Respiratory Protection in U.S. Industry – an Evaluation of Program Quality Indicators and Occupational Health Outcomes

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ABSTRACT

Previous research on respirator use has mainly focused on the individual worker and not at the establishment level. We examined the quality of an establishment's respiratory protection program by linking the "Survey of Respirator Use and Practices" from the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS) with the "Survey of Occupational Injuries and Illnesses" from the BLS. Our findings indicated that a majority of small establishments (1-10 employees) had "Poor" respirator programs. The two leading program deficiencies across essentially all industries were the lack of a written program or an evaluation of program effectiveness. The study was unable to discern an impact of an establishment's respiratory protection program quality on the reported incidence of occupational illnesses, but the findings can help guide practical approaches for further investigations in this field.

Keywords: respiratory protective devices, occupational exposure, respiratory protection standard, occupational health

INTRODUCTION

The use of respiratory protection to reduce the risk of adverse health outcomes among persons exposed to inhalational hazards in the workplace is an accepted exposure control method, once administrative and engineering interventions have been optimized and while engineering controls are being installed. Prior research has attempted to characterize respirator use among workers by identifying key health and physical workplace factors (Li et al., 2002; Jennison et al., 1996) or behavioral and social dynamics (Jaraidei et al., 1994; White et al., 1988) that affect individual compliance. At the establishment level, respiratory protection programs have been assessed through the investigation of respirator maintenance (Brosseau and Traubel, 1997) and the patterns of program deficiencies noted during audits by the Occupational Safety and Health Administration (OSHA) (Rosenthal and Paul, 1985). However, further research is needed at the establishment level to document the relationship between adherences to the requirements of the OSHA respiratory protection standard (Code of Federal Regulations, 1998) and indicators of worker health.

The present study represents an initial attempt to address this relationship through a collaborative effort between the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS). Two national surveys of U.S. industry, the "Survey of Occupational Injuries and Illnesses" – SOII (Bureau of Labor Statistics, 1999) and the "Survey of Respirator Use and Practices" – SRUP (Bureau of Labor Statistics, 2003) were linked at the establishment level. Using this novel approach, we attempted to describe characteristics of industrial establishments that rely on respiratory protection (e.g., type of industry, number of employees) and to investigate the quality of a respiratory protection program (SRUP) and the occurrence of respiratory diseases and systemic intoxications (SOII). Although this linking approach was unable to detect an impact of respiratory protection program quality on worker health, this study provides important observations and recommendations for further research in this field.

METHODS

Survey of Occupational Injuries and Illnesses (SOII)

The SOII is an annual survey that collects national information on occupational injuries and job-related illnesses from roughly 250,000 private U.S. employers. The SOII is a major source of occupational morbidity data (Bureau of Labor Statistics, 1999), although under-reporting is a recognized problem, particularly for illnesses (Azaroff, et al., 2002). In this study, SOII results for calendar year 1999 were used to examine three disease outcomes: dust diseases of the lungs, respiratory conditions due to toxic agents (e.g., pneumonitis, pharyngitis, occupational asthma), and poisoning (i.e., systemic effects of toxic materials). These outcomes are reported as the incidence per 10,000 full-time workers. The SOII excludes self-employed individuals, employees in the public sector, and employees on small farms.

Survey of Respirator Use and Practices (SRUP)

Between August 2001 and February 2002, NIOSH and BLS cooperated in mailing a Survey of Respirator Use and Practices (SRUP) to a random sample of 40,002 private establishments (response rate 75.5%) selected from among the 250,000 employers surveyed in the 1999 SOII (response rate 92%). In order to augment data validity, the individual who was considered most familiar with each establishment's respiratory protection program was requested to complete the SRUP survey. The questions included in SRUP had a number of research objectives (Bureau of Labor Statistics, 2003). In the current study, we focused on responses from establishments with mandated employee use of respirators and utilized the SRUP results to assess compliance of the site-specific respiratory protection program with six of the nine basic requirements of the OSHA respiratory protection standard (Code of Federal Regulations, 1998). The SRUP respiratory protection program indicator items inquired about: 1) the presence of a written program; 2) procedures for evaluating respirator program effectiveness; 3) procedures for respirator maintenance; 4) employee respirator training programs; 5) employee medical evaluation protocols; and 6) respirator fit testing. The replies to each of these items were dichotomized: ***positive*** responses indicated adherence to the particular basic requirement in the OSHA respiratory protection standard whereas ***negative*** responses indicated non-adherence (Code of Federal Regulations, 1998). For each establishment, negative responses to the six SRUP indicator items were summed and then the establishment's program was categorized into one of the following SRUP program quality categories: poor (5 to 6 indicators of an inadequate program), intermediate (2 to 4 indicators), and good (0 to 1 indicator). All SRUP responses were stratified by either Major Industry Division – MID (Office of Management and Budget, 1987) or employment size groups (1 to 10, 11 to 49, 50 to 249, 250 to 999, ≥ 1000 employees).

