

Analysis of Occupational Safety and Health Administration (OSHA) noise standard violations over 50 years: 1972 to 2019

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Abstract

Introduction: Noise exposure has long been an occupational health concern and has been an important area of focus of the Occupational Safety and Health Administration (OSHA) since its founding. Nevertheless, it remains unclear what effects OSHA's noise standards have had on employer efforts to reduce risks. Consequently, a review of OSHA noise standard violations was performed to clarify the violation trends between 1972 and 2019.

Methods: Using the OSHA Information System, researchers identified 119 305 violations involving four noise standards between 1972 and 2019: 29 CFR 1910.95, occupational noise exposure in general industry; 1926.52, occupational noise exposure in construction; 1926.101, hearing protection in construction, and 1904.10, recording criteria for cases involving occupational hearing loss. Violation frequencies of noise standard subparagraphs and relationships to factors such as industry differences were analyzed using descriptive statistics and *t* tests.

Results: The most commonly violated noise standard was 1910.95 in manufacturing. Such violations rose between 1972 and 1985 and then declined steadily. Whether in general industry or construction, four noise standards were most-frequently cited: lack of feasible administrative or engineering controls (1910.95[b] and 1926.52[d]) and inadequate hearing conservation program (1910.95[c] and 1926.52[b]). These violations were more highly penalized (mean = \$1036.50) than other subparagraph violations (mean = \$915.80). Programmed and unprogrammed inspections generated similar violation quantities except between 1980 and 1985, when programmed inspections exhibited a sharp spike in violations.

Conclusion: The study identified trends in OSHA noise standard violations and possible explanations for those trends. The study findings can support development of more practical noise-exposure protection policy.

KEYWORDS

construction standards, environmental monitoring, general industry standards, noise standards, noise-induced hearing loss, occupational noise, Occupational Safety and Health Administration (OSHA), regulatory enforcement

1 | INTRODUCTION

The US Centers for Disease Control and Prevention (CDC) reports that 22 million American workers are exposed to potentially damaging noise each year.¹ The US Occupational Safety and Health Administration (OSHA) is a federal agency that seeks to protect the safety and health of American workers by setting and enforcing standards and by providing training, outreach, education, and assistance to American employers. Soon after its creation, OSHA published occupational noise exposure standards for general industry (29 CFR 1910.95) in 1974,² and subsequently, for construction (29 CFR 1926.52) in 1979.³ These standards require employers to protect workers from the harmful effects of noise exposure. When noise levels exceed certain thresholds, employers must take various actions including implementation of engineering and administrative controls to reduce noise levels, provision of personal protective equipment (eg, hearing protectors), training of workers, and administration of a hearing conservation program. OSHA later engaged in additional rulemaking regarding proper hearing protection in construction (29 CFR 1926.101)³ and record-keeping criteria for all cases involving occupational hearing loss (29 CFR 1904.10).⁴

Since OSHA began enforcing noise standards nearly 50 years ago, many aspects of the US economy have changed. Employees in manufacturing (where noise exposures frequently occur) now make up a smaller fraction of the total workforce.⁵ Additionally, new technologies and increased automation have changed the type and intensity of noise present. Changes in the regulatory and political climate have also likely affected OSHA's enforcement priorities. Like any enforcement agency, OSHA has a tradition of assessing its quality measures, performing internal audits, and evaluating its programs. However, there have been few reviews of OSHA enforcement actions related to occupational noise standards and their impacts.

Through the description of the numbers and types of violations of OSHA occupational noise exposure standards, the goal of this study was to determine whether the data demonstrate industry-specific patterns, identify employer actions for preventing employee hearing loss, and reveal the composition and deficiencies of employer noise protection programs, all of which could have implications for OSHA policy.

2 | MATERIALS AND METHODS

2.1 | Ethics review and approval

The study protocol was presented, in advance, for review by an Institutional Review Board (IRB) and it was determined that the activity did not represent human subjects research (Protocol # 2019-0764). Only deidentified data from OSHA personnel were used for this study analysis.

