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Hearing Protector Use in Noise-Exposed Workers: A Retrospective Look at 1983

Although hearing protectors have been available for more than 60 years, little field surveillance has been done to assess their appropriate wear in noisy occupational environments. This study examined historical field survey data to determine whether workers use hearing protection when exposed to loud noise. Data from the 1981–83 NIOSH National Occupational Exposure Survey were analyzed to determine whether workers in noise greater than or equal to 85 dBA were using hearing protection. The study also looked at the effect of company personal protective equipment (PPE) policies on hearing protector compliance. This study found that, in 1981–83, an estimated 4.1 million industrial workers were exposed to noise greater than or equal to 85 dBA. Of these, 41% were wearing some form of hearing protection. This percentage varied from 79% of workers exposed in SIC 76 (Miscellaneous Repair Service) to less than 1% in Communications (SIC 48), Wholesale Trade Nondurable Goods (SIC 51), and Automotive Dealers & Service Stations (SIC 55). Whether an establishment had a written policy on wearing PPE seemed to make no difference, because there appeared to be no tie between the percentage of workers wearing of hearing protection and presence of a PPE policy.

Keywords: hearing protection, National Institute for Occupational Safety and Health, National Occupational Exposure Survey, noise, surveillance

Long-term, unprotected exposure to loud noise usually leads to damage to the ear. In an occupational setting, noise exposure is supposed to be controlled by government regulation. In the United States, workers cannot legally be exposed to noise exposures greater than or equal to 85 dBA time-weighted average (TWA) without being enrolled in a hearing conservation program. Workers may be exposed up to a 90-dBA 8-hour TWA (TWA₈) noise environment before noise controls, administrative controls, and/or hearing protection use must be instituted, unless the worker sustains a standard threshold shift (defined by Occupational Safety and Health Administration [OSHA] regulations as an average change in hearing threshold from a baseline of 10 dB or more at 2, 3, and 4 kHz in either ear). It would be very useful for researchers and regulators to be able to determine the number of workers exposed to high-level noise in the United States and also the percentage of those workers correctly wearing

hearing protection. This information would presumably indicate whether American workers are being protected from noise.

In 1976 Bolt, Beranek, and Newman (BBN)⁽¹⁾ estimated the percentage of workers exposed to levels of noise of 75, 80, 85, and 90 dBA by Standard Industrial Classification (SIC) code as part of testimony in support of the OSHA Hearing Conservation Amendment to the OSHA Noise Standard (Table I). OSHA⁽²⁾ (1981, p. 4109) indicated that it had “chosen to use the BBN exposure estimates because they remain the most comprehensive and detailed estimates of occupational noise exposure in U.S. industry.” BBN estimated that, of the 12.9 million total manufacturing production workers, 4.5 million workers were exposed to noise with an 8-hour time-weighted average (TWA₈) greater than or equal to 85 dBA and, within that group, 2.5 million workers were exposed to TWA₈ noise greater than or equal to 90 dBA. (In 1981, OSHA indicated that the total number of workers in these industries was about 2 million more

TABLE I. Estimated Percentage of Production Workers Exposed to Noise, 1981

SIC	90 dB	85 dB	80 dB	70 dB
20 Food	16%	28%	47%	—
21 Tobacco	6.6	9.7	28	—
22 Textile	52	75	87	—
23 Apparel	0	1	20	—
24 Lumber	72	94	97	—
25 Furniture	12	30	53	—
26 Paper	21	40	59	—
27 Printing	19	45	66	—
28 Chemicals	20	37	55	—
29 Petrol. Refining	52	76	82	—
30 Rubber	8.9	20	40	—
31 Leather	0	1	20	—
32 Stone, Glass, Concrete	4.8	16	42	—
33 Metal	38	63	81	—
34 Fab. Metal	19	34	56	—
35 Machinery	13	26	48	—
36 Elect. Machinery	2.5	7	27	—
37 Trans. Eq.	13	23	42	—
49 Utilities	30	74	89	—
Total	19.3%	34.4%	53.1%	71.5%

Note: Reprint of Table 11, Percentage of Production Workers Exposed to Noise, from Bolt, Beranek, and Newman⁽¹⁾ (pp. 2-7 and BBN worksheets).

than the 1976 BBN estimate.) The data used in the BBN report were based on a relatively small sample (70 plants employing 62,000 workers) and previous undocumented knowledge of the surveyors. In addition, the estimates were generated by a model that inferred that the distribution of noise levels in American industry was a normal distribution with the median located at 80 dBA. No estimate of hearing protector use in exposed populations was made in this study. The BBN data are useful for comparison with the National Occupational Exposure Survey (NOES) data presented here.