Linking SRUP and SOII

Individual facility codes were used by BLS to link each establishment's responses on the SRUP to the three occupational disease outcomes (described above) reported by the establishment on the 1999 SOII. To generate national estimates, the linked results were weighted, benchmarked, and adjusted for non-response by established BLS procedures (Bureau of Labor Statistics, 2003). Data was withheld by BLS if the linking process could potentially compromise an establishment's confidentiality or if the relative standard error for an estimate exceeded a predetermined limit (Bureau of Labor Statistics, 1999).

Statistical Analysis

The Mantel – Haenszel test for linear trend was used to assess the relationship between establishment size groups and "Good" SRUP category (Figure 1). In Table I, for each industry category, the 95% confidence interval (CI) of the proportion of "Good", "Intermediate", and "Poor" programs were computed using the standard error of the estimate. In Table II, the 95% confidence interval (CI) of the proportion for each SRUP indicator was also computed across each employment size group using the standard error of the estimate. When comparing the proportions in Tables I and II, if the 95% confidence intervals did not overlap, then the difference in the proportion was considered to be statistically significant. The 95% CI was calculated according to the following formula:

$$P(X/T) = [X \pm 1.96\ (SE_X)] / [T \pm 1.96\ (SE_T)]$$

Where P = estimated proportion of indicators in a specific industry; X = estimated number of indicators in a specific industry; T = total estimated number of indicators in a specific industry; SE_X = standard error of X; SE_T = standard error of T. The confidence interval was determined by selection of the smallest and largest values of the proportion from the above formula.

RESULTS

The distribution of SRUP program quality categories across all Major Industry Divisions (MID) is presented in Table I. Construction, manufacturing, and services represented more than 70% of the establishments surveyed, each having over 40,000 total establishments. Only manufacturing and transportation had "Good" SRUP ratings for at least 40% of establishments. In contrast, at least 50% of the establishments in agriculture and retail trade had "Poor" SRUP ratings. Differences in the program quality categories by industry in Table I are considered statistically significant if the confidence intervals do not overlap.

Table II displays the relationship between individual SRUP negative responses and employment size groups. Establishments with 1 – 10 employees had the highest percentages of negative responses for the program elements evaluated. Increasing employment size groups had an associated decrease in the proportion of negative responses. For example, establishments with ≥ 1000 employees had negative responses that ranged from 2 to 15% versus the 37 to 63% in establishments with 1-10 employees. Interestingly, written program and program effectiveness indicators were the most resistant to improvement with increasing employment size groups. The proportion of negative responses were significantly difference for all cells in Table II except for "written program" in the 1-10 and 11-49 employment size groups, where there was overlap in the confidence intervals for the two groups.

The relationship between an establishment's SRUP program quality category and employment size group is shown in Figure 1. This figure demonstrates a significant linear trend between the proportion of "Good" respirator programs and the number of employees. Indeed, when the employment

size group increases from 1 – 10 to ≥ 1000, the proportion of "Good" programs increases from 16% to 89%.

Reports of occupational health outcomes (i.e., dust diseases, respiratory conditions, and poisonings) by SRUP respirator program quality categories for all industries are displayed in Figure 2. Both "Poor" and "Intermediate" SRUP programs unexpectedly had fewer reports of adverse occupational health outcomes compared to "Good" SRUP programs. Figure 3 demonstrates the incidence rates for the three health outcomes are disparate between the SOII and the smaller SRUP. The SRUP was designed to sample more heavily from industries likely to use respirators. These observations were consistent when the data was analyzed by MIDs (construction, manufacturing, and services) or establishment size categories (results not shown).

