations. Measures from NHANES audiometric testing represent an objective and presumably unbiased quantification of HL, but the small sample limits the generalizability of the results. The self-reported measures of HL from the National Health Interview Survey have a larger sample but are subject to various types of bias. The Medical Expenditure Panel Survey data, which are based on diagnosed HL, represent the gold standard of clinical evaluation but are influenced by the low percentage of individuals with HL who seek diagnosis and treatment (Sataloff, 2012). We believe the difference between the estimates reflects the degree to which HL is underreported and not officially documented (Kochkin, 2007; Sataloff, 2012), and we consider the Lin et al. estimate to be the most nationally representative and least biased U.S. HL prevalence estimate available. There is a possibility of a secular trend in HL, with some evidence of rates of HL increasing over time (particularly among young people; Shargorodsky, Curhan, Curhan, & Eavey, 2010), but other data suggesting no secular trend (Lee, Gómez-Marín, Lam, & Zheng, 2004). The cross-sectional estimates we present here make no assumptions regarding temporal trends in HL.

On the basis of the estimates of Dobie (2008) and Nelson et al. (2005), along with estimates of prevalence of U.S. environmental noise exposures high enough to result in NIHL (an estimated 104 million individuals in the United States in 2013; Hammer, Swinburn, & Neitzel, 2014), we assume a reasonable upper limit of HL attributable to occupational and environmental noise to be 25%. An estimated 10% (Dobie, 2008) to 16% (Nelson et al., 2005) of HL, or approximately half of our assumed upper limit of NIHL, is attributed to occupational noise alone, whereas additional NIHL results from environmental and non-occupational noise exposures such as shooting firearms, listening to music, and participating in other noisy recreational activities, which have been shown to potentially contribute a substantial portion of total noise exposure in a number of studies (Neitzel, Gershon, McAlexander, Magda, & Pearson, 2012; Neitzel, Seixas, Goldman, & Daniell, 2004).

Estimating the Impact of HL on Productivity

With a shift away from physical labor and toward employment that involves greater interpersonal communication, the impact of hearing and communication-related disorders on worker productivity increases (Ruben, 1999). Workers with HL face daily employment challenges—communication problems and frustrations, increased fatigue, burnout, emotional exhaustion, and stress (Hasson et al., 2011; Kramer et al., 2006; Ruben, 1999)—and these challenges affect earnings and employment. Ruben (1999) estimated that unemployment and underemployment (employment at reduced wages compared with others doing similar work, or employed less than full time when an employee would like to be full time) among those with sensory disabilities equaled 2.5%–3% of the gross national product ($154 billion to $186 billion) in 2000, and if we assume that the share of these costs associated with HL is proportionate to the HL population among those with sensory disabilities, approximately one third of these costs were from HL. By comparison, vision loss affects a similar percentage of the adult population as HL (14.3%–20.5%), according to a recent Centers for Disease Control and Prevention study (Bailey et al., 2006).

Building an estimate by analyzing wage differential by HL status, Kochkin (2007) estimated that untreated HL from all causes in the United States costs $100 billion annually in lost productivity due to lower wages, and that workers with severe HL earn $12,000 less annually than those with mild HL. Jung and Bhattacharyya (2012) estimated an odds ratio of 2.5 for not earning a wage among subjects of working age with HL, and calculated that employees with HL earned an estimated 75% of the wages earned by employees with typical hearing. Emmett and Francis (2015) estimated that U.S. adults with bilateral HL (an estimated 9% of the U.S. adult population) are nearly 2 times as likely to be unemployed or underemployed as those with typical hearing. As mentioned previously, medically-diagnosed coding identifies a much smaller percentage of the population with HL because of underreporting and lack of treatment. However, the prevalence of underemployment/unemployment is relatively similar among the HL population, even with different measures of HL. We therefore believe that both standards are worth considering and applying to the broader HL population, and we consider both in our assessment and uncertainty analyses. We consider the Jung and Bhattacharyya odds ratio (2.5) as our core estimate, because it is based on "wage earning" versus "not wage earning," which eliminates some confusion as to whether or not someone is employed, unemployed, or not in the labor force for a variety of reasons. The Jung and Bhattacharyya data also separate "not wage earning" (similar to unemployment) from underemployment and provide a more specific estimate for wage differential (those with HL earn an estimated 75% of the wages of those with typical hearing), not provided by Emmett and Francis, which adds to these analyses. We note that the distinction here is by HL, defined as described previously. These definitions include individuals with correction or assistive devices and also both unilateral and bilateral HL. In our estimates later considering a reduction in the population with NIHL, we assume that this reduction includes a proportionate representation of those with assistive technologies and unilateral and bilateral HL.

