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Workers' Compensation Costs for Occupational Hearing Loss Claims in the United States, 2009–2013

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ABSTRACT

This study estimated the average annual number of U.S. workers' compensation (WC) claims for occupational hearing loss (OHL) and their associated cost and identified the industry/occupation classifications with the highest numbers of OHL claims. The most recent U.S. cost estimate ($242 million) was based on data from one state in 1 year (1991). WC data from the National Council on Compensation Insurance, Inc. (35 states) and two additional individual states were examined, incorporating data from 37 states and the District of Columbia. Costs and numbers of claims were estimated for the 13 missing states to develop estimates for the United States. Sensitivity analyses were also performed to develop ranges for the point estimates. The estimated U.S. average annual OHL claim cost fell within the range of $49 to $67 million during 2009–2013, with a point estimate of $60 million (2013 dollars). The estimated average annual number of OHL claims ranged from 4,114 to 5,986, with a point estimate of 4,965 claims. Based on data available from 36 states and DC, 18 of the 40 industry/occupation classifications with ≥50 OHL claims were in the

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manufacturing sector. WC data underestimate the true burden of OHL. Most OHL cases are not compensated. WC laws, industry composition and other factors vary widely by state, so estimates must employ data for many states. This study incorporated data from most states and utilized sensitivity and comparative analyses to obtain estimates. Workers in a wide range of industry/occupation classifications need special attention to prevent OHL.

KEYWORDS: occupational hearing loss, workers' compensation, National Council on Compensation Insurance, hearing loss claim, claim cost, manufacturing, surveillance

In the United States, 12% of the working population has reported hearing difficulty,[1] but among workers who are exposed to noise that can damage hearing, 23% have hearing difficulty.[2] The costs of occupational hearing loss (OHL) are both intrinsic and monetary. The intrinsic cost is high. Hearing loss can greatly impact quality of life, affecting communication and relationships with family, friends, and co-workers, potentially leading to social isolation, fatigue, and stress, and it is strongly associated with depression and depressive symptoms.[3–6] It is also associated with dementia and cognitive decline.[4]

Monetary costs for OHL include the cost of hearing aids and clinical rehabilitation, higher rates of absenteeism, reduced earnings, and an association with an increased risk of accidents, hospitalizations, and associated health care costs.[4,7] It is estimated that the economic impact of hearing loss (both occupational and non-occupational) due to lost productivity alone was nearly $615 billion in 2013.[7] Workers' compensation (WC) systems provide some medical care and partial wage replacement for hearing loss among workers covered by WC insurance. Payments for lost wages typically take two forms. These include payments for temporary total disability (lost wages associated with lost work-days) and permanent partial disability (estimated future earnings lost due to impairment). Benefits paid are typically designed to compensate for two-thirds of lost wages and are not taxed.[8] It has been difficult to determine the cost of U.S. WC claims for OHL, and published estimates have been scarce.

The challenges for producing estimates of U.S. WC claims for OHL and other types of specific outcomes are due to several factors. There is not a single source of national U.S. WC claims data since the WC systems are state-regulated, and federal workers are covered under separate WC systems. Access to state and federal WC claims data systems is typically limited. Although there are standards to reporting WC claims, states and the federal systems vary in terms of reporting requirements. As a result, the detail and comprehensiveness of WC data also differ by state and federal systems. Regulations for coverage requirements, benefit levels, and type of insurers also vary. For example, in most states, insurance is provided by either private or state-fund insurers and all but two states (North Dakota and Wyoming) allow employers to self-insure if fiscally able. For these reasons, any attempt to produce national estimates of claims or costs must rely on a number of assumptions, and often this involves combining data from a number of sources.

The most recent prior U.S. cost estimate available was reported by the National Institute for Occupational Safety and Health (NIOSH) in 2001.[9] It estimated that $242 million was being spent in the United States each year on OHL claims. However, this estimate was based on data from one state in 1 year, specifically the state of Washington in 1991. Daniell et al reported that the State of Washington paid $4.8 million that year in disability settlements alone, with medical costs not included.[10] This estimate was then extrapolated to the entire United States, assuming all states had WC laws identical to the State of Washington in 1991. Washington may have had comparatively higher claim costs. Ninety percent of 1991 Washington OHL claims included permanent partial disability payments,[10] and these

payments became much less frequent after Washington's permanent partial disability compensation criteria were tightened in 2004.[11] WC laws vary widely by state[12,13] and some states have "no specific provisions" for compensation.[12] Industry composition and other factors are also highly variable. In general, a sharp decrease in reported illnesses and injuries has been observed in the United States over time.[14–17] For example, the incidence count of reported occupational injuries and illnesses decreased from 6,799,400 in 1992 to 2,814,000 in 2019.[15,17] As such, the $242 million was likely an overestimate of the actual annual cost for OHL claims in the United States.[4] A more reliable and up-to-date estimate, incorporating data for many states over several years and incorporating sensitivity analyses, was needed.

A unique set of data from the National Council on Compensation Insurance, Inc. (NCCI) was used to develop this estimate. NCCI is a private company that collects WC claims data from 35 states and the District of Columbia (DC) for companies covered by private and state-fund insurance carriers. It provides analysis of WC claim costs to inform the setting of rates (premiums) by insurance companies and rate regulation by state agencies.[18] Data include all claims in those states except for workers employed by self-insured companies. It is the most comprehensive multistate WC dataset available. NCCI data do not include data for California. California has an independent WC rating bureau called the Workers' Compensation Insurance Rating Bureau (WCIRB), which collects similar information. NCCI also does not include data for Ohio, which is collected by the Ohio Bureau of Workers' Compensation (OHBWC).[19,20] Using primarily NCCI data during 2009–2013, supplemented with WCIRB and OHBWC data for California and Ohio, the objectives of this study were to (1) provide a more accurate and reliable estimate and range of non-federal WC costs for OHL in the United States and (2) identify the industry/occupation classifications and associated NIOSH National Occupational Research Agenda (NORA)[21] industry sectors with the highest numbers of hearing loss claims.

METHODS

Study Design and Population

This was a cross-sectional study estimating WC claim counts (numbers of claims), costs, and rates for OHL in the United States over 5 years. It also identified the industry/occupation classifications with the highest numbers of claims. Definitions and calculations for cost and rate are provided in the Statistical Analysis section. NCCI, OHBWC, and WCIRB claim data for OHL that occurred in 2009–2013 were examined. These are claims covered under policies issued by private and state-fund insurance carriers, which do not include federal employees. Claim data for workers employed in self-insured companies were estimated as no data from these companies were available. The term "companies" is used throughout to denote different types of employers, including state and local governments. The 2009–2013 time period was chosen since it was the most recent 5-year period for which NCCI data were available with sufficient cost information. Multiple years were examined to obtain more reliable estimates of average annual claim counts and costs. Supplemental data were obtained from OHBWC for Ohio and from WCIRB for California during 2009–2013. In all, data for 37 states and DC were included in the study sample.

The 13 states for which WC data were not available were Delaware, Indiana, Massachusetts, Missouri, Minnesota, New Jersey, New York, North Carolina, North Dakota, Pennsylvania, Washington, Wisconsin, and Wyoming. However, limited information was available from Massachusetts and Pennsylvania for comparison to this study's estimates. WC claims for OHL were identified in the NCCI and WCIRB systems using nature of injury codes established by the Workers' Compensation Insurance Organizations (WCIO).[22] These WCIO nature codes included 31 traumatic hearing loss or impairment and 72 cumulative loss of hearing. WC claims for OHL were identified in the OHBWC system using diagnoses that were assigned to each claim and incident narrative information consistent with the WCIO nature codes. Diagnoses were based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).[23] No information on worker's age,

gender, race/ethnicity, or education were available in any of the claim data. This activity was reviewed by the Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and CDC policy (see, e.g., 45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.). This means that this study was determined to be surveillance and not human subjects research.

Industry Sector Assignment

Claims from every industry sector were included in the study. Claim data included industry/occupation classification information and corresponding NCCI insurance class codes.[24] NIOSH NORA industry sector groupings[21] were assigned by the authors, which are based on the North American Industry Classification System (NAICS).[25] The first three study authors independently assigned a primary industry sector to each industry/occupation classification, referencing information in the following sources: a NCCI class code-NAICS crosswalk from the International Risk Management Institute,[26] NAICS and Standard Occupational Classification (SOC) code descriptions,[27] the NCCI code manual,[28] and OHBWC data with the distribution of payroll amounts and numbers of claims for each NCCI industry/occupation classification by NAICS code. If all three authors did not assign the same sector, additional research was performed and there was discussion until a consensus was reached.