There has not been an in-plant survey of hearing protector use or industrial noise exposure on a national scale since the NOES, conducted from 1981 to 1983⁽³⁻⁵⁾ by the National Institute for Occupational Safety and Health (NIOSH). Its purpose was to update information collected 10 years earlier during the 1972-1974 National Occupational Hazard Survey (NOHS).⁽⁶⁻⁸⁾ In both studies NIOSH surveyors recorded the presence of chemicals and physical agents in the workers' environments during walk-through surveys of a sample of industrial facilities. The NOES surveyors considered any reading greater than or equal to 85 dBA on a sound level meter equal to or longer than 30 min per week to be hazardous and marked it as such on the survey tool. (These criteria were chosen because they were more amenable to surveyor time constraints and survey purpose than hanging a dosimeter on a worker for a day. Even for the chemical exposures, no TWA₈ data or actual exposure data were collected.) They also recorded personal protective equipment (PPE) use. Although not strictly designed to examine hearing protector use, NOES data are useful because the surveyors kept noise information tightly linked with PPE information as well as industry classification. Summaries of the NOES survey are available to the public⁽³⁻⁵⁾ but the raw data are unpublished.

The PPEU (Personal Protective Equipment Usage) survey was a 1989 telephone survey conducted under contract for OSHA. Data collected during the PPEU survey were used to describe industry practices regarding the use of PPE. The survey was representative of all nonconstruction businesses in the United States subject to OSHA regulations on PPE use. No restrictions were put on the number of employees at the facility. The presence and

use of PPE at the facility were determined during a 45-min telephone questionnaire administered to the persons in charge of safety at each facility. Telephone interviews were completed at 5314 facilities out of a total 10,927 survey facilities, a response rate of 49%. Summaries and data from the PPEU were used for regulatory analysis and never published.

Davis and Sieber⁽⁹⁾ utilized data from two NIOSH surveys (NOHS and NOES) and the 1989 OSHA (PPEU) survey to track trends in hearing protector use. Their article showed that the use of hearing protection had increased from the first NIOSH survey in 1972 to the OSHA survey in 1989. They showed hearing protector use increased from 9 to 43% of all manufacturing production workers over the 18-year time frame (1972-1989). They did not estimate the number of workers wearing hearing protection while exposed to noise.

Berger⁽¹⁰⁾ surveyed the literature on hearing protector utilization around the world and found 112 publications between 1981 and 1999. Of those, he was able to summarize 67 studies. In industry he found studies with usage levels as low as 4% (Malaysia) to a high of 92% (Singapore). He notes that most studies found fewer than 50% of workers were wearing hearing protection.

The purpose of the present study was to revisit the NIOSH NOES data to estimate the percentage of workers who were observed wearing hearing protection, by industry classification, while exposed to hazardous noise. One limitation on the data was the age of the survey. However, not having newer comparable data, the authors felt it worthwhile to analyze and report these results as a historical baseline for future surveillance. To put this study in historical perspective, these data were collected during the time of the OSHA Hearing Conservation Amendment to the OSHA Noise Standard, proposed for implementation in 1981 and finally promulgated in 1983. With the NIOSH NOES data in hand, the current study attempted to look at hearing protector use in loud noise. Analysis allowed the present authors to break down the survey into four groups: a group wearing hearing protectors in hazardous noise, a group not wearing hearing protectors in hazardous noise, a group not wearing hearing protectors in safe noise, and an interesting group observed wearing hearing protection in

a nonhazardous noise condition. These data should give us a quantitative window on hearing protector use in noisy environments, information unavailable before.

METHOD

NOES was designed by NIOSH to observe chemical and physical agents in a representative sample of American work sites. Industries were classified using the 1972 SIC code.⁽¹¹⁾ The sample of businesses surveyed in NOES consisted of 4490 establishments in 98 different geographic locations throughout the United States having eight or more workers. Each site visit was conducted by NIOSH-trained surveyors and had two parts: administration of a questionnaire to management about health and safety practices and a walk-through survey of the facility production area.

Exposure to continuous noise was recorded during the walk-through survey of the facility production area if the level measured on a sound level meter was equal to or greater than 85 dBA and the noise was known to be present 30 min or more per week. The number of employees exposed and use of PPE also was recorded. (In the NOES protocol, hearing protection was classified as PPE, isolation and enclosure, or administrative controls. A search of the database indicated that hearing protection consisted almost exclusively of PPE.) No attempt was made to record the actual noise level, nor the TWA_8 of the noise. The surveyors recorded the use of hearing protection only if they saw employees wearing hearing protection.