Our approach builds on these estimates by combining unemployment and wage variation by HL and providing estimates for the impacts of reduction in HL illustrative of feasible reductions in preventable NIHL—an important estimate for environmental and planning policy affecting noise and NIHL. Note that we exclude consideration of the impact of available or emerging treatment for HL (i.e., hearing aids, cochlear implants, and therapeutic agents) in our estimates, because this impact would substantially increase the uncertainty of our estimates.

Estimation of the Economic Impact of HL in 2013: Core Estimate

We estimated the economic impact of HL on the basis of a core estimate described in the following, and then performed uncertainty analyses showing the impacts of variations in key assumptions. We estimate that 23.6 million people of working age (ages 18–64 years) in the United States have HL (unilateral or bilateral). This represents 13.4% of the working-age population, from our own calculations on the basis of HL prevalence reported by age by Lin et al. (2011). Table 1 provides more detail.

On the basis of the statistically significant impact of HL on employment and income estimated by Jung and Bhattacharyya (2012), we assumed that those with HL were 2.5 times more likely to be not earning wages than individuals with typical hearing, and that mean earnings among employed people with HL were approximately 25% less than those among employed people with typical hearing. We note here the odds ratio of 2.5 applies to anyone "not earning wages," rather than only those who are unemployed (which implies active participation in the labor force). We also note that we assumed that Jung and Bhattacharyya's wage and employment differentials of HL status are entirely attributable to HL, given other confounding factors such as age, gender, educational attainment, and so on, that were considered in that study.

We applied the reductions in employment and earnings to the estimated 13.4% of the working-age population with HL to estimate employment and earnings by HL status in 2013. In the core scenario, overall employment and average wages were assumed to be fixed, whereas the distribution of employment and average wages among those with and without HL were estimated using the assumptions already detailed.

Employment by hearing status was calculated using the following equation:

$$N_t = (P_h \times R_h) + (P_l \times R_h \times 2.5), \quad (1)$$

where N_t is the total number of nonwage earners of working age, P_h is the population of working age without HL,

Table 1. Estimate of prevalence of hearing loss (HL) among those of working age.

	From Lin et al. (2011, p. 4)		Authors' calculations estimating hearing loss among those of working age			
Age (years)	A. Prevalence of hearing loss > 25 dB HL, bilateral and unilateral (%)	B. Number with hearing loss (millions)	C. Total population by age (millions; = B/A/0.01)	D. Inclusion in working-age population (%)[a]	E. Working-age population (millions; = C × D)	F. Number among working-age population with hearing loss (millions; = A × 0.01 × E)
12–19	2.3	0.76	33.0	25	8.3	0.2
20–29	3.2	1.20	37.5	100	37.5	1.2
30–39	5.4	2.30	42.6	100	42.6	2.3
40–49	12.9	5.60	43.4	100	43.4	5.6
50–59	28.5	9.60	33.7	100	33.7	9.6
60–69	44.9	9.50	21.2	50	10.6	4.8
70–79	68.1	10.80	15.9	0	0.0	0.0
80+	89.1	8.30	9.3	0	0.0	0.0
Total		48.1	236.6		176.0	23.6
				HL in working-age population (%)		13

Note. Working age = 18–64 years.