Statistical Analysis

The primary independent variable was the industry/occupation classification and assigned industry sector. The primary dependent variables were number of claims, claim rate, and cost for OHL. Specifically, these included total number of claims during 2009–2013, average annual number of claims, claim rate per 10,000 jobs (some workers have more than one job), average annual cost per claim, total claim cost during 2009–2013, and average annual claim cost. Ranges were also provided for the average cost per claim, the average annual number of claims, and the average annual cost for all OHL claims, by calculating high and low alternative estimates for each, based on sensitivity analyses. The term "cost" is used to denote the total incurred costs, which include everything that has been paid to date on a claim for medical treatments and lost wages, plus reserves for future anticipated payments. Costs were valued based on the fifth report of claim cost, which becomes available in the fifth year after the year of injury/illness. The fifth report for 2009–2013 claims became available in 2014–2019, and were chosen because they represent the most fully developed costs that are available and consistent for all claim years. The term "rate" is the number of OHL claims per 10,000 jobs. The total number of U.S. OHL claims and OHL claim costs were calculated through a series of steps. Steps and calculations for estimating number of claims, total

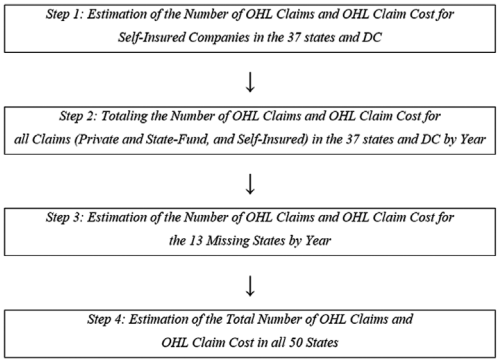

Figure 1 Main steps for estimating the number of occupational hearing loss (OHL) claims, total claim cost, and ranges for 37 states and the District of Columbia (DC).

claim cost, and ranges are provided in the subsequent sections (see sections for Steps 1 to 4 and Sensitivity Analyses and Comparative Analyses) and in Fig. 1.

Using data from NCCI and OHBWC only (36 states and DC), industry/occupation classifications with 50 or more OHL claims were identified, each with the associated class code, assigned industry sector, and number of claims. The WCIRB data for California were not used for industry/occupation analyses since the class codes used by WCIRB do not always map to a single NCCI class code. Complete denominator information was not available for individual industry/occupation classifications. For each of the industry/occupation classifications with $\geq$50 claims, the percent of OHL claims represented by each reported industry/occupation classification and the total OHL claim cost for each classification are provided, as well as information on the distribution of claims among states. This included the number of states with OHL claims for each classification, the highest percent of OHL claims for each classification that occurred in a single state, and the state in which the highest percent of OHL claims occurred for each classification.

STEP 1: ESTIMATION OF THE NUMBER OF OHL CLAIMS AND OHL CLAIM COST FOR SELF-INSURED COMPANIES IN THE 37 STATES AND DC

Since the available OHL claim data were for claims covered under policies from private and state-fund insurance carriers, the number of OHL claims and costs for workers employed by self-insured companies had to be estimated. Published information from the National Academy of Social Insurance (NASI) was used.[29–34] NASI provides the total benefits paid of all WC claims (OHL and non-OHL) by insurance arrangement and is the single best source of national WC summary data. NASI total benefits paid is a measure of the cost of all claim payments made in that year for all claims, regardless of the year in which they were originally filed, and is denoted in this study as "NASI cost." NASI cost is different from the total cost discussed earlier, which includes reserves for future anticipated payments. This information was used to obtain a ratio of total NASI cost for self-insured employers to total NASI cost for private and state-fund insurance carriers in DC and the states for which claim data were available. This ratio (an overall WC benefit ratio) was then multiplied by the number of private and state-fund insurance claims for OHL (in each state and year) to estimate the number of self-insured claims for OHL in DC and the 37 states for which data were available. The same overall WC benefit ratio was also multiplied by the OHL claim costs for private and state-fund WC insurance carriers (in each state and year) to estimate the cost of OHL self-insured claims in DC and the 37 states for which data were available. This is expressed in algebraic format below.

For each of the 37 states and DC for which private and state-fund insurance claim information is available, and for each individual year during 2009–2013, and where SI = self-insured companies and PSF = private and state-fund insured companies:

$$\left(\frac{\textit{Total NASI cost for SI in state A in year X}}{\textit{Total NASI Cost for PSF in state A in year X}}\right) \times (\textit{\# OHL claims for PSF in state A in year X}) = \textit{Estimated \# OHL claims for SI in state A and year X}$$

$$\left(\frac{\textit{Total NASI cost for SI in state A in year X}}{\textit{Total NASI cost for PSF in state A in year X}}\right) \times (\textit{OHL costs for PSF in state A in year X}) = \textit{Estimated OHL claim costs for SI in state A in year X}$$

These estimates were based on two assumptions. The first is that the costs of all individual claims (OHL and non-OHL claims) are similar for both the self-insured and the private and state-fund insured. The second is that the proportion of OHL claims out of all WC claims is also similar for both the self-insured and the private and state-fund insured, even if the self-insured have a higher or lower overall claim rate. The first assumption is similar to one that was used in a landmark study by Leigh (2011) that produced an estimate of the national costs of occupational injuries and illnesses[35] that has been relied upon by NIOSH and others as the best available. Leigh's study assumed that, for all companies in all states, the average cost of WC claims that paid only for medical care were similar, and the average cost of WC claims that paid for both medical care and lost earnings were also similar. The second assumption of similar proportions of OHL claims among both self-insured companies and private and state-fund insured companies is addressed by a preliminary assessment of claims data from 35

states performed by the Workers Compensation Research Institute (WCRI). It found that the proportions of OHL claims out of all WC claims (OHL and non-OHL) were similar for self-insured companies (0.107%) and companies with private and state-fund insurance (0.118%), indicating that the assumption of similar proportions of OHL claims was reasonable (J. W. Ruser, personal communication, August 18, 2021; J. W. Ruser, personal communication, February 26, 2021).

STEP 2: TOTALING THE NUMBER OF OHL CLAIMS AND OHL CLAIM COST FOR ALL CLAIMS (PRIVATE AND STATE-FUND, AND SELF-INSURED) IN THE 37 STATES AND DC BY YEAR

The number of private and state-fund insured OHL claims for each of the 37 states and DC was added for each year. The number of self-insured OHL claims for each of the 37 states and DC was also added for each year. The two sums for 2009, 2010, 2011, 2012, and 2013 were added to estimate the total number of OHL claims for all types of insurance in the 37 states and DC for each year.

The cost of private and state-fund insured OHL claims for each of the 37 states and DC was added for each year. The cost of self-insured OHL claims for each of the 37 states and DC was also added for each year. The two sums for 2009, 2010, 2011, 2012, and 2013 were added to estimate the total cost of OHL claims for all types of insurance in the 37 states and DC for each year.

STEP 3: ESTIMATION OF THE NUMBER OF OHL CLAIMS AND OHL CLAIM COST FOR THE 13 MISSING STATES BY YEAR

The next step was to estimate the number and cost of OHL claims from states for which data were not available. The number of OHL claims in the 37 states and DC for which data were available was divided by the total NASI cost for all WC claims in these states (OHL and non-OHL), for each year during 2009–2013. These five results were then multiplied each by the NASI cost for all WC claims (OHL and non-OHL) in the 13 missing states for the corresponding year. This yielded the estimated number of OHL claims for the 13 missing states by year. Similarly, the cost of OHL claims in the 37 states and DC was divided by the total NASI cost for all WC claims in these states (OHL and non-OHL), for each year. These five results were then multiplied each by the NASI cost for all WC claims (OHL and non-OHL) in the 13 missing states for the corresponding year. This yielded the estimated OHL claim cost for the 13 missing states by year. The number of claims and cost estimation calculations are expressed in algebraic format below.

$$\left(\frac{\#\ of\ OHL\ claims\ for\ 37\ states\ and\ DC\ in\ year\ X}{Total\ NASI\ cost\ for\ 37\ states\ and\ DC\ in\ year\ X}\right) \times (Total\ NASI\ cost\ for\ the\ 13\ missing\ states\ in\ year\ X) = Estimated\ \#\ of\ OHL\ claims\ for\ the\ 13\ missing\ states\ in\ year\ X$$

$$\left(\frac{OHL\ claim\ costs\ for\ 37\ states\ and\ DC\ in\ year\ X}{Total\ NASI\ cost\ for\ 37\ states\ and\ DC\ in\ year\ X}\right) \times (Total\ NASI\ cost\ for\ the\ 13\ missing\ states\ in\ year\ X) = Estimated\ OHL\ claim\ costs\ for\ the\ 13\ missing\ states\ in\ year\ X$$

These estimates were based on two assumptions. The first is that the average cost of all individual claims (OHL and non-OHL) is about the same for the 37 states and DC and for the 13 missing states. A similar assumption was also made in the Leigh study cited above.[35] The second is that the proportion of OHL claims out of all WC claims is also similar for both the 37 states and DC and the 13 missing states. These assumptions imply that the proportion of OHL claim costs out of all WC claim costs and the ratio of OHL claims to all WC claim costs are the same for the 37 states and the 13 missing states. Sensitivity analyses were performed to ensure that these assumptions were reasonable and examine how estimates would vary if these assumptions were changed (see section Sensitivity Analyses and Comparative Analyses).