2.2 | Methods

OSHA uses electronic databases to record their enforcement activities. While selected details of each inspection are publicly accessible online through a data enforcement web site,⁶ an entire data is stored internally. The Integrated Management Information System (IMIS) contains records from inspections opened up until 2012. More recent inspections are recorded in the OSHA Information System (OIS). The authors obtained a master file from these sources containing all OSHA noise violations issued from 8 March 1972, through 30 April 2019. The file included violations issued by federal OSHA and by OSHA-approved state plans in all 50 states, the District of Columbia, and five US protectorates (Guam, Puerto Rico, American Samoa, US Virgin Islands, and Northern Mariana Islands).

Using the master file, the authors then created a data subset consisting of violations of four noise-related violations: 29 CFR 1910.95 occupational noise exposure in general industry,² 1926.52 occupational noise exposure in construction,³ 1926.101 hearing protection in construction,³ and 1904.10 record-keeping criteria for cases involving occupational hearing loss.⁴ Specific data in the subset included: the date of the inspection; the reason for the inspection; the name, address, and industry (North American Industry Classification System [NAICS] and Standard Industrial Classification [SIC] codes, as available) of the employer; and the OSHA standard (part, paragraph, and subparagraph) violated. Employer-specific information was replaced by a unique identifier for each inspection. When a single inspection generated more than one noise-related violation, one row was included in the database for each violation. The authors dichotomized the type of inspection as programmed vs unprogrammed. Programmed inspections are that were scheduled as part of an OSHA region's ongoing enforcement plan, whereas unprogrammed inspections occur in response to unexpected events such as work-site accidents or employee complaints. Codes POTH (Programmed Other), PP (Program Planned), PREL (Program Related), M (Monitoring), and FU (Follow-up) were classified as programmed inspections. The codes C (Complaint), A (Accident), FC (Fatality/Catastrophe), REF (Referral), UNP (Unprogrammed), UNPREL (Unprogrammed Related), and UNPOTH (Unprogrammed Other) were classified as unprogrammed inspections.

The authors then performed descriptive statistics such as frequency, percentage (%), mean (*M*), and standard deviations (*SD*) for variables of interest using R 3.5.3. For ease of temporal analysis, the authors analyzed dates in 5-year bins (eg, 1970-1974, 1975-1979, etc.) corresponding to the government fiscal year, which begins on 1 October and ends on 30 September. Standards were analyzed as both CFR paragraphs (eg, 29 CFR 1910.95) and subparagraphs (eg, 29 CFR 1910.95[b][1]). The *t* test was performed to compare penalty differences between the four OSHA noise standard subparagraphs. In the *t* test, group 1 was composed of the two most-frequently violated subparagraphs and group 2 was composed of all other subparagraphs (except group 1). It was inferred that the two most-frequently violated

TABLE 1 Numbers of violations of four noise standards, 1972 to 2019

Standard	Standard description	Number of violations
1910.95	Occupational noise exposure (general industry)	115 770
1926.52	Occupational noise exposure (construction)	2425
1926.101	Hearing protection (construction)	894
1904.10	Record-keeping criteria for cases involving occupational hearing loss	414