Table I. Percent* Distribution of SRUP Program Quality Categories by Industry**

(n = total number of establishments***)	(0 to 1 Neg. SRUP Indicator)	(2 to 4 Neg. SRUP Indicator)	(5 to 6 Neg. SRUP Indicator)
Agriculture (n = 13,186)	12 (95% CI 10.9-12.9)	25 (95% CI 23.2-25.9)	50 (95% CI 46.9-53.3)
Mining (n = 3,493)	38 (95% CI 36.7-38.9)	44 (95% CI 42.9-45.2)	13 (95% CI 12.2-12.8)
Construction (n = 64,172)	22 (95% CI 21.2-21.8)	15 (95% CI 15.2-15.7)	40 (95% CI 39.3-40.4)
Manufacturing (n = 48,556)	40 (95% CI 40.2-40.4)	23 (95% CI 23.1-23.3)	25 (95% CI 24.5-24.8)
Transportation (n = 10,351)	44 (95% CI 42.2-46.0)	32 (95% CI 29.1-34.5)	7 (95% CI 6.5-7.6)
Wholesale Trade (n = 31,238)	37 (95% CI 35.7-37.7)	21 (95% CI 20.0-21.3)	18 (95% CI 17.7-18.9)
Retail Trade (n = 16,948)	18 (95% CI 17.1-18.8)	21 (95% CI 20.6-22.3)	53 (95% CI 50.2-55.1)
Finance, Insurance, & Real Estate (n = 4,202)	15 (95% CI 10.1-23.7)	42 (95% CI 20.7-78.4)	16 (95% CI 10.6-25.6)
Services (n = 89,629)	18 (95% CI 17.7-18.8)	34 (95% CI (32.6-34.5)	31 (95% CI 30.6-31.8)

* Percentages by industry may not total to 100% due to rounding and non-response to indicator questions

** SRUP – BLS/NIOSH Survey of Respirator Use and Practices

*** Estimates of the total number of U.S. establishments are based on SRUP survey of 40,002 establishments

Table II. Percent* Distribution of Indicators of an Inadequate Respiratory Protection Program on SRUP by Employment Size Groups**

	Employment Size Groups (%)				
SRUP Indicator	**1 - 10**	**11 - 49**	**50 - 249**	**250 - 999**	**≥ 1000**
Written Program	61 (95% CI 60.1-61.8)	60 (95% CI 59.2-60.2)	42 (95% CI 41.4-42.2)	27 (95% CI 26.1-27.3)	12 (95% CI 12.0-13.0)
Program Effectiveness	63 (95% CI 61.9-63.7)	53 (95% CI 52.6-53.5)	40 (95% CI 39.6-40.4)	30 (95% CI 29.5-30.8)	15 (95% CI 14.0-15.1)
Respirator Maintenance	51 (95% CI 49.9-51.3)	43 (95% CI 42.4-43.1)	29 (95% CI 29.0-29.7)	17 (95% CI 16.9-18.0)	6 (95% CI 6.2-6.7)
Respirator Training	42 (95% CI 41.3-42.5)	35 (95% CI 34.8-35.5)	25 (95% CI 24.6-25.3)	8 (95% CI 8.0-8.4)	2 (95% CI 1.8-2.0)
Medical Fitness	51 (95% CI 50.0-51.2)	49 (95% CI 48.2-49.0)	29 (95% CI 28.7-29.4)	10 (95% CI 10.0-10.5)	4 (95% CI 4.1-4.5)
Fit Testing	37 (95% CI 36.8-37.8)	41 (95% CI 41.0-41.7)	30 (95% CI 29.5-30.2)	17 (95% CI 16.0-17.0)	5 (95% CI 5.1-5.6)

* Percentages by employment size groups may not total to 100% due to rounding and non-response to indicator questions.