STEP 4: ESTIMATION OF THE TOTAL NUMBER OF OHL CLAIMS AND OHL CLAIM COST IN ALL 50 STATES

The total number of OHL claims for DC and the 37 states for which data were available and the total number of OHL claims for the 13 missing states as estimated in Step 4 were summed for 2009, 2010, 2011, 2012, and 2013 to estimate the total number of OHL claims in the United States by year. These five estimates were summed to estimate the total number of OHL claims for all 50 states during 2009–2013. This total number of claims was

divided by 5 to estimate the average annual number of OHL claims.

The total OHL claim cost for DC and the 37 states for which data were available and the total OHL claim cost for the 13 missing states as estimated in Step 4 were summed for 2009, 2010, 2011, 2012, and 2013 to estimate the total OHL claim cost in the United States by year. Each of these annual figures were adjusted for inflation to 2013 dollars using the gross domestic product (GDP) deflator published by the Bureau of Economic Analysis at the U.S. Department of Commerce.[36] Then these five estimates were summed to estimate the total OHL claim cost for all 50 states during 2009–2013. This total claim cost was also divided by 5 to estimate the average annual cost for all OHL claims. The average cost per claim was calculated by dividing this total OHL claim cost by the total number of claims.

The claim rate was estimated by dividing the total number of OHL claims for all 50 states during 2009–2013 by the total number of private, local, and state government (non-federal) jobs covered by WC insurance during those years. The claim rate was expressed as the number of OHL claims per 10,000 jobs. The number of non-federal WC-covered jobs was estimated as follows. First, the estimates of the total number of WC-covered jobs from NASI[29] for 2009, 2010, 2011, 2012, and 2013 were added together. This total includes federal jobs, which cannot be included in the denominator for the non-federal claim rate. In order to remove them, the numbers of federal jobs in 2009, 2010, 2011, 2012, and 2013 reported by the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) were also added together and then subtracted from the total number of WC-covered jobs.[37–39] The number of WC-covered jobs was used in the denominator for the claim rate rather than number of employees, because some workers have more than one job and may be covered in some jobs but not others. These workers cannot be classified as covered or uncovered by WC insurance.

SENSITIVITY ANALYSES AND COMPARATIVE ANALYSES

Sensitivity and comparative analyses were performed to produce ranges for the key estimates and to ensure the reasonableness of all the estimates. Estimates were based on assumptions that may not have been as accurate as presumed, so sensitivity analyses were performed to provide insight into how much larger or smaller the number of OHL claims and OHL claim costs might have been in the 13 missing states as compared with this study's point estimates. Alternative high and low estimates were calculated for OHL claim cost, the number of OHL claims, and average cost per claim as delineated below. Summary state WC data used in these calculations are provided in Appendix A.

HIGH/LOW ALTERNATIVE ESTIMATES FOR AVERAGE ANNUAL OHL CLAIM COST

It was observed that most of the individual states in the group of 13 states were relatively large and represented an aggregate amount of WC costs much larger than any single state. While such a large aggregation of states might have had a different ratio of OHL claim cost to total WC claim cost (NASI cost), it was not likely to have an extremely high or low OHL claim cost ratio as compared to the national average or the 37 states and DC. The inherent variability among states and probability for inaccuracy would have been far greater if trying to estimate the claim cost for individual states rather than for a grouping of states. Therefore, using the data for the 37 states and DC, two groups of states were selected, both with about the same total WC costs (OHL and non-OHL) as the 13 missing states. The first group included the states with the highest OHL claim cost ratios and the second included the states with the lowest OHL claim cost ratios. To identify these groups of states and calculate the alternative high and low OHL claim cost ratios, the 37 states and DC were ranked by the ratio of their OHL claim cost to total WC claim cost (proportion of OHL claim cost out of all WC claim cost in that state). Total WC claim costs were reported by NASI, as defined earlier (NASI cost). The NASI cost was adjusted for each state in each year to 2013 levels.

The first group of states with the highest OHL claim cost ratios were identified by starting with the highest OHL claim cost ratio state and proceeding down the list to add additional states until the total WC claim costs of the first

group approximately equaled the total WC claim costs of the 13 missing states. The OHL claim costs for this first group of states were added together so that the OHL claim cost ratio could be calculated. This ratio was then used to calculate the alternative high estimate of the average annual OHL claim cost for all 50 states. The same procedure was followed to identify the second group of states with the lowest OHL claim cost ratios, starting at the bottom of the list with the lowest OHL claim cost ratio state and proceeding up the list to add additional states until the total WC claim costs of the group approximately equaled the total WC claim costs of the 13 missing states. The OHL claim cost ratio for the second group was then used to calculate the alternative low estimate of the average annual OHL claim cost for all 50 states. Since the total WC cost of the missing 13 states was quite large, the first group with the highest OHL claim cost ratios and the second group with the lowest OHL claim cost ratios overlapped by one state (California), with 21 states in the high OHL claim cost ratio group and 18 states in the low OHL claim cost ratio group. The estimated ratio of OHL claim costs to all WC claim costs for the 37 states and DC was 0.099%, the high alternative ratio estimate was 0.134%, and the low alternative ratio estimate was 0.045%.

HIGH/LOW ALTERNATIVE ESTIMATES FOR AVERAGE ANNUAL NUMBER OF OHL CLAIMS

Alternative high and low estimates for the U.S. average annual number of OHL claims were obtained in a similar manner to the average annual OHL claim cost. High and low number of claim groups of states with approximately the same total NASI cost as the 13 missing states were identified. The NASI cost was first adjusted for each state in each year to 2013 levels. Then for each state, the numbers of claims for all 5 years were combined and divided by the sum of adjusted NASI cost for all 5 years. This yielded a ratio of number of claims per dollar of NASI cost for each state so that the 37 states and DC could be ranked from highest to lowest. The first group of states with the highest ratios were identified by starting with the highest ratio state and proceeding down the list to add additional states until the total WC claim costs of the first group approximately equaled the total WC claim costs of the 13 missing states. The same procedure was followed to identify the second group of states with the lowest ratios, starting at the bottom of the list with the lowest ratio state and proceeding up the list to add additional states until the total WC claim costs of the group approximately equaled the total WC claim costs of the 13 missing states. After the high and low number of claim state groups were identified, the total number of claims per dollar of NASI cost for each state group was calculated, yielding a high and low ratio. The first group with the highest number of OHL claims to NASI cost ratios included 27 states and the second group with the lowest number of OHL claims to NASI cost ratios included 11 states. The estimated ratio of number of OHL claims to NASI cost for the 37 states and DC was 8.57 E-08; the high alternative ratio estimate was 1.37 E-07 and the low alternative ratio estimate was 4.32 E-08. These two ratios were then multiplied by the 5-year NASI cost for the 13 missing states. This yielded the estimated high and low number of claims for the 5-year period for the 13 missing states, and the high and low average annual number of claims after dividing by 5. These estimates were combined with the number of claims in the 37 states and DC to calculate the alternative high low estimates of the average annual number of claims for all 50 states.

HIGH/LOW ALTERNATIVE ESTIMATES FOR ANNUAL COST PER CLAIM

Alternative high and low estimates for average cost per OHL claim were also obtained following a similar procedure. The OHL claim cost was adjusted for each state in each year to 2013 levels. Then for each state, data were combined across years to obtain an overall cost per claim over the 5-year period. These state costs per claim were used to rank the 37 states and DC and identify the group of high cost per claim states and the group of low cost per claim states, each of which had a total NASI cost similar to the 13 missing states. The overall costs per claim for the high cost per claim group and the low cost per claim group were calculated. The high and low average costs per claim for the United States for the 5-year period were estimated by calculating

the average, weighted by total NASI cost, of the cost per claim for the missing 13 states and the other 37 states and DC.

These analyses indicated that the estimates of the average annual OHL claim cost, average annual number of OHL claims, and average cost per OHL claim for all 50 states did not vary greatly when using the alternative high or low OHL claim cost ratios as compared with the point estimates from the calculations in steps 1 to 4. Developing estimates for a grouping of states, rather than for individual states, lowered the impact of state-to-state variability and allowed for more reliable estimates.

Additional analyses were performed to compare this study's results to those based on separate methods and data sources, to identify any potential errors of magnitude or direction. Analyses were also performed to determine the sensitivity of this study's results to outliers. This study's results were compared to recent available state-produced estimates with partial information for California,[40] Massachusetts,[41] and Pennsylvania (not a public report), which included some combined estimates for both self-insured companies and companies covered by private and state-fund insurance.

To further validate the study results, a second method was also used to estimate the number of OHL claims and OHL claim costs using NASI payroll estimates instead of NASI total costs. Total payroll is used by the WC industry to measure the size of insured worker populations, project claim costs, and determine premiums. NASI provided this study's authors with state payroll information separately for self-insured companies and companies with private and state-fund insurance. The ratios of the number of OHL claims and OHL claim costs for the 37 states and DC to the total payroll for companies with private and state-fund insurance in those states was calculated by state and year during 2009–2013 and multiplied by the payroll for self-insured companies in those states. These ratios were then multiplied by each year's total payroll for the group of 13 missing states. After the total number of claims and OHL claim cost for all years were added, the average annual number of claims and costs were obtained. Costs for years 2009–2012 were adjusted to 2013 dollars.