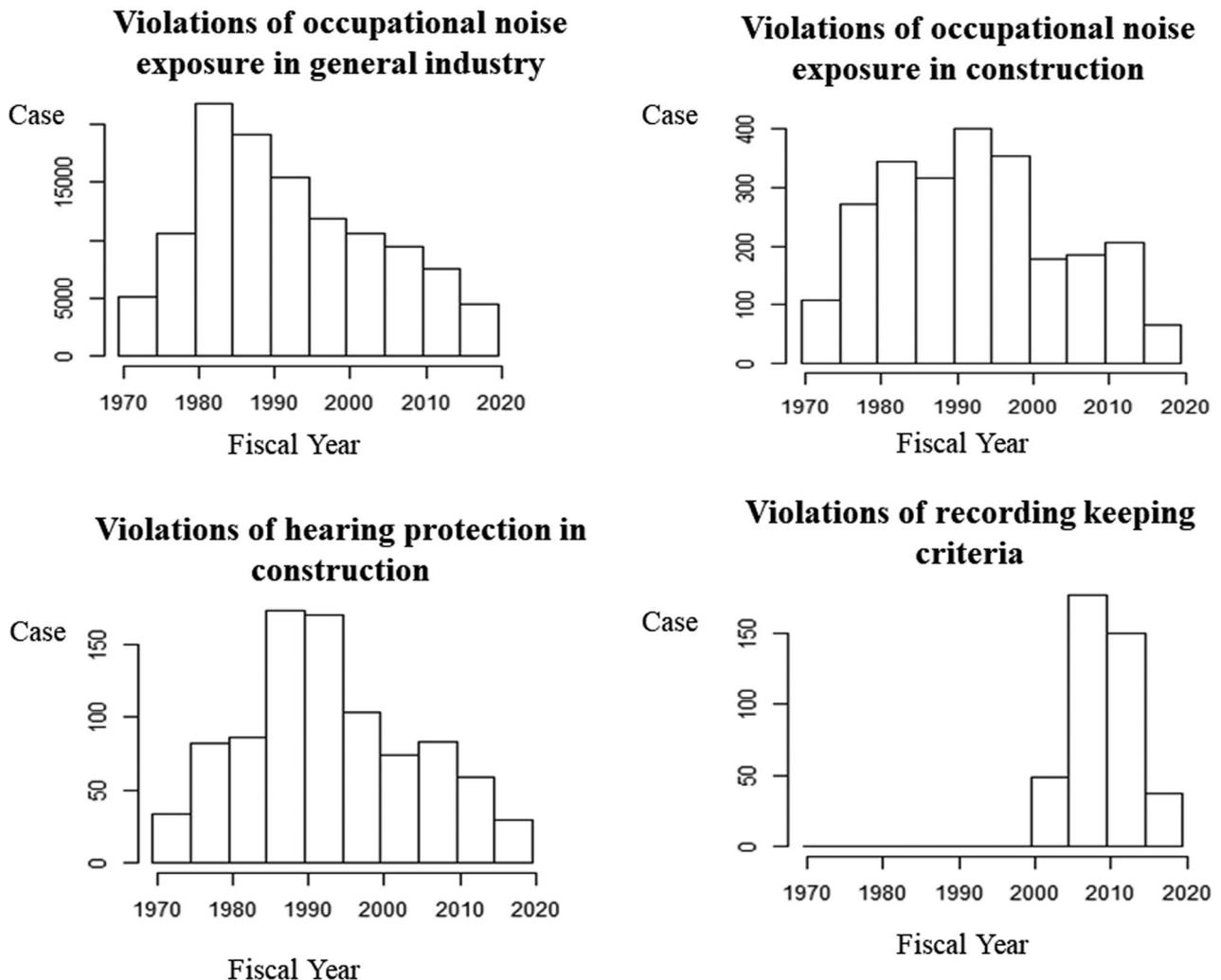
subparagraphs in both general industry and construction carried a higher penalty than other subparagraph violations. In addition, descriptive statistics for analysis of SIC codes were obtained.

3 | RESULTS

The final sample for analysis contained 119 503 OSHA noise violations issued from 1972 through 2019. As presented in Table 1, most

(115 770 of 119 305; 97.0%) of the violations were for violations of the occupational noise exposure standard in general industry. Violations of the construction industry noise standards were less than 3% (3319 of 119 305) (Table 1).

Figure 1 demonstrates the temporal trend in noise violations over time. After an initial rise, violations of the general industry noise exposure standard (29 CFR 1910.95) consistently declined after 1985. Violations of standards 1926.52 and 1926.101 also decreased after 1990, although less precipitously. For three of the four noise

**FIGURE 1** Violations of the four noise standards in 5-year bins, 1970 to 2020

standards, the largest numbers of violations occurred during the period immediately after their promulgation (1975 to 1985), when OSHA first enforced regulations to protect employees' hearing in workplace settings. Standard 1904.10 was not enforced until 2001 and thus it exhibited no violations before that year.

Among the four standards, there were violations of 463 distinct subparagraphs. Table 2 lists the 16 most-frequently cited subparagraphs of general industry-standard 1910.95. Lack of feasible administrative or engineering controls (1910.95 [b][1]) represented the largest portion of the violations (18 790 of 115 770; 16.2%), followed by failure to administer a continuing (15.5%) effective hearing conservation program (1910.95 [c][1]) and failure to develop and implement a monitoring program (1910.95 [d][1]).