In addition to this survey tool, a second questionnaire was completed by plant management. This questionnaire requested statistical information about the plant including information about the health program. The question from the management questionnaire of special interest was:

47. Are there areas in this facility in which personal protective devices or equipment are required or recommended?
1. Yes, required
 2. Yes, recommended
 3. Yes, both
 4. No (Skip to question 53)

Notes

To require the use of personal protective devices meant that there was a formal management policy that some or all employees must use protective equipment as a condition of employment.

To recommend the use of personal protective equipment means the management encouraged the use of protective devices, but did not make employment conditional on their use.

Personal protective devices and equipment include, but are not limited to, safety glasses, goggles, ear plugs, face shields, hard hats, gloves, safety shoes, rubberized clothing, welding helmets and respirators.

Details on methods for calculations of estimates of the proportions and numbers of production employees using hearing protection can be found in References 4 and 5.

RESULTS

An analysis by SIC code is presented as Table II. This table is sorted by the percentage of workers exposed to hazardous

noise (greater than or equal to 85 dBA) and wearing hearing protection. One clarification should be made. OSHA regulations do not require hearing protection until the noise reaches 90 dBA time-weighted average over the course of 8 hours. This is the OSHA definition of hazardous noise. The NOES study defined hazardous noise as any noise greater than or equal to 85 dBA for more than 30 min per week. Clearly, these are major differences in definition. In many cases OSHA would not require these workers to be protected (if they fell between 85 and 90 dBA exposure time-weighted average). One must keep these differences in mind when analyzing results discussed in the present article.

Based on 1981 NOES data, an estimated 4.1 million manufacturing production workers out of 14.1 million total in sampled industries were exposed to noise greater than or equal to 85 dBA. Of these, 41% (Table II) were wearing some form of hearing protection during survey walk-throughs. This percentage varied from 79% of noise-exposed workers in SIC 76 (Miscellaneous Repair Service) to less than 1% in Railroad Transportation (SIC 40), Communications (SIC 48), Wholesale Trade Nondurable Goods (SIC 51), and Automotive Dealers & Service Stations (SIC 55).

The fact that an establishment had a written policy on wearing PPE seemed to make no difference, because there appeared to be no correlation between the wearing of hearing protection and written requirements (e.g., Leather and Leather Products, SIC 31, 18% of workers exposed to loud noise were wearing hearing protection, yet 100% of facilities had a written policy in place requiring the wearing of protective equipment). Figure 1 is a scatter diagram of percentage noise-exposed workers in each SIC code wearing hearing protectors and the percentage of facilities in a SIC code with a written policy requiring PPE. There is no simple relationship between a written policy and workers wearing hearing protection.

The authors estimate that 2.4 million (59%) production workers were exposed to loud noise but were not wearing hearing protection. They also estimate that 10 million production workers were not exposed to loud noise and were not wearing hearing protection.

DISCUSSION

NOES provides valuable data analysis opportunities. Although it would be very useful to know the actual levels of noise exposure by the different industries, this study shows that conclusions can be reached with limited data collected. Because the NOES data linked hearing protection with noise exposure, and because of the large sample size, estimates can be made of the numbers of workers who were exposed to loud sounds and were wearing hearing protection.

Figure 1 could be misleading. First, the NOES definition of hazardous noise (85 dB or greater for 30 min or more per week) is not the same as OSHA regulation (90 dB TWA_8). Second, these data were collected during the time of the implementation of the Hearing Conservation Amendment, so regulation was in a transition. Third, a PPE policy may be in place, but for hazards other than noise. The present authors still believe it is an interesting result to show the relationship between potential noise exposure and written policies.

Sampling error is always a concern in a survey such as this. Error is inversely related to the size of the sample taken. Because only a single large sample can be collected for each SIC, a standard error term is generated by randomly taking smaller samples from the bigger SIC sample. This results in an estimate of the error

TABLE II. Industries Sorted by Percentage Workers Wearing Hearing Protection in Loud Noise (Greater than or Equal to 85 dB for at Least 30 Min per Week)