The number of OHL claims and OHL claim cost for each state, year, and class code were analyzed to identify outliers. Estimates were calculated with and without these outliers to detect their impact on the combined estimates. Claim data for Tennessee in 2010 were an extreme outlier. The 2009–2013 claim data for the State of Tennessee were included in the estimates for the 37 states and DC, but the Tennessee data for 2010 were not used when developing estimates for self-insured companies and estimates for the 13 missing states. Instead, the average of the 2009 and 2011 years for Tennessee data was used as an imputed value for Tennessee in 2010. Also, the State of Texas does not require the reporting of WCIO nature of injury codes, which means that the number of OHL claims and the OHL claim cost for Texas could be underestimates. Since Texas represents a large portion of the data, sensitivity analyses were performed by calculating results with and without Texas to assess the impact on the combined estimates. The Texas data were ultimately retained.

RESULTS

Data for 12,708 WC claims were available for examination. These included 10,464 claims from NCCI during 2009–2013, 1,966 claims from WCIRB during 2009–2013, and 278 claims from OHBWC during 2009–2013. No age, gender, race/ethnicity, or education information were available for claims.

Table 1 (left side) provides the estimated number of U.S. WC claims for OHL in all 50 states during 2009–2013, along with estimates of the total number of jobs covered by WC insurance, OHL claim rate, total OHL claim cost for all 5 years, average cost per OHL claim, and the high and low alternative estimates (range) for the average cost per OHL claim. All costs were expressed in 2013 dollars. The average cost per claim fell between $10,806 and $12,896, with a point estimate of $12,051. Table 1 (right side) provides U.S. average annual estimates based on the 5-year estimates. The estimated average annual number of OHL claims ranged from 4,114 to 5,986, during 2009–2013, with a point estimate of 4,965 claims. The average annual OHL claim

Table 1 Estimated overall U.S. count, rate, and cost of workers' compensation (WC) claims for occupational hearing loss (OHL), 2009–2013[a]

Combined estimates for all 5 years (2009–2013)						Average per year			
Total number of claims	Total no. of jobs[b]	Claim rate per 10,000 jobs[c]	Total cost	Average cost per claim[d]	High/Low alternative estimates for average cost per claim[e]	Average annual number of claims[f]	High/Low alternative estimates for average annual number of claims[g]	Average annual cost[h]	High/Low alternative estimates for average annual cost[i]
24,827	621,071,789	0.40	$299,196,866	$12,051	$10,806–$12,896	4,965	4,114–5,986	$59,839,373	$48,895,249–$66,795,071

[a]Estimates were generated using 12,708 WC claims from 37 states and the District of Columbia. These included 10,464 claims from the National Council on Compensation Insurance (NCCI) during 2009–2013; 1,966 claims from the Workers' Compensation Insurance Rating Bureau (WCIRB) of California during 2009–2013; and 278 claims from the Ohio Bureau of Workers' Compensation (OHBWC) during 2009–2013. All wages and costs were expressed in 2013 dollars using the gross domestic product (GDP) deflator.
[b]These are the total number of non-federal jobs covered under WC insurance during 2009–2013.
[c]The unadjusted claim rate per 10,000 jobs is the total number of claims during 2009–2013 divided by the total number of jobs.
[d]The average cost per claim is the total cost during 2009–2013 divided by the total number of claims.
[e]Range based on the high and low alternative estimates that were developed via sensitivity analyses.
[f]The average annual number of claims is the total number of claims divided by the number of available years of data (five).
[g]Range based on the high and low alternative estimates that were developed via sensitivity analyses.
[h]The average annual cost is the total cost divided by the number of available years of data (five).
[i]Range based on the high and low alternative estimates that were developed via sensitivity analyses.

cost fell in the range of $49 to $67 million during 2009–2013, with a point estimate of $60 million. The second NASI WC payroll-based method produced similar estimates (data not shown).

Table 2 provides information on the 40 industry/occupation classifications that had 50 or more OHL claims out of the 10,742 claims from 36 states and DC. WCIRB data for California were not included. All but two classifications had a single primary industry sector (NIOSH NORA industry sector grouping). The Clerical Office Employees—Not Otherwise Classified (NOC) classification was distributed across many industry sectors and was designated as MULTI (multiple), and Automobile Service or Repair Center and Drivers had two primary industry sectors (Services and Wholesale and Retail Trade). Every classification had claims represented in one or multiple states, with a range of 1 to 35 states (36 being the maximum possible number of states for this table). Eighteen of these classifications had a large percentage of their claims in one state ($\geq$40%). The percent of the 10,742 claims that fell within a single classification ranged from <1 to 9%, and 61% of the claims occurred within the 40 classifications.

Among the 40 industry/occupation classifications, 18 were in Manufacturing; 5 were in Transportation, Warehousing, and Utilities; 3 were in Construction; and 3 were in Services. The other industry sectors had two or fewer classifications represented. The industry/occupation classifications with the highest numbers of claims were Aviation—All Other Employees and Drivers (922), Coal Mining—NOC (715), Coal Mining—Surface and Drivers (347), Clerical Office Employees—NOC (347), Furniture Manufacturing—Wood—NOC (328), and Upholstering (295).

DISCUSSION

This study found that the average annual cost of WC claims for OHL was in the range of $49 to $67 million, far lower than the most recent estimate of $242 million. The $242 million estimate relied on data from one state and 1 year, without the benefit of sensitivity or comparative analyses.[9] That estimate filled a

Table 2 Industry/Occupation classifications with the highest numbers of workers' compensation claims for occupational hearing loss (OHL), 2009–2013 ($N = 6{,}505$)[a]

NCCI[b] industry/occupation classification	NCCI class code[c]	Primary industry sector code[d]	Number of claims (n)	% of claims[e]	Total cost[f]	Number of states with claims[g]	Highest % of claims in one state[h]	State with highest % of claims[i]
Aviation—All Other Employees and Drivers	7403	TWU	922	8.58	$13,211,048	25	78.96	OK
Coal Mining—NOC[j]	1016	MIN	715	6.66	$8,795,281	9	38.18	KY
Coal mining—Surface and Drivers	1005	MIN	347	3.23	$6,636,224	9	59.94	KY
Clerical Office Employees—NOC	8810	MULTI	347	3.23	$2,176,260	36	14.12	FL
Furniture Manufacturing—Wood—NOC	2883	MNF	328	3.05	$6,713,508	6	96.95	TN
Upholstering	9522	MNF	295	2.75	$6,983,874	3	98.98	TN
Unknown (Censored Information)	NA[k]	Unknown	249	2.32	$3,633,019	29	26.91	OR
Police Officers and Drivers	7720	PSF	211	1.96	$2,301,268	29	24.17	OH
Automobile Service or Repair Center and Drivers	8380	SRV and WRT	209	1.95	$1,198,955	27	14.35	FL
Brewery and Drivers	2121	MNF	186	1.73	$841,274	8	86.02	MO
Aviation—Air Carrier – Scheduled, Commuter, or Supplemental – Flying Crew	7405	TWU	185	1.72	$823,516	14	26.49	FL
Rubber Tire Manufacturing	4420	MNF	175	1.63	$2,416,653	5	89.14	TN
Firefighters and Drivers	7710	PSF	173	1.61	$2,918,436	17	41.04	OH
Airplane Manufacturing	3830	MNF	145	1.35	$1,330,367	19	24.83	FL
Paper Manufacturing	4239	MNF	112	1.04	$1,343,163	13	29.46	OR
College—Professional Employees and Clerical	8868	SRV	104	0.97	$750,826	27	16.35	OR
Iron or Steel – Manufacturing – Steelmaking – and Drivers	3004	MNF	104	0.97	$1,334,268	10	49.04	OK
Sheet Metal Products Manufacturing – Shop Only	3076	MNF	103	0.96	$1,062,786	18	42.72	TN
Machine Shop—NOC	3632	MNF	99	0.92	$713,860	26	13.13	OK
Hospital—Professional Employees	8833	HSA	98	0.91	$962,097	18	68.37	VA
	3724	CON	92	0.86	$2,723,606	23	13.04	OR

Table 2 (*Continued*)