[a]An equal distribution of population and HL is assumed across each year of each age group.

R_h is the rate of nonwage earners among those without HL, and P_l is the population of working age with HL.

Wages by hearing status were calculated using this equation:

$$W_t = (E_h \times W_h) + (E_l \times W_h \times 0.75), \qquad (2)$$

where W_t is total wages, E_h is the number of employees without HL, W_h is the average wage among those without HL, and E_l is the number of employees with HL.

Uncertainty Analyses

We performed uncertainty analyses considering variation among three key assumptions: (1) the percentage of working-age adults with HL (ranging from 9% to 16%), (2) the odds ratio for not earning wages of those with HL compared with those with typical hearing (ranging from 1.875 to 2.5), and (3) the mean reduction in wages of employed people with HL compared with those with typical hearing (ranging from 18.75% to 31.25%). With few data points for possible values for these variables, we chose these variations as highs and lows from the available literature, or percentages above or below the core estimate. These variations allow for consideration of the impacts of some of our assumptions; for example, if unilateral HL has a different effect on earnings from that of bilateral HL, we may overestimate the mean reduction in wages between employed people with HL compared with those with typical hearing. The variations considered are presented in the Appendix.

With Assumption 1, we believe that it is reasonable to assume that the reduction in earnings and employment observed by Jung and Bhattacharyya (2012) also applies to the wider population with HL described by Lin et al. (2011). We believe this is the more generalizable estimate because it draws from a significantly larger sample than the study by Emmett and Francis (2015). Given the different HL identification between the two studies, we have also included a 25% reduction in this effect and the 1.98 odds ratio from Emmett and Francis among the assumptions considered in the uncertainty analyses.

Results

Table 2 shows the core estimates of employment and wages by HL status. Nearly 70% of those of working age with HL were not earning wages, compared with 30% of those with typical hearing. Workers with HL earned an average of $35,000, compared with $47,000 for those with typical hearing, and total wages earned were nearly $6.2 trillion.

Table 3 illustrates the economic impact of scenarios reducing HL, with the other assumptions of the core estimate remaining unchanged. In a scenario where all 198 million people of working age are assumed to have typical hearing and are employed at the rate (73%) and average wage ($47,182) of those with typical hearing, total wages earned were nearly $6.8 trillion, a 10% increase. Therefore, the estimated cost of HL on productivity in 2013 was nearly $615 billion. Not all HL can be prevented or reduced, but some forms—particularly NIHL—are completely preventable and, as described previously, may potentially account for up to 25% of HL. In a hypothetical scenario where the number of individuals with HL was reduced by 10% (and these individuals moved to the status "without HL"), employment and wage increases resulted in increased earnings of $61 billion. When HL was reduced by 20%, the earnings increase was $122 billion. A 10%–20% reduction in HL illustrates what could be possible with reduction or near elimination of preventable NIHL, and we believe this is considerably conservative. As described before, we consider that up to 25% of HL

Table 2. Core estimate of 2013 wages and employment, by population with and without hearing loss.

Population	Working-age population	Mean wage ($)	Median wage ($)	Employed among those of working age (%)	Not employed among those of working age (%)[a]	Number employed among those of working age	Number not employed among those of working age[a]	Total wages earned ($)
Total	197,838,893[b]	46,440[d]	35,085[d]	67[b,d]	33[b,d]	1,325,888,103	65,250,083	6.157 trillion
Without hearing loss	171,269,698[c]	47,182[e]	35,085[e]	73[f]	27[f]	124,253,686	47,016,011	5.862 trillion
With hearing loss	26,569,195[c]	35,386[e]	26,314[e]	31[f]	69[f]	8,335,124	18,234,072	295 billion

Note. Working age = 18-64 years.