Industry (SIC Code) ^a	Estimated Number of Workers Exposed to Hazardous Noise and Wearing Hearing Protection (%) ^b	Estimated Number of Workers Exposed to Hazardous Noise (%) ^c	Estimated Total Number of Production Workers, 1983 (Std. Error) ^d
Miscellaneous Repair Service (76)	9993 (79)	12,628 (9)	143,302 (29,668)
Instruments and Related Productions (38)	32,441 (68)	48,014 (9)	555,109 (132,495)
Electric, Gas, & Sanitary Services (49)	61,143 (68)	89,730 (15)	588,041* (149,419)
Textile Mill Products (22)	175,112 (67)	262,108 (42)	625,322 (77,416)
Chemicals and Allied Products (28)	60,359 (59)	102,671 (17)	592,059 (83,241)
Transportation Equipment (37)	136,588 (57)	238,609 (18)	1,311,750 (181,493)
Paper & Allied Products (26)	92,337 (56)	164,808 (34)	488,101 (76,606)
Business Services (73)	6196 (55)	11,246 (2)	766,108 (83,441)
Lumber & Wood Products (24)	102,242 (52)	196,489 (46)	428,539 (72,378)
Primary Metal Industries (33)	139,845 (52)	269,270 (33)	824,725 (119,133)
Transportation by Air (45)	47,214 (50)	94,656 (30)	312,931 (66,269)
Fabricated Metal Products (34)	157,170 (47)	336,919 (29)	1,151,777 (92,293)
Agricultural Services (07)	8140 (46)	17,618 (20)	89,189* (23,190)
Food & Kindred Products (20)	156,618 (46)	343,030 (29)	1,188,267 (123,379)
Miscellaneous Manufacturing Industries (39)	17,776 (45)	39,307 (9)	418,805* (154,493)
Tobacco Manufacture (21)	25,166 (43)	57,764 (54)	106,399* (59,397)
Stone, Clay, & Glass Products (32)	42,100 (43)	98,215 (21)	457,983 (67,465)
Wholesale Trade Durable Goods (50)	47,745 (43)	110,283 (21)	528,659 (72,022)
Machinery, Except Electrical (35)	92,656 (40)	229,509 (15)	1,544,883 (123,036)
Furniture & Fixtures (25)	47,481 (39)	121,271 (28)	428,539 (82,776)
Rubber & Miscellaneous Plastics Products (30)	47,625 (35)	135,611 (23)	595,525 (88,412)
Petroleum & Coal Products (29)	10,800 (34)	31,998 (30)	106,516* (43,323)
Local & Interurban Passenger Transport (41)	4971 (34)	14,832 (9)	171,428* (43,346)
Electric & Electronic Equipment (36)	33,423 (32)	104,553 (8)	1,287,842 (122,315)
Heavy Construction Contractors (16)	34,720 (28)	124,610 (24)	517,969 (77,674)
Printing & Publishing (27)	41,326 (27)	154,862 (21)	724,707 (65,962)
Pipe Lines, Except Natural Gas (46)	5339 (25)	21,334 (6)	387,505 (57,853)
Apparel & Other Textile Products (23)	28,560 (19)	150,824 (14)	1,082,236 (99,689)
Leather & Leather Products (31)	1681 (18)	9346 (6)	144,200 (32,414)
General Building Contractors (15)	12,179 (12)	105,299 (16)	664,833 (77,837)
Special Trade Contractors (17)	21,281 (11)	191,087 (16)	1,228,744 (64,748)
Trucking & Warehousing (42)	3012 (8)	39,150 (7)	561,058 (60,050)
Health Services (80)	236 (2)	15,677 (0.6)	2,679,610 (261,562)
Oil and Gas Extraction (13)	507 (1)	76,525 (23)	330,841* (91,202)
Personal Services (72)	246 (1)	33,462 (9)	366,545 (47,441)
Auto Repair, Services, & Garages (75)	177 (1)	33,997 (11)	320,459 (47,595)
Communication (48)	(<1)	23,124 (6)	387,505 (57,853)
Wholesale Trade Nondurable Goods (51)	(<1)	5287 (5)	99,410* (29,126)
Automotive Dealers & Service Stations (55)	(<1)	4543 (1)	334,063* (94,278)
Total	1,704,405 (41.4)	4,119,550 (29)	14,154,473 (363,994)

Note: Blanks indicate none observed.

^aIndustry name with the 1972 SIC code in parentheses.

^bEstimated number of workers exposed to noise and wearing hearing protection. The number in parentheses is the percentage value wearing hearing protection in noise.

^cEstimated number of workers exposed to hazardous noise. The number in parentheses is the percentage of workers exposed to noise (column 3 ÷ column 4). This allows direct comparisons with Table I.

^dEstimated number of workers employed in that industry in 1983 with the standard error of the estimate in parentheses. An asterisk indicates only a small number of workplaces were sampled in that SIC code, resulting in high levels of standard error (greater than 25%), which indicates the estimate may be unreliable.