Of the 119 503 total violations, 56 263 (47.1%) resulted from programmed inspections and 63 235 (52.9%) from unprogrammed inspections. The reason for the inspection was unknown in five cases. Figure 2 shows the number of violations of the three most-commonly violated major paragraphs of the general industry noise standard (1910.95[b], 1910.95[c], and 1910.95[d]) stratified by inspection type (programmed vs unprogrammed). Notably, the number of violations of paragraph 1910.95(b) (administrative or engineering controls and personal protective equipment) abruptly decreased from 1980 to 1984 and also from 1985 to 1989. Violations of the other two paragraphs also occurred less frequently over time, but the decreases were not as pronounced. Noise violations (from programmed and unprogrammed inspections) have steadily decreased since 1990.

The most-frequent noise violations in construction involved inadequate hearing conservation programs (1926.52[d]) accounting for 1222 (50.7%) of 2411 violations, followed by the need for feasible administrative or engineering controls or personal protective equipment with 594 (24.6%) violations and general failure to protect against the harmful effects of noise exposure with 579 (24.0%) violations (Table 3). The fact that construction showed the highest number of top-level paragraph violations for the hearing conservation program is a notable difference from the general industry which had no violations of this paragraph between 1970 and 1980 (Figure 2).

Of the initial 119 503 violations identified, 170 (0.1%) were excluded from the analysis because they contained unclassified codes, and 6427 violations (5.4%) that contained only NAICS codes were converted to SIC codes for the analysis. A total of 119 333 violations were analyzed by SIC code and are presented in Tables S1 and S2. The analysis revealed that of 11 industries, six were most-frequently cited for noise violations due to an inadequate hearing conservation program: (a) agriculture, forestry, fishing; (b) transportation and public utilities; (c) wholesale trade; (d) retail trade; (e) finance, insurance, real estate; and (f) services (Table S3).

Overall, the following OSHA noise standards were most-frequently cited (Tables 2 and 3): lack of feasible administrative or engineering controls (1910.95[b] and 1926.52[d]) and inadequate hearing conservation program (1910.95[c] and 1926.52[b]). A total of 42 324 violations (35.4% of 119 503) were analyzed using the *t* test to compare penalty

differences between violations involving the four most-frequently cited OSHA noise standard subparagraphs and violations involving others; 77 179 violations (64.6%) were excluded from this analysis because no penalty was assigned. Significant differences in penalties were observed between violations of the four most frequently cited OSHA noise standards subparagraphs and violations of others ($P < .001$; Table 4). Violations of subparagraphs 1910.95(b), 1910.95(c), 1926.52(b), and 1926.52(d) were more costly ($M = \$1036.5$, $SD = \$2379.4$) than violations of other subparagraphs ($M = \$915.8$, $SD = \$2718.0$).

Violations of standard 1926.101 hearing protection in construction ($n = 892$) and standard 1904.10 record-keeping ($n = 414$) were analyzed as shown in Tables S4 and S5. In construction, noise exceedances of the PEL requiring the use of ear protective devices were cited most often (776 of 894 [86.8%]), followed by hearing-protective devices fitting (11.7%). In record-keeping, standard threshold shift (STS) was most often cited (394 of 414 [95.2%]), followed by implementation questions (4.8%).

4 | DISCUSSION

OSHA has enforced occupational noise exposure standards in the United States for almost five decades. From the initiation of enforcement actions until the present day, the agency has regularly encountered violations of these noise standards. Although several industry-specific OSHA noise-exposure measurement analyses exist,^{5,7} no comprehensive analysis of OSHA noise standard violations has been performed for all industries.

A comprehensive review of the data presented revealed a marked decrease in the number of noise violations after 1984. The timeframe of this decrease is particularly interesting in light of the elaboration of STS criteria for the industry as a whole that occurred in 1983.^{8,9} OSHA's decision to reduce enforcement of workplace noise standards during the mid-1980s gave employers more flexibility with respect to noise controls. As a possible consequence, federally directed occupational hearing loss prevention declined considerably.⁸ Although there is no evidence of a direct connection between these events and causality cannot be established, the correlation is one that may merit further review.

While this study was not able to provide solid evidence due to the limited data available for analysis, the observed decrease in the number of noise standard violations may be explained by various factors. One explanation may be that employer access to noise reduction strategies and worker hearing protection information improved, increasing compliance with occupational noise-exposure standards.¹⁰ This trend may also be attributable to a decrease in the number of manufacturing and production facilities in the country, the fact that automation eliminated workers in locations and industries with high noise levels, a shift in OSHA's administrative priorities resulting in fewer noise-related inspections,¹¹ a combination of these factors, or other factors that the data set does not reveal.