** SRUP – BLS/NIOSH Survey of Respirator Use and Practices

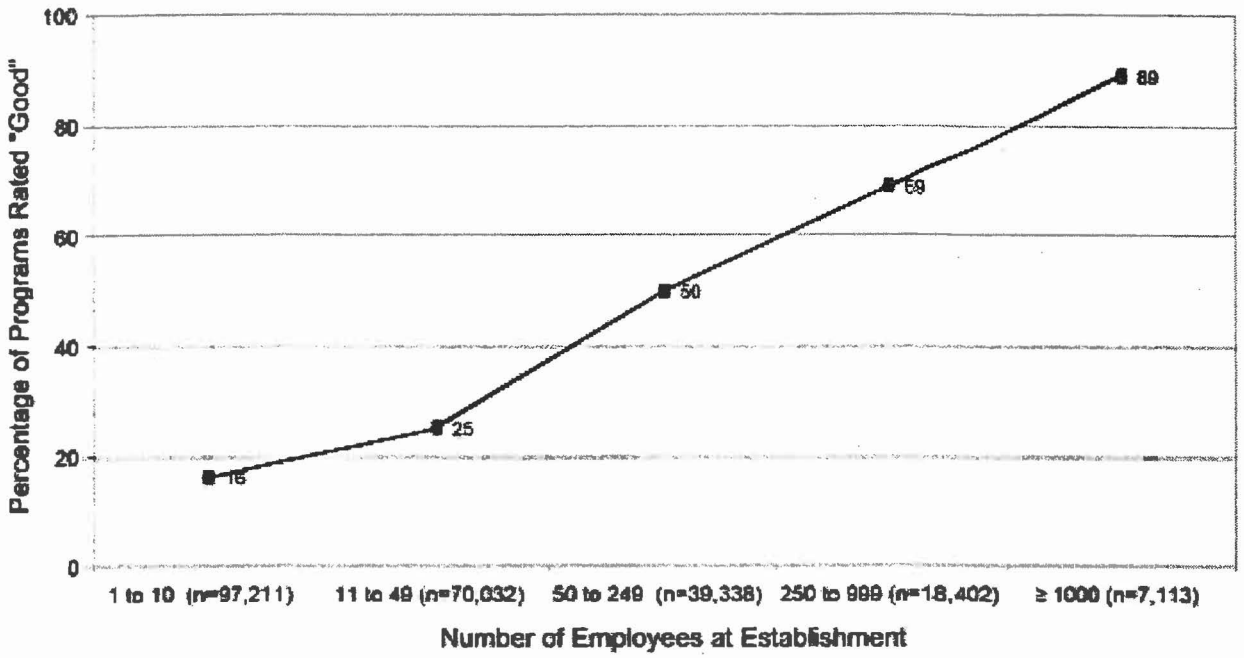

Figure 1. Percentage of establishments with "Good" respiratory protection programs by number of employees at establishment. "Good" respiratory protection programs had 0 to 1 negative program indicators reported on Survey of Respirator Use and Practices (n=estimated number of establishments); Mantel - Haenszel test for linear trend, < 0.0001.