^ePercentage of establishments in that industry with written policies requiring personal wear of protective equipment.

^fPercentage of establishments in that industry having written policies recommending the wearing of PPE.

^gPercentage of establishments in that industry having written policies and recommendations about PPE in certain parts of their plants.

^hPercentage of establishments in that industry having no written policy about PPE.

term. Although seemingly large, the error terms in this sample are not out of line with other surveys of comparable magnitude. Any SIC codes in which the relative standard error exceeded 25% have been eliminated. These SIC codes were not targeted by NOES for gathering large samples.

The hearing conservation program has two actors: the employer, who by regulation must provide noise exposure assessment and control, audiometry, hearing protection, and training; and the

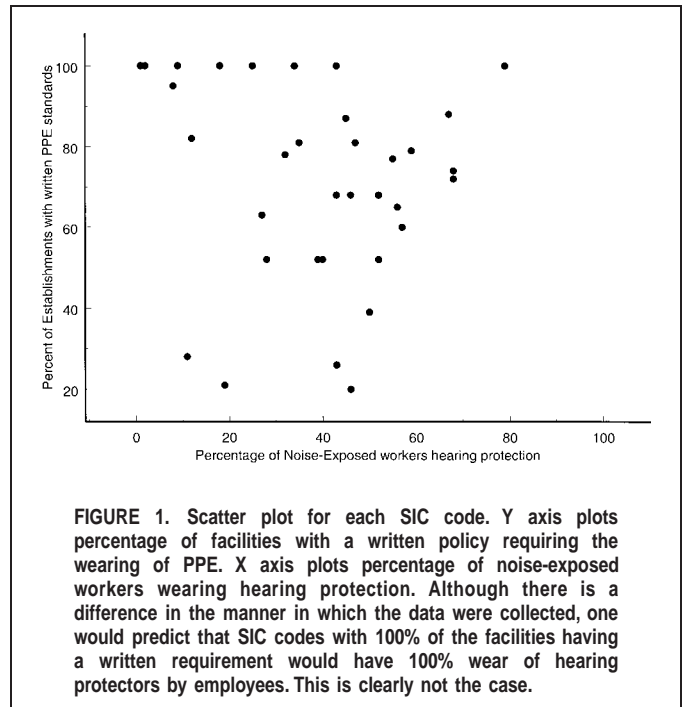
employee, who must maintain controls and wear hearing protection to prevent permanent hearing loss. The present study shows that in only 11 industrial classifications did more than 50% of the workers exposed to noise over 85 dBA wear hearing protection. Other industries did not approach this level of compliance. Maximum compliance for wearing hearing protection in any industry was 79% of noise-exposed workers. Policies requiring the wearing of safety equipment in certain parts of the plant did not seem to

TABLE II. Extended.

% Establishments with Written Policy Requiring PPE ^E	% Establishments Recommending Wearing of PPE ^F	% Written Policy in Parts of Plant, Recommendations in Other Parts ^G	% No Policy ^H
100			
74	<5	26	
72		28	
88	2	10	
79		21	
60	5	35	
65	<5	35	
77		23	
52	21	27	
68		32	
39	7	34	
81	5	15	
20			80
68	2	30	
87		13	
100			
68	2	31	
26	3	71	
52	2	46	
52	18	29	<.5
81	<0.5	19	
			100
100			
78		22	
52		48	
63	10	27	
100			
21	30	49	
100			
82		28	
28	29	36	6
95		5	
100			
100			
			100
100			

correlate highly with increased use of hearing protection. Having policies in place is probably a very important step in an effective hearing conservation program. However, it has been determined that effective educational programs are really what motivate workers to take action to protect their hearing.⁽¹²⁾

Newer data must be collected to update these 20-year-old results. Changes in the American economy from a manufacturing to a service base may lead to differing results in the future. Discussions are currently underway to determine whether and when a new National Occupational Exposure Survey can and should be undertaken. Analysis of the NOES data does not allow any conclusions to be drawn about the effectiveness of the hearing protection worn. For example, no attempt was made to note what kind of hearing protector was in use. It is known that earplugs are more difficult to properly insert and seal than ear muffs.⁽¹³⁾ It would be very useful to know the percentage of workers wearing earplugs versus ear muffs. It would also be very useful to know



the actual noise exposure levels and the noise reduction ratings of the hearing protectors to determine information about the hazard of the exposure. These data were not captured in the 1981 NOES database. It is suggested that hearing protector type be included in future surveys. With careful planning, the current data can be utilized as baseline information for the newer survey, providing trend analysis.

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