The most frequently cited OSHA noise standards over the last 50 years involved reducing physical impairment by means of feasible

TABLE 2 Most common violations of subparagraphs of 1910.95 (occupational noise exposure in the general industry), 1972 to 2019

Rank	Subparagraph	Description	Number of violations		Total number
			Programmed inspection	Unprogrammed inspection	
1	1910.95(b)(1)	Feasible administrative or engineering controls, personal protective equipment used to reduce sound levels	11 283	7507	18 790
2	1910.95(c)(1)	Administer a continuing, effective hearing conservation program	8203	9746	17 977
3	1910.95(d)(1)	Develop and implement a monitoring program	4879	5282	10 161
4	1910.95(k)(1)	Institute a training program and ensure employee participation in the program	3979	4648	8628
5	1910.95(g)(1)	Establish and maintain an audiometric testing program	3220	3881	7101
6	1910.95(l)(1)	Make available to affected employees or their representatives' copies of this standard and shall also post a copy in the workplace	3400	3639	7039
7	1910.95(i)(2)	Wear personal protective equipment	2579	3011	5590
8	1910.95(g)(6)	Annual audiogram. At least annually after obtaining the baseline	2006	1742	3748
9	1910.95(g)(8)	Follow-up procedures	1245	1235	2481
10	1910.95(i)(3)	Employees select their hearing protectors from a variety of suitable hearing protectors provided by the employer	891	1155	2046
11	1910.95(g)(5)	Baseline audiogram	910	1088	1998
12	1910.95(k)(3)	The employer shall ensure that each employee is informed of the appropriate knowledge of hearing prevention	844	975	1819
13	1910.95(k)(2)	Training program repeated annually for each employee included in the hearing conservation program	781	679	1460
14	1910.95(n)(1)	Appendices A, B, C, D, and E to this section are incorporated as part of this section and the contents of these appendices are mandatory	1207	230	1437
15	1910.95(m)(2)	Audiometric tests	826	576	1402
16	1910.95(o)(1)	Exemptions. Paragraphs (c) through (n) of this section shall not apply to employers engaged in oil and gas well drilling and servicing operations	1096	195	1291

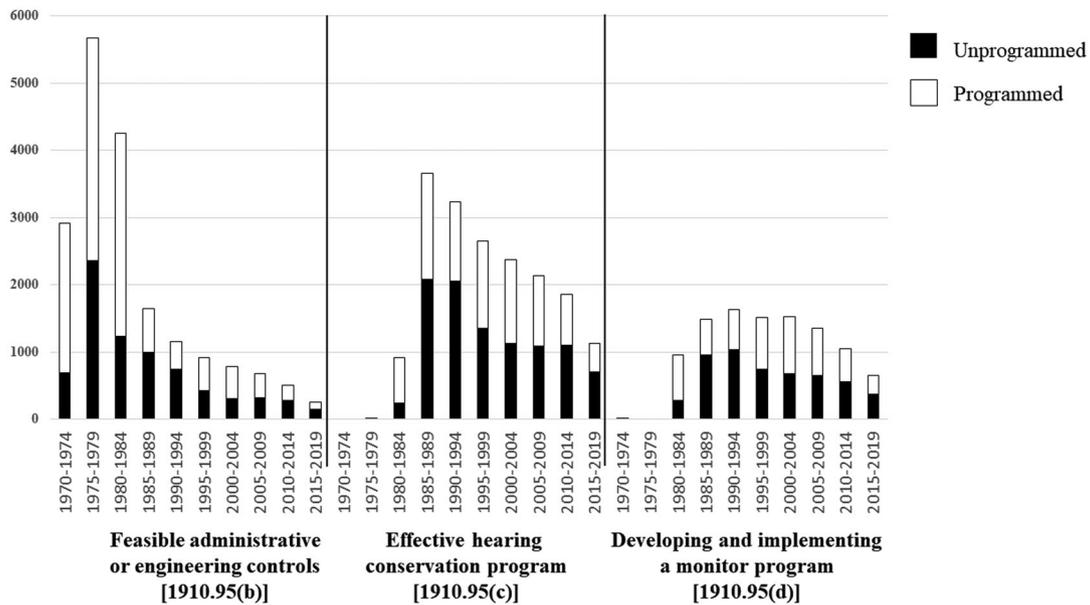


FIGURE 2 Violations of three major paragraphs of 1910.95 (occupational noise exposure in the general industry) in 5-year bins