NCCI[b] industry/occupation classification	NCCI class code[c]	Primary industry sector code[d]	Number of claims (n)	% of claims[e]	Total cost[f]	Number of states with claims[g]	Highest % of claims in one state[h]	State with highest % of claims[i]
Machinery or Equipment Erection or Repair – NOC and Drivers								
Store—Retail—NOC	8017	WRT	92	0.86	$493,275	29	11.96	FL
Plastics Manufacturing – Molded Products—NOC	4484	MNF	90	0.84	$960,669	20	43.33	MO
Oil Refining – Petroleum – and Drivers	4740	MNF	89	0.83	$1,652,005	10	75.28	TX
Construction or Agricultural Machinery Manufacturing	3507	MNF	83	0.77	$943,511	18	22.89	IA
Trucking: Local Hauling Only – All Employees and Drivers	7228	TWU	79	0.74	$728,115	21	35.44	KY
Electric Light or Power Co. NOC—All Employees and Drivers	7539	TWU	75	0.70	$740,893	18	18.67	OK
Salespersons or Collectors – Outside	8742	SRV	74	0.69	$834,417	25	18.92	FL
Electric Power or Transmission Equipment Manufacturing	3643	MNF	70	0.65	$289,301	16	47.14	UT
Street or Road Construction – Paving or Repaving and Drivers	5506	CON	68	0.63	$1,033,887	14	47.06	WV
Excavation and Drivers	6217	CON	65	0.61	$1,271,789	15	32.31	KY
Oil or Gas Lease Operator – All Operations and Drivers	1320	OGE	64	0.60	$826,770	10	54.69	AK
Electrical Apparatus Manufacturing—NOC	3179	MNF	62	0.58	$811,317	19	25.81	TX
Smelting, Sintering or Refining – Metals – Not Iron or Lead – NOC and Drivers	1438	MNF	62	0.58	$681,597	9	41.94	MO
Food Products Manufacturing—NOC	6504	MNF	62	0.58	$288,566	16	22.58	KS

(*Continued*)

Table 2 (*Continued*)

NCCI[b] industry/occupation classification	NCCI class code[c]	Primary industry sector code[d]	Number of claims (n)	% of claims[e]	Total cost[f]	Number of states with claims[g]	Highest % of claims in one state[h]	State with highest % of claims[i]
Pipe or Tube Manufacturing – Iron or Steel and Drivers	3028	MNF	61	0.57	$253,726	8	59.02	TX
Furnace Manufacturing – Oil or Gas Fired	3169	MNF	54	0.50	$178,950	1	100.00	TN
Barber or Beauty Parlor Supply House	8018	WRT	53	0.49	$236,368	19	24.53	TN
Advertising Material Distribution – Mobile and Door to Door – and Drivers	7380	MULTI	52	0.48	$1,046,910	18	19.23	TN
Automobile Haulaway or Driveaway – Long Distance Hauling – and Drivers	7229	TWU	51	0.47	$1,331,972	17	23.53	OK

[a]Includes industry/occupation classifications with 50 or more claims. Table estimates were generated examining 10,742 WC claims from 36 states and the District of Columbia. These included 10,464 claims from the National Council on Compensation Insurance, Inc. (NCCI) during 2009–2013; and 278 claims from the Ohio Bureau of Workers' Compensation (OHBWC) during 2009–2013.
[b]NCCI = National Council on Compensation Insurance, Inc.
[c]NCCI industry/occupation classification code.
[d]National Institute for Occupational Safety and Health (NIOSH) National Occupational Research Agenda (NORA) industry sector grouping based on the North American Industry Classification System (NAICS) and assigned by the study authors referencing information in multiple sources, including a NCCI-NAICS crosswalk from the International Risk Management Institute (IRMI) and NAICS code and Standard Occupational Classification (SOC) code descriptions. NIOSH NORA sectors: CON = Construction; HSA = Health Care and Social Assistance; MNF = Manufacturing; MIN = Mining; OGE = Oil and Gas Extraction; PSF = Public Safety and Fire; SRV = Services; TWU = Transportation, Warehousing, and Utilities; and WRT = Wholesale and Retail Trade.
[e]Percent of the total number of claims used to generate this table (10,742 claims from 36 states and DC). The 40 industry/occupations in the table represent 60.56% of the 10,742 claims. The remaining 39.44% not presented had industry/occupation classifications with <50 claims.
[f]Total cost is the total incurred costs, which includes everything that has been paid to date on a claim for medical treatments, lost wages, and reserves for future anticipated payments. Cost was expressed in 2013 dollars using the gross domestic product (GDP) deflator.
[g]Number of states with claims in this industry/occupation classification.
[h]Highest percent of claims for this industry/occupation classification that occur in a single state.
[i]Includes the state with the highest percent of claims for this NCCI industry/occupation classification. State abbreviations: AK = Alaska, FL = Florida, IA = Iowa, KS = Kansas, KY = Kentucky, MO = Missouri, OH = Ohio, OK = Oklahoma, OR = Oregon, TN = Tennessee, TX = Texas, UT = Utah, VA = Virginia, and WV = West Virginia.
[j]NOC = not otherwise classified.
[k]Class code "NA" indicates that the information was censored by NCCI, and no industry/classification was available for these claims from multiple unknown classifications.

critical void at the time, as there were no available estimates for OHL claim costs for all 50 states, and there is value to making a cost-based argument for hearing loss prevention. However, the $242 million estimate failed to take account of the high variability among states—their WC laws, industry composition, enforcement of safety standards, and other factors—resulting in a highly inflated number indicating that far more workers were being compensated, and at higher levels of compensation, than in actuality.

This study demonstrated that it is critical to employ data from many states and that extensive analyses are necessary to verify the reasonableness of both the methodology and estimates to *approach* the "true" number of OHL claims and OHL claim cost in the United States. Without complete WC data in every state, even a well-conceived estimate will only be in the vicinity of the true value, and while point estimates are useful and necessary, it is important to focus more on the ranges around the point estimates. These ranges are not synonymous with confidence intervals where one can state with certainty that the interval will contain the parameter 95 or 99% of the time. Rather, they are based on high and low alternative estimates that very likely encompass the "true" number.

This study found that the average annual number of claims during 2009–2013 fell in the range of 4,114 to 5,986 claims. In 2014, approximately 18.5 million U.S. civilian workers reported that they had hearing difficulty.[1] Among noise-exposed workers that year, there were 9.2 million cases of hearing difficulty, with 5.3 million cases directly attributable to occupational noise exposure.[1] These numbers are for perspective and not directly comparable to the number of OHL claims because (1) most OHL is permanent; so, a worker would report hearing loss every year after diagnosis but would likely have only one WC claim at onset and (2) not all hearing losses reported by workers are work-related, although this would not apply to the 5.3 million cases mentioned earlier. A more directly comparable example would be the annual number of recordable "standard threshold shifts" (significant losses in hearing) among noise-exposed workers deemed work-related and recorded on the Occupational Safety and Health Administration (OSHA) 300 log[42,43] or similar mechanism for the Mine Safety and Health Administration (MSHA). These incidence counts are collected by the BLS Survey of Occupational Injuries and Illnesses (SOII).[37] The number of work-related significant losses in hearing were 21,700, 21,100, 20,700, 21,000, and 21,200 in years 2009, 2010, 2011, 2012, and 2013, respectively.[44–48] Even though BLS SOII incidence statistics likely underestimates the true incidence of work-related hearing loss by an order of magnitude,[4] they are still far higher than the estimated annual number of OHL claims.

This discrepancy between the number of cases in the BLS SOII and claims in the WC system may be due to a combination of factors. The annual process that identifies significant losses in hearing to be recorded on an OSHA 300 log or equivalent (BLS SOII cases) is required for noise-exposed workers by federal regulation in most industries. This process has no connection to the WC system, and an identified significant loss in hearing does not trigger a WC claim. There is also no regular process for identifying workers with hearing losses severe enough to meet state WC claim requirements. Hearing loss is an invisible disease which is often not recognized by the workers themselves or is accepted as an expected part of the job. Workers may not recognize the need to seek treatment or require time off the job to recover, and thus may not see a need to file a WC claim. State WC claim requirements also vary widely, and some states have no specific provisions for OHL compensation (although they do have OHL claims and some OHL claim coverage). Some states may have fewer claims due to laws versus fewer actual OHL cases.

However, there are company incentives to underreporting both significant losses in hearing on the OSHA 300 log (BLS SOII cases) and to discourage or contest WC claims.[6,49,50] More claims can lead to higher insurance premiums and too many entries on the OSHA 300 log can lead to inspections and fines. Being able to tout a better or "perfect" safety record can attract new customers and better candidates for open positions, and also improve performance evaluations for managers.

In both instances, companies have significant influence in what losses are reported on the OSHA log and what claims are submitted.[6,49,50]

This study's results indicate that WC estimates are a poor measure of the true magnitude and burden of OHL, and that most occurrences of OHL in the United States are not compensated by WC insurance. OHL cases for which no WC claim is filed, or that are not recognized as work-related, may be treated outside the WC system. Treatment of such cases may be paid for by a combination of private health insurance, Medicare and Medicaid, and/or the workers themselves. Since coverage of hearing loss by other forms of insurance is inconsistent and may be inadequate, the lack of WC may contribute to a lack of treatment and missed opportunities to improve quality of life and overall health. Treatment, including clinical rehabilitation, can be greatly beneficial to workers with hearing loss. This could include fitting hearing aids, learning how to lip read and use other strategies to compensate for diminished hearing,[51] and, more rarely after a catastrophic loss, cochlear implant surgery and follow-up care.[52] Workers with hearing impairment lose healthy years of life (disability-adjusted life years) during the working years, and, left untreated, this can culminate to the loss of many more years of healthy life during retirement.[53] It follows that it is important that the amount of compensation is sufficient for adequate treatment. As an example, the cost of a pair of hearing aids can easily exceed $5,000 and one pair does not last a lifetime. The NCCI claim data indicate that for "all" compensated OHL claims (traumatic and cumulative loss), the range of compensation was <$100 to >$800,000 (one claim). However, 63% of OHL claims was ≤$5,000 and 89% was ≤$30,000. Most of the claim cost came from those few claims at the top of the compensation scale. The 63% of OHL claims compensated ≤$5,000 represented only 5% of costs and the 89% compensated ≤$30,000 represented only 37% of costs.