[a]Those who are “not employed” include anyone not earning wages (unemployed and not in the labor force). [b]Data source: U.S. Census Factfinder estimates of population by age (https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml). [c]Authors’ calculations of hearing loss drawn from Lin et al. (2011): An estimated 13.4% of those ages 18–64 have hearing loss. [d]Data source: U.S. Bureau of Labor Statistics, National Occupational Employment and Wage Estimates (https://www.bls.gov/oes/current/oes_nat.htm). [e]Authors’ calculations of wage differential between those with and without hearing loss drawn from Jung and Bhattacharyya (2012), assuming mean and median wages of employed individuals with hearing loss are 25% less those of than employed individuals who do not have hearing loss. [f]Authors’ calculations of employment distribution on the basis of Jung and Bhattacharyya’s (2012) estimate that those with hearing loss are more likely to be not employed than those without hearing loss, at an odds ratio of 2.5.

Table 3. Change in wages earned with scenarios related to hearing loss (HL; 2013 illustration).

Population	Wages earned ($) —original estimate	Hypothetical scenario: Wages earned ($) —scenario with no HL	Wages earned ($)—scenario if 10% of those with HL are moved to without HL	Wages earned ($)—scenario if 20% of those with HL are moved to without HL
Total	6.16 trillion	6.77 trillion	6.22 trillion	6.28 trillion
Without HL	5.86 trillion	6.77 trillion	5.95 trillion	6.04 trillion
With HL	295 billion	0	265 billion	236 billion
Difference between original estimate and hypothetical scenario		615 billion	61 billion	122 billion

may be attributed to NIHL, on the basis of data of HL across the whole population, and the effect on the working-age population may be even greater.

Uncertainty Analyses

Table 4 presents the results of our uncertainty analyses, which applied a range of values for three key assumptions as described in the Appendix. As described previously, we believe the assumptions in the core scenario are based on the best evidence available. The uncertainty analyses consider other possible values for these assumptions, showing how altering these assumptions would change the estimates.

In estimating the impact of a 10% reduction in HL, the variations modeled produced a range of results from a maximum of $76 billion to a minimum of $29 billion, compared with the core estimate of $61 billion. In estimating a 20% reduction in HL, the maximum and minimum values were $152 billion and $58 billion, respectively, compared with the core estimate of $123 billion.

Discussion

HL from any cause is a permanent, irreversible disease that has substantial and profound impacts on the occupational, social, and personal lives of those affected. Individuals with HL have significantly lower rates of employment and lower wages than those with typical hearing, and because HL affects more than 13% of the working-age population, the economic impact of this disease is significant. Our analyses suggest that reductions in HL of 10%–20% (which could be achieved by reducing or nearly eliminating completely preventable NIHL) would yield considerable economic benefits. If HL prevalence were hypothetically reduced by 10%–20% through, for example, reductions in occupational and environmental noise exposure (NIHL), our core estimates suggest that total earnings would increase by $61 billion to $123 billion. Comparing this to the previous estimate by Kochkin (2007), which estimated annual productivity loss from reduced wages due to all HL at $100 billion, our combined wage differential and unemployment estimate suggests a significantly greater productivity loss from HL.

Our uncertainty analyses suggest that the impacts of reduction in HL on productivity are sensitive to assumptions regarding wage and employment differentials between individuals with and without HL, as well as assumptions regarding the prevalence of HL. Considering the variance of these assumptions in the literature, a 10% reduction in HL produced a modeled increase in earnings ranging from $29 billion to $76 billion, and a 20% reduction in HL produced an increase in earnings ranging from $58 billion to $152 billion. We caution that in actual application in a given model year such increases in earnings would be subject to the prevailing macroeconomic conditions, and they would need time to accrue.