TABLE 3 Violations of major paragraphs of 1926.52 (occupational noise exposure, construction), from 1972 to 2019

Major paragraph	Description	Number of violations
1926.52(d)	Hearing conservation program	1222
1926.52(b)	Need for feasible administrative or engineering controls or personal protective equipment	594
1926.52(a)	Protection against the effects of noise exposure shall be provided when sound levels exceed tabulated values	579
1926.52(c)	Noise is considered continuous if variations involve maxima at intervals of 1 s or less	8
1926.52(e)	Exposure to impact noise should not exceed 140-dB peak sound pressure level	8
1926.52(g)	No reference	7
1926.52(f)	No reference	1

administrative or engineering controls (1910.95[b] and 1926.52[d]) and hearing conservation programs (1910.95[c] and 1926.52[b]). Violations of these four OSHA noise standards resulted in higher penalties than did violations of other noise standards. As to standards 1910.95(b) and 1926.52(d), employers are required to apply “feasible” administrative or engineering controls to address and decrease noise exposures. Violations are issued only when hearing protections are ineffective or the cost of controls is less than the cost of an effective hearing conservation

program. OSHA has long defined “feasible” in financial terms as opposed to the practical ability to take action, and this approach has hindered the protection of employees from harmful noise in their work environment. In fact, OSHA itself has stated that the current interpretation of “feasible” is “contrary to the plain meaning of the standard.”^{12,13} OSHA needs to fully and accurately explain the rationale underlying a violation of noise standards to justify the expense that the employer will accrue in resolving the violation. Standards 1910.95(c) and 1926.52(b) notwithstanding,

TABLE 4 *t* Test results for penalty differences by citations regarding Occupational Safety and Health Administration (OSHA) noise standards

	OSHA noise standards						<i>t</i> Test
	Group 1			Group 2			
	n	Mean	Standard deviation	n	Mean	Standard deviation	
Penalty	17 941	1036.5	2379.4	24 383	915.8	2718.0	4.8*

Note: Group 1 = two subparagraphs; feasible administrative or engineering controls (1910.95[b] and 1926.52[d]) and conservative hearing program (1910.95[c] and 1926.52[b]). Group 2 = other subparagraphs except group 1.

**P* < .001.

hearing conservation programs are controversial in terms of whether or not they are cost-effective. In one study, employers were found to accrue a financial burden of about \$350 per worker per year in complying with noise standards.¹⁴

The analysis presented here examined all OSHA violations for occupational noise exposure violations across different industries. The vast majority of violations occurred in the general industry as opposed to construction. Whether SIC codes or NAICS codes were used, the manufacturing industry showed the largest number of noise standard violations as well as the greatest number of significant threshold shifts among various industries.^{5,11} This finding is likely due to a combination of factors. First, OSHA field staff face far fewer practical limitations in collecting noise data in fixed locations such as warehouses or production facilities, whereas noise sampling at construction sites is more difficult. That is, quantifying noise exposure for construction workers is challenging, especially because over a matter of days, different staff may work at different job sites with various types and levels of noise exposure. In addition, although OSHA requires construction companies to have a noise exposure protection program under OSHA Standard 1926, the protection elements are less well defined than those for general industry (Standard 1910.95).¹⁵ For this reason, violations of standard 1926 should be supported by clear letters of interpretation. For example, a letter of interpretation for the construction industry could state that every employer's hearing conservation program must incorporate as many of the following elements as feasible¹⁶:

- Monitoring of noise exposures for employees
- Implementation of engineering, work practice, and administrative controls for excessive noise
- Provision of each overexposed employee with an individually fitted hearing protector having an adequate noise reduction rating
- Employee training and education regarding noise hazards and protection measures
- Baseline and annual audiometry
- Procedures for preventing further occupational hearing loss by an employee whenever such loss has been identified
- Record-keeping

Including these elements in the letter would allow an employer to point out the elements that are not feasible in the construction industry. Finally, employers in construction have no obligation to test employees' hearing; for this reason, the data available for the construction industry are not fully comparable with the data for general industry.¹⁷

4.1 | Strengths

This study reveals the trends in OSHA noise standard violations over the past 50 years and presents results by fiscal year and industry type. The study also offers recommendations for OSHA to consider when inspecting industry sites for noise standard violations.