Nearly half of the 40 industry/occupation classifications with the highest numbers of OHL claims were in the Manufacturing sector. This was not surprising. Manufacturing has consistently been one of the top three sectors (along with Mining and Construction) for high burden and risk of hearing loss.[4,54] Eighteen percent of all Manufacturing workers report hearing difficulty.[1] Among those Manufacturing workers exposed to occupational noise, the prevalence of a material hearing impairment, which is a hearing loss severe enough to impact the understanding of speech, is 20% overall, with the highest prevalences in Petroleum and Coal Products Manufacturing (24%), Primary Metal Manufacturing (24%), Leather and Allied Product Manufacturing (24%) and Machinery Manufacturing (24%). About 46% of Manufacturing workers are exposed to occupational noise.[1] However, 28% of those exposed also report not wearing their hearing protection.[55] More work is needed to safeguard the hearing of these workers, and to identify and treat their hearing losses early.

Most of the other identified industry/occupation classifications were in line with hearing loss risks observed elsewhere in the literature. However, there were a few that could have been perceived as "low risk," including the following: Clerical Office Employees—NOC; College—Professional Employees and Clerical; Hospital – Professional Employees; Store – Retail – NOC; and Salespersons or Collectors – Outside. There has been some research indicating higher than expected risks for hearing loss in less recognized or unrecognized industries. These include health care and professional industries such as Finance and Insurance, Real Estate, Education Services, and Professional, Scientific and Technical Services.[4] Hearing losses in these groups typically occurred among the small proportions of noise-exposed workers.[4] However, the industry/occupation classifications identified here, especially Clerical Office Employees – NOC, Store – Retail, and Salespersons or Collectors – Outside, are very large, employing many millions of workers. The more workers who fall in these classifications, the more likely there will be more WC claims. Since complete denominator data were not available for these classifications, the effect of the classification size cannot be isolated.

Beyond these specific classifications, in addition to a lack of denominator data, some industry/occupation classifications and associated class code definitions are very complex, and more information would be needed beyond

what is available in the WC data for a complete understanding. There can also be significant variations among states in how certain class codes are defined. More broadly, there are additional deficiencies in the available OHL claim information that prevent a clear understanding of the nature and cause of events and the severity of the hearing loss. Research is needed to better comprehend and categorize the "types" of OHL claims (e.g., single event or chronic exposure, sources of causation).

Limitations and Strengths

This study had limitations. OHL claim data for federal workers, which represent about 2% of the workforce, were not available and are not included in this study's estimates. Other types of workers that are typically not required to be covered under WC insurance comprise nearly 15% of the workforce. The largest group among these potentially uninsured workers are the self-employed. Other groups include some domestic and farm positions paying less than a threshold amount; some local and state jobs (e.g., elected positions); and positions in some nonprofit organizations (e.g., religious organizations in some states). Non-covered workers do not have the opportunity to submit WC claims. All states except Texas and Wyoming require WC insurance coverage,[29] though the majority of companies in these states do maintain coverage. For example, in 2020, 71% of Texas private sector companies had WC coverage, representing 81% of the Texas workforce.[56] Railroad workers are covered under a separate program under the Federal Employer's Liability Act (FELA) and longshore and harbor workers are covered separately under the Longshore and Harbor Workers' Compensation Act, and this study did not have access to these data.

OHL claim data were not available for 13 states, although limited information was available for Massachusetts[41] and Pennsylvania (not a public report) for comparison with this study's estimates. The estimated counts of OHL claims for these states were similar to the numbers reported in these sources. Extrapolating WC cost data from the grouping of 35 NCCI states and DC to other states has established precedent.[35] The use of the ratios of OHL claims cost and counts to NASI total WC costs was a novel approach to extrapolation, but a separate payroll-based method produced similar estimates. Sensitivity analyses were also used to generate alternative high and low estimates. In addition, this study developed estimates for a grouping of states, thereby avoiding larger errors that would be associated with developing estimates for individual states whose OHL claim rates vary widely. However, this cannot completely eliminate the possibility that missing data for states with very high or low rates may have led to error. In addition, since Texas does not require the reporting of WCIO nature of injury codes, the number of OHL claims and OHL claim cost for Texas may be underestimated. Also, outliers were identified and one was removed and replaced with an imputed value for the development of estimates for self-insured companies and the 13 missing states (2010 claim data for Tennessee). Although the majority of the missing states were from the Midwest (5) and Mid-Atlantic region (4), which may tend to be more highly industrial, this should have not biased the results for several reasons. First, regional differences are likely due to a number of factors including industry mix and state WC differences. Second, the Southwest, South, and West Regions actually had higher ratios of OHL claim cost and counts compared to NASI cost in the Midwest and Mid-Atlantic regions in the NCCI data. Finally, sensitivity analyses were performed to account for potential differences in the NCCI data and missing state data.

A lack of claim data for self-insured companies contributed to uncertainty in the estimates. The NASI cost ratio, which is the ratio of self-insured to private and state-fund insured costs for all WC claims in each year, was used to represent the ratio of self-insured to private and state-fund insured OHL claim costs occurring in the same year. This method takes account of the possibility that self-insured companies may have a greater general capacity to control WC costs but assumes that any such differential would apply equally to OHL claims and other types of claims, and that the percentage of WC claims related to OHL is similar among self-insured and private and state-fund insured companies. The average ratio of self-insured

to private and state-fund insured NASI costs was 0.34 during 2009–2013; so self-insured costs were estimated to be 34% as large as the private and state-fund insured costs for OHL claims. As noted previously, the assumptions for this calculation had empirical support from a preliminary analysis indicating that the ratio of OHL claims to all WC claims was similar for self-insured and private and state-fund insured companies. However, this analysis did find that the percentage of WC OHL claims was 9.3% lower among self-insured companies (J. W. Ruser, personal communication, August 18, 2021; J. W. Ruser, personal communication, February 26, 2021). It is also not known whether the cost per OHL claim for self-insured and private and state-fund insured companies differ. However, even if the cost of self-insured OHL claims was actually lower than the cost of private and state-fund insured claims by twice that percentage (18.6%), this would be equivalent to an alternative ratio of 0.2768. This lower ratio yields a cost estimate for the United States that is only $2.83 million (4.7%) lower than the point estimate of $60 million.

Another limitation is related to the use of NASI cost to measure the relative amount of total costs of private and state-fund insured companies and self-insured companies and to measure the relative amount of total costs in the states with and without available OHL claim data. See Appendix B for a discussion of potential inaccuracy due to nonequivalence of NASI cost (paid cost for all claims to date within a calendar year) and cost (incurred cost for all claims for injuries or illnesses occurring in a calendar year). This study was limited to estimating the claim cost paid to OHL claimants (benefits paid). Additional costs associated with WC claims are difficult to measure. These include administrative costs for processing claims, the cost of underwriting, risk control services, and other costs of the WC insurance system. These additional costs are estimated by one study to be equal to 48% of the size of actual benefits paid for all WC claims.[35] Study estimates also do not include the entire amount of lost earnings, much of which is borne by the injured worker.[57] WC payments for lost wages can include those for temporary total disability and permanent partial disability as described earlier. However, research has indicated that the actual percentage often falls substantially below that[57,58] because (1) benefits are capped at 100 to 200% of the state average weekly wage and (2) there are long-term declines in earning ability that are not captured as lost work time. Some reductions in productivity associated with OHL are also likely to be borne by companies, but there is little research available to quantify this cost. This study also employed data from the fifth report of claim cost, which becomes available in the fifth year after the year of injury. Later reports incorporate more information on actual costs and tend to result in upward revisions of estimates of total cost. Although the time period used (2009–2013) spans the Great Recession, the potential impacts of the economic recession on the analysis appears minimal. The NASI cost for all claims varied only slightly during this period, ranging from $59 billion in 2009 to $60 billion in 2013.

No demographic information for OHL claims was available for analysis. The combined industry/occupation classifications had some limitations. Separate industry and occupation information is the gold standard for identification and surveillance purposes, although these classifications were fairly detailed. Industry/occupation classifications were assigned by companies and insurance carriers based on state law, which can vary. For example, NCCI allows states to create state-specific industry/occupation classifications. Companies and insurers can make mistakes in classification, and there is some incentive for companies to classify themselves into industries with lower WC costs in order to pay lower insurance premiums. While this study's authors took great care to assign NIOSH NORA industry sectors based on the industry/occupation classifications and associated information available, sector misclassification was also possible.