Conclusion

HL is prevalent, and the associated economic costs are significant. This suggests that even incremental improvements in reducing HL (unilateral and bilateral) by 10% or 20%—with a particular emphasis on the most easily preventable form of HL, NIHL—are likely to have significant economic benefits. Environmental and public health policies and programs that reduce noise, and therefore NIHL, can include estimates of these resulting benefits in their cost–benefit analyses. The lack of quantification of the costs of HL has made prevention and treatment programs a low priority in most developed nations (WHO Regional Office for Europe, 2011); this study represents a relatively crude but nevertheless important first step toward understanding the significant costs of HL. Although we have focused on lost wages, it is important to note that the impact of HL goes far beyond impacts of wage, including costs associated with special education, health care, and reduced quality of life. It is also important to note that our analyses here did not consider treatment approaches that could at least partially mitigate the impact of HL. Further research to better track the number of people in the United States affected by HL, and to build on these early estimates, will help HL prevention be valued accurately with mitigation programs for other environmental and public health hazards, and will also help to identify currently unrecognized biases in the available data upon which we have built our estimates, which can then be addressed in subsequent analyses. Additional costs of HL, including health care, special education, lost quality of life, and caregivers, cannot easily be quantified but would likely further increase the benefits associated with HL prevention.

Table 4. Uncertainty analyses.

	Assumption			Increase in earnings ($) if…	
	1	2	3		
Scenario	Working-age adults with HL (%)	Odds ratio for not earning wages, those with HL compared with those without HL	Reduction in earnings (%), those with HL compared with those without HL	10% of those with HL are moved to without HL	20% of those with HL are moved to without HL
Core scenario	13.4	2.5	–25.00	61,451,489,733	122,902,979,466
		1.98		49,334,627,100	98,669,254,200
		1.875		46,686,264,906	93,372,529,812
		2.5	–31.25	64,165,602,432	128,331,204,865
		1.98		52,953,286,661	105,906,573,322
		1.875		50,498,365,897	100,996,731,795
		2.5	–18.75	58,758,959,714	117,517,919,428
		1.98		45,754,921,628	91,509,843,257
		1.875		42,917,539,935	85,835,079,869
	16.0	2.5	–25.00	72,410,681,380	144,821,362,759
		1.98		58,600,857,249	117,201,714,499
		1.875		55,544,930,597	111,089,861,194
		1.98	–31.25	63,129,858,335	126,259,716,669
		1.875		60,289,845,073	120,579,690,145
		2.5	–18.75	68,917,951,591	137,835,903,181
		1.98		54,131,884,880	108,263,769,759
		1.875		50,866,158,799	101,732,317,599
	9.0	2.5	–25.00	42,083,264,737	84,166,529,473
		1.98		33,273,735,172	66,547,470,344
		1.875		31,392,365,628	62,784,731,255
		2.5	–31.25	43,611,071,179	87,222,142,357
		1.98		35,489,282,840	70,978,565,681
		1.875		33,752,495,735	67,504,991,469
		2.5	–18.75	40,562,522,172	81,125,044,345
		1.98		31,073,211,368	62,146,422,736
Maximum estimate	16.0	2.5	–31.25	75,939,229,550	151,878,459,100
Minimum estimate	9.0	1.875	–18.75	29,049,325,866	58,098,651,732

Note. Working age = 16–64 years.
HL = hearing loss.

Acknowledgment

We gratefully acknowledge the University of Michigan School of Public Health Risk Science Center for their support of this work.

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Appendix

Variations in key assumptions considered in sensitivity analyses.

Assumption 1: Percentage of working-age U.S. Americans with hearing loss	
Core estimate (authors' calculations)	13.43%
Schoenborn & Heyman (2008)	16.00%
Emmett & Francis (2015)	9.00%
Assumption 2: Odds ratio for not earning wages, those with hearing loss compared with those with typical hearing	
Core estimate (Jung & Bhattacharyya, 2012)	2.5
Emmett & Francis (2015)	1.98
Lower bound: 25% less than core estimate	1.875
Assumption 3: Mean difference in earnings, employed individuals with hearing loss compared with those with typical hearing	
Core estimate (Jung & Bhattacharyya, 2012)	–25%
Upper bound: 25% more than core estimate	–31.25%
Lower bound: 25% less than core estimate	–18.75%