4.2 | Limitations

Past OSHA inspections may not have included a representative sample of employers in specific industries, as the study was confined to employers having received violations from OSHA inspections, excluding broader information on employer reported violations. Thus, these results cannot be generalized to all industrial employers. The lack of data on the conditions and circumstances of inspections makes it impossible to analyze what occupational factors affect noise levels and how OSHA standards can be associated with other factors such as SIC codes.

Additionally, the information on the circumstances of individual inspections is unavailable. From the information available, it is unclear how the number of all-cause violations resulting from unprogrammed inspections differed from the number resulting from programmed inspections. OSHA data reports the number of violations that were fined and not fined, however, there is no explanation of why 64% of OSHA noise standards violations had no fines.

Furthermore, there are limitations to the data set used in this study. First, current data does not indicate work structures, organizational policies, or employer efforts to reduce occupational noise risks at the time of the violation. In addition, there is no information on the effect of the noise violation on workers or the number of workers affected. This data also does not include noise measurement data, including PEL exceedance data, and does not specify causation for the standard or standards breached at the time of the report. The absence of data that details the factors surrounding violations reduces the potential for current and future analyses.

The data collection and trend analysis process conducted for this study demonstrates both the key limitations to current data and the need for further research into the associations between noise standard violations and cases of employee occupational hearing loss. Furthermore, since it is difficult to determine how hearing conservation programs and engineering control standards influence key stakeholders' compliance perceptions, future exploration of these influences would be worthwhile.

5 | CONCLUSION

As the industrial workplaces of Americans change over time, a set of national noise standards must remain in place along with an effective monitoring and enforcement process that can maintain employer compliance and keep employees safe from harm. On the basis of the analysis of OSHA noise standard violations over 50 years, the two most-frequent violations involved lack of feasible administrative or engineering controls and an inadequate hearing conservation program, and this was the case in both general industry and construction. Although specific reasons for noise standard violations in particular industries remain unclear, the analysis offers potential explanations for trends and differences in OSHA noise standard violations in industry, such as differences in the content of standards between general industry and construction. In addition, the study

describes means by which OSHA could obtain more comprehensive data for noise violations. Further study should focus on means of promoting complete and consistent record-keeping by OSHA field workers to accumulate comprehensive data on noise violations in all industries. These data would serve as a foundation for consideration of new occupational safety and health policy and legislation to address employee noise exposures in the 21st century context.

ACKNOWLEDGMENTS

The authors are grateful to Dr. Michael Hodgson, Dr. Aaron Tustin, Ms. Sheila Arbury, Mr. Andre Taylor, and other staff at Office of Occupational Medicine and Nursing, OSHA for providing their insightful comments in the preparation of this manuscript. Also, the authors express their appreciation to Mr. Jon Mann of the University of Illinois at Chicago for his editorial assistance, and to Dr. Kathleen M. McPhaul for her encouragement to publish this paper.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

SP conceptualized and designed the study, MJ also participated in the study conceptualization and design. SP acquired OSHA data and performed the data analysis and interpreted the results of the analysis. MJ assisted in the analysis and interpretation of the data. MJ and SP completed the first draft document and was involved in further revisions for intellectual content. SP drafted and completed the manuscript under the guidance of OH. OH contributed to review of the manuscript and the final version.

ETHICS APPROVAL AND INFORMED CONSENT

The deidentified data from OSHA was analyzed after determination by the Institutional Review Board of the University of Illinois at Chicago that this activity does not represent human subjects research (Protocol # 2019-0764).

DISCLAIMER

This study uses OSHA's data on noise standard violations. The interpretation of the findings and discussions are solely the responsibilities of the authors and do not necessarily represent the official views of OSHA.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Park S, Johnson MD, Hong O. Analysis of Occupational Safety and Health Administration (OSHA) noise standard violations over 50 years: 1972 to 2019. *Am J Ind Med.* 2020;63:616–623. <https://doi.org/10.1002/ajim.23116>