The industry/occupation classifications presented in Table 2 are only those with claim counts $\geq$50. This is numerator information. Complete denominator information was not available by industry/occupation classifications. Thus, large classifications that occur in most industries, such as clerical, may have higher

counts, in part, due to having a larger denominator rather than a higher risk for OHL. There were some OHL claims (2%) for which no industry/occupation classification was available, preventing identification of potential exposures for this small percentage of workers. Narrative event descriptions were not available for NCCI and WCIRB claims, which included nearly all of the claims analyzed in this study. Narratives were available only for OHBWC claims. These narratives provided only limited information such that the events leading to each hearing loss could not be precisely determined or the severity of the hearing loss in most cases. If such information had been available, it may have enabled more accurate identification and characterization of OHL claims. Instead, nature of injury codes were generally relied upon.

Despite these limitations, this study was the only recent one to incorporate data from most states (37 and DC) to estimate the total number of OHL claims and the OHL claim cost for all 50 states. The last study that did this was published in 1979.[59] These data were not a sample, but rather complete data for all claims from private and state-fund insured companies in these states and DC. This is also the first study to provide ranges for key OHL claim estimates based on alternative high and low estimates. Five years of data were used to strengthen the reliability of the estimates. Both sensitivity and comparative analyses were employed to support the validity of the assumptions for estimates and the accuracy of the estimates themselves.

CONCLUSIONS

This study demonstrated that to develop a valid and reliable estimate approaching the "true" number of OHL claims and OHL claim cost in the United States, it is critical to incorporate data from many states and perform extensive analyses to test the reasonableness of both the methodology and estimates. States vary widely in their WC laws, mix of industries, claim costs, and rates as shown in Appendix A, and other factors. The prior estimate of annual OHL claim cost in the United States ($242 million) was an overestimate likely due to being based on data for one state in 1 year. This study estimated that the average annual OHL claim cost ranged from $49 to $67 million and that the average annual number of OHL claims ranged from 4,114 to 5,986 claims.

The average annual number of OHL claims is very low compared to the number of hearing loss cases identified in other worker health surveillance sources such as CDC surveys and the BLS SOII. This indicates that WC estimates do not provide an accurate picture of the true burden of OHL in the United States and significantly underestimate the problem. It also indicates that most cases of OHL are not being compensated through the WC system. Most treatment would then need to be paid for by the worker's private health insurance, Medicare, Medicaid, or out of pocket. Insurance coverage may be inadequate and workers may not have the funds for such treatment; so, poor WC insurance coverage or application may contribute to fewer workers receiving medical attention critical for preserving quality of life and reducing years of healthy life lost.

Nearly half of the industry/occupation classifications with the highest numbers of OHL claims were in Manufacturing. Workers in this industry and others who are at the highest risk for hearing loss—those who are noise-exposed—need special attention to prevent OHL. Finally, additional research is needed to better understand the events leading to each OHL claim, and the severity of the hearing loss. The demographics of OHL claimants also need to be explored. High-risk groups for OHL are well-documented in the literature. Examining demographics among WC claimants could elucidate whether there are similar patterns among WC claimants.

CONFLICT OF INTEREST

None declared.

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DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, or the views of the National Council on Compensation Insurance, Inc.

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Appendix A: 2009–2013 Summary state workers' compensation data for occupational hearing loss (OHL) and rankings

State	Region[a]	Have state OHL data	NASI cost[b,c]	Private and state-fund % of NASI cost[a]	Private and state-fund NASI cost[b]	Total OHL claims cost[c,d]	Ratio of total OHL claims cost to private and state-fund NASI cost[b,d]	Rank of ratio of total OHL claims cost to private and state-fund NASI cost[a]	No. of OHL claims[d]	Ratio of no. of OHL claims to private and state-fund insured NASI cost[b,d]	Rank of ratio of no. of OHL claims to private and state-fund insured NASI cost[b]	Average cost per OHL claim[c,d]	Rank of average cost per OHL claim[c]
WV	S	Yes	$2,348,241,539	87.92	$2,066,620,235	$12,373,210	0.005987171	1	681	3.29524E-07	2	$18,169	1
OK	SW	Yes	$4,416,035,987	79.86	$3,526,685,458	$19,140,237	0.005427259	2	1223	3.46785E-07	1	$15,650	4
KY	S	Yes	$3,528,212,332	69.2	$2,440,847,359	$10,592,128	0.004339529	3	743	3.04402E-07	4	$14,256	5
TN	SW	Yes	$4,105,658,028	79.9	$3,279,362,247	$13,066,746	0.003984539	4	1000	3.04785E-07	3	$13,073	9
OR	W	Yes	$3,268,022,786	81.34	$2,659,171,969	$10,157,836	0.003819925	5	621	2.33531E-07	5	$16,357	3
MO	MW	Yes	$4,323,850,879	75.62	$3,270,228,492	$5,046,706	0.001543227	6	513	1.5687E-07	6	$9,838	18
IA	MW	Yes	$3,155,961,308	78.54	$2,478,160,692	$3,623,185	0.001462046	7	258	1.04109E-07	12	$14,043	6
LA	S	Yes	$4,435,895,939	68.24	$3,026,270,119	$3,176,436	0.001049621	8	181	5.98096E-08	27	$17,549	2
AK	W	Yes	$1,215,970,810	71.92	$874,387,708	$903,106	0.001032844	9	95	1.08647E-07	10	$9,506	21
NE	MW	Yes	$1,613,368,299	79.28	$1,279,019,253	$1,290,776	0.001009192	10	117	9.14763E-08	15	$11,032	14
MT	W	Yes	$1,318,549,542	83.76	$1,104,317,298	$1,062,698	0.000962312	11	94	8.51205E-08	17	$11,305	13
TX	SW	Yes	$8,463,534,186	80.02	$6,772,298,577	$6,349,573	0.00093758	12	718	1.0602E-07	11	$8,843	22
NM	SW	Yes	$1,460,677,891	67.88	$992,245,861	$925,214	0.000932445	13	74	7.45783E-08	19	$12,503	10
AL	S	Yes	$3,275,482,940	48.26	$1,580,802,064	$1,434,943	0.000907731	14	136	8.60323E-08	16	$10,551	16
UT	W	Yes	$1,435,751,029	82.64	$1,186,560,452	$983,873	0.000829181	15	183	1.54227E-07	7	$5,376	30
VA	S	Yes	$4,562,454,988	77.24	$3,523,881,205	$2,868,985	0.000814155	16	422	1.19754E-07	8	$6,799	26
AZ	SW	Yes	$3,651,580,175	81.66	$2,981,285,125	$2,359,941	0.000791585	17	199	6.67497E-08	23	$11,859	11
HI	W	Yes	$1,287,447,514	65.44	$842,520,531	$567,652	0.000673754	18	59	7.0028E-08	20	$9,621	19
KS	MW	Yes	$2,150,866,421	71.56	$1,539,584,713	$943,624	0.000612908	19	170	1.10419E-07	9	$5,551	29
FL	S	Yes	$14,692,448,649	70.22	$10,295,556,013	$6,273,069	0.000609299	20	659	6.40082E-08	25	$9,519	20
CA	W	Yes	$54,599,326,211	69.92	$38,219,734,051	$22,898,103	0.000599117	21	1966	5.14394E-08	28	$11,647	12
CT	NE	Yes	$4,479,880,899	74.86	$3,351,967,251	$1,689,067	0.000503903	22	163	4.86282E-08	29	$10,362	17
MD	NE	Yes	$4,945,803,601	72.14	$3,567,855,657	$1,740,535	0.000487838	23	128	3.58759E-08	34	$13,598	7
SC	S	Yes	$4,605,181,449	79.06	$3,641,614,301	$1,757,283	0.000482556	24	132	3.62477E-08	33	$13,313	8
AR	S	Yes	$1,063,724,398	74.34	$788,969,518	$378,331	0.000479526	25	66	8.36534E-08	18	$5,732	27
ID	W	Yes	$1,294,726,668	93.94	$1,214,233,005	$571,334	0.000470531	26	79	6.50616E-08	24	$7,232	23
MS	S	Yes	$1,720,316,646	63.7	$1,095,434,521	$481,802	0.000439827	27	67	6.11629E-08	26	$7,191	24
CO	W	Yes	$4,311,828,085	78.34	$3,368,306,617	$1,314,486	0.000390251	28	309	9.17375E-08	14	$4,254	34
NV	W	Yes	$2,053,051,280	68.28	$1,401,882,650	$467,514	0.00033349	29	98	6.9906E-08	21	$4,771	32
SD	MW	Yes	$489,738,091	95.96	$469,981,515	$149,917	0.000318985	30	32	6.80878E-08	22	$4,685	33
OH	MW	Yes	$11,475,167,213	82.48	$9,465,746,693	$2,964,275	0.000301252	31	278	2.93691E-08	36	$10,663	15

(*Continued*)

(*Continued*)

State	Region[a]	Have state OHL data	NASI cost[b,c]	Private and state-fund % of NASI cost[a]	Private and state-fund NASI cost[b]	Total OHL claims cost[c,d]	Ratio of total OHL claims cost to private and state-fund NASI cost[b,d]	Rank of ratio of total OHL claims cost to private and state-fund NASI cost[a]	No. of OHL claims[d]	Ratio of no. of OHL claims to private and state-fund insured NASI cost[b,d]	Rank of ratio of no. of OHL claims to private and state-fund insured NASI cost[b]	Average cost per OHL claim[c,d]	Rank of average cost per OHL claim[c]
ME	NE	Yes	$1,371,607,127	70.58	$969,973,184	$261,131	0.000269214	32	92	9.4848E-08	13	$2,838	37
IL	MW	Yes	$15,139,924,575	75.4	$11,416,036,337	$2,967,685	0.000259958	33	414	3.62648E-08	32	$7,168	25
GA	S	Yes	$7,577,101,805	73.92	$5,600,910,156	$1,112,853	0.000198691	34	195	3.48158E-08	35	$5,707	28
NH	NE	Yes	$1,182,003,044	76.18	$902,150,874	$135,506	0.000150203	35	36	3.99046E-08	31	$3,764	35
DC	MA	Yes	$527,924,516	80.18	$421,128,293	$41,543	9.86474E-05	36	8	1.89966E-08	38	$5,193	31
VT	NE	Yes	$733,177,883	86.94	$637,381,312	$54,778	8.59424E-05	37	18	2.82406E-08	37	$3,043	36
RI	NE	Yes	$856,101,727	85.66	$733,313,965	$60,377	8.23349E-05	38	30	4.09102E-08	30	$2,013	38
DE	NE	No	$1,132,712,345	81.72	$925,661,823								
IN	MW	No	$3,251,057,851	89.3	$2,903,201,145								
MA	NE	No	$5,147,036,704	75.14	$3,865,634,903								
MI	MW	No	$6,657,407,336	63.48	$4,228,159,139								
MN	MW	No	$5,433,982,216	75.72	$4,114,148,949								
NJ	MA	No	$11,004,835,426	78.98	$8,690,421,552								
NY	MA	No	$25,637,112,468	69.16	$17,720,706,115								
NC	S	No	$7,394,915,203	75.84	$5,606,826,692								
ND	MW	No	$718,301,259	100	$718,301,259								
PA	MA	No	$15,116,831,979	78.6	$11,882,925,615								
WA	W	No	$12,007,455,003	78.16	$9,382,894,647								
WI	MW	No	$5,736,112,089	87.44	$5,014,382,548								
WY	W	No	$844,680,709	100	$844,680,709								

[a]U.S. states were categorized into six geographical regions based on U.S. Embassy groupings.[60] Mid-Atlantic (MA) = Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, DC. Midwest (MW) = Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. New England (NE) = Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. South (S) = Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Southwest (SW) = Arizona, New Mexico, Oklahoma, and Texas. West (W) = Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.
[b]National Academy of Social Insurance (NASI) provides the total benefits paid of all WC claims (OHL and non-OHL) by insurance arrangement and is the single best source of national WC summary data. NASI total benefits paid is a measure of the cost of all claim payments made in that year for all claims, regardless of the year in which they were originally filed, and is denoted in this study as "NASI cost." NASI cost is different from the total cost, which includes reserves for future anticipated payments.
[c]Adjusted to 2013 dollars using the gross domestic product (GDP) deflator.
[d]Data imputed for Tennessee in 2010.

APPENDIX B: UNCERTAINTY ASSOCIATED WITH THE USE OF NASI COST (PAID COST) RATIOS TO REPRESENT INCURRED COST RATIOS

In order to estimate OHL claim costs for self-insured companies and the 13 states for which data were unavailable, calculations relied upon the observed ratios of "cost" (total incurred OHL claim cost) to "NASI cost" (total paid cost of all WC claims) among private and state-fund insured companies in the 37 states and DC for which data were available. In each of the 37 states and DC, this ratio was multiplied by the NASI cost for self-insured companies to obtain estimates of self-insured incurred OHL claim costs. Similarly, for the 13 missing states, the overall ratio for the group of 37 states and DC was multiplied by the NASI cost for companies in the 13 missing states to obtain estimates of incurred OHL costs in these states. However, there is a technical issue with this method that arises because of the possible discrepancy between NASI paid costs and incurred costs. It would have been natural to base calculations on the ratio of the incurred cost of OHL claims to the total incurred cost of all WC claims, but total incurred cost of all WC claims in the years of this study (2009–2013) was unavailable. This led to the use of total NASI cost instead. But as explained above in the Methods section, there are important differences between NASI paid cost and incurred cost. NASI costs paid in a year are payments made on all open claims for injuries and illnesses of past years as well as the current year, while incurred cost refers to costs incurred by injuries and illnesses occurring in a single year and includes projected future costs not yet paid. Thus, the relative amount of NASI cost may not accurately represent the relative amount of cost of self-insured companies versus private and state-fund insured companies, or the relative amount of cost of the states with and without available data.

To explore the impact of the possible non-equivalence of NASI cost (paid) and cost (incurred) ratios on the estimates, an examination can be made of changes over time in the relative amount of NASI costs of two groups: companies for which data were available and companies for which data were not available. More specifically, where SI = self-insured companies and PSF = private and state-fund insured companies:

$$\left(\frac{\textit{Total NASI cost for SI in 37 states and DC + Total NASI cost for the 13 missing states}}{\textit{Total NASI cost for PSF in 37 states and DC}}\right)$$
$$= \textit{NASI paid cost ratio of companies without data to companies with data}$$

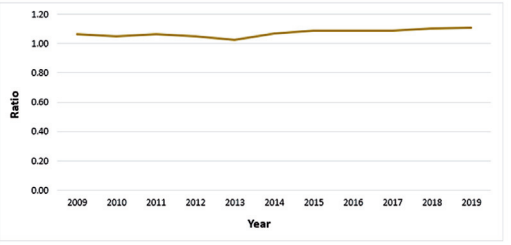
The estimation of OHL costs among companies for which data ara unavailable depends in part on the assumption that the NASI paid cost ratio is equal to the ratio of incurred costs for these two groups of companies, defined as:

$$\left(\frac{\textit{Total incurred cost for SI in 37 states and DC + Total incurred cost for the 13 missing states}}{\textit{Total incurred cost for PSF in 37 states and DC}}\right)$$
$$= \textit{Incurred cost ratio of companies without data to companies with data}$$

If the NASI paid cost ratio is stable over time, this suggests that the corresponding incurred cost ratio is also stable and is similar. This is because incurred cost ratios are actuarial predictions of paid cost ratios in the future after all costs for a year's claims are paid, and if these predictions are approximately the same each year, then each year's cost ratio should be approximately the same each year as well. Incurred cost may not accurately predict future NASI paid costs, but there is no known reason why any bias in these predictions should be different for the two large groups of companies and thus cause a deviation of the incurred cost ratio from the NASI paid cost ratio. If the NASI paid cost ratio is not stable, and instead is shifting significantly over time, this suggests that each year's incurred cost ratio is different from the NASI paid cost ratio and is also shifting each year so as to cause the NASI paid cost ratio to adjust to include the costs of an additional year of claims. The magnitude of any variation in the NASI cost ratio thus suggests the potential size of the difference between the NASI and incurred cost ratios.

Fig. B.1 gives the NASI paid cost ratio of companies without data to companies with data over the 5-year study period and the following 6 years, based on pooled cost for all states. The overall picture is one of fair stability. The NASI paid cost ratio ranged between 1.025 and 1.067

in 2009–2013, with an average ratio of about 1.05. There is some evidence of a downward trend during 2011–2013, suggesting that the incurred cost ratio may have been below the NASI paid cost ratio in 2012–2013. An example calculation can suggest the potential magnitude of error. If the incurred cost ratio was the same as the NASI paid cost ratio in 2009–2011 when the NASI paid cost ratio was steady, but then fell below the observed paid cost ratio of 1.037 in 2012–2013 to an average of 1.01, then the average incurred cost ratio in 2009–2013 would have been 1.04. Calculation with this value would have decreased the estimate of overall claim cost by about $0.31 million, a decrease of 0.54% from the main point estimate of $60 million. While the incurred cost ratio could have been still lower than 1.01 in 2012–2013, the subsequent upward trend from 2013 to 2019 suggests that any underestimate of the ratio in 2012–2013 may be limited. This trend implies that the incurred cost ratio was increasing during 2014–2019. It also suggests that the ratio of costs incurred during the study period may have been higher than indicated by the NASI paid cost ratios, since study period claim costs are an important share of NASI cost during 2014–2019 and especially in 2014–2015. Thus, the evidence is somewhat mixed on the question of whether the incurred cost ratio may have been higher or lower than the NASI paid cost ratio during 2009–2013. This, along with the reasonable stability of the ratio, suggests that there is likely to be a modest difference between NASI paid and incurred cost ratios.



Appendix Figure B.1 National Academy of Social Insurance (NASI) Cost Ratio of companies without data to companiesQ3 with data.[29–34]