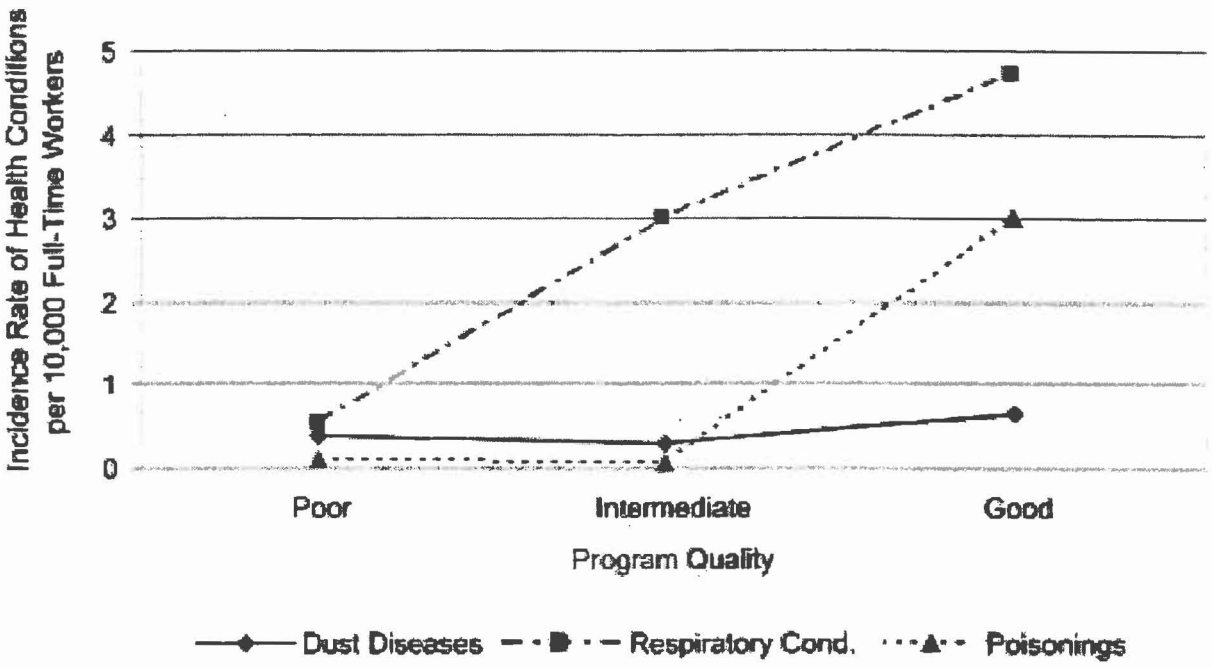

Figure 2. Incidence rate of health conditions by respiratory protection program quality.

DISCUSSION

The first goal of this study was to describe characteristics of respirator programs at U.S. industrial establishments that require respirator use, and two key descriptive findings deserve mention in this regard. First, an association is apparent between the quality of an establishment's respiratory protection program and the number of employees. Specifically, only 16% of establishments with 1- 10 employees had "Good" SRUP programs (See Figure 1), and these small establishments had the highest percentage of negative SRUP indicators (See Table II). The Survey of Respirator Use and Practices (Bureau of Labor Statistics, 2003) indicated that only 2.7% of all establishments with 1 to 10 employees reported any required respirator use. Therefore, the absence of a formal respiratory protection program seems to be the norm at these smaller sized establishments, and for those that attempt such a program, the quality will likely be inconsistent with the OSHA standard (Code of Federal Regulations, 1998). This observation is analogous to a previous OSHA national telephone survey of 7,117 establishments regarding medical surveillance programs (Conway, et al., 1993). Among the small establishments (1-19 employees) in that survey, only 3.8% reported having a medical surveillance program, compared to 55.8% of establishments with 250 or more employees. Since many of the capabilities needed to maintain a respiratory protection program are comparable to those of medical surveillance programs (Muhm, 1999) the current study reinforces the deduction from the previous OSHA study that small business establishments often lack the necessary resources to implement and properly execute occupational health programs. A second key finding was that the lack of a written program and a failure to assess program effectiveness were the two

leading deficiencies in respirator programs across all industries. This suggests that many establishments with respiratory protection programs inadequately document their procedures and do not assess the effectiveness of their program. These are two fundamental elements of an adequate respiratory protection program.

The second goal of this study was to determine the relationship between the quality of an establishment's respiratory protection program and the occurrence of adverse occupational health outcomes. Our study relied upon the available expertise and resources at each establishment to implement a proper respiratory protection program and also to recognize and report occupational diseases. This approach had several limitations, as detailed below.

First, the two individual surveys that were linked utilized different sampling techniques and sample sizes, and were not intended for matching purposes. The dissimilarities between these surveys are emphasized in Figure 3 by the differences in recorded health outcomes between SOII and SRUP. Second, occupational disease outcomes that are likely to be affected by a respiratory protection program are rare events. Previous research (Leigh and Miller, 1998) demonstrates that the specific outcomes evaluated in the current study have historically had very low reported incidences on the SOII: dust diseases (0.5 per 10,000 full-time workers in 1986, 0.3 in 1992), respiratory conditions due to toxic substances (1.7 in 1986, 3.1 in 1992) and systemic poisonings (0.6 in 1986, 0.9 in 1992), in comparison to acute conditions such as trauma (6.4 in 1986, 36.8 in 1992) and skin disorders (5.9 in 1986, 8.2 in 1992). This historical trend continued in the 1999 survey (Bureau of Labor Statistics, 1999) with trauma and skin disorders being the two leading reportable conditions (27.3 and 4.9 respectively) in contrast to the lower reported rates for dust diseases (0.2), respiratory conditions (1.8), and poisonings (0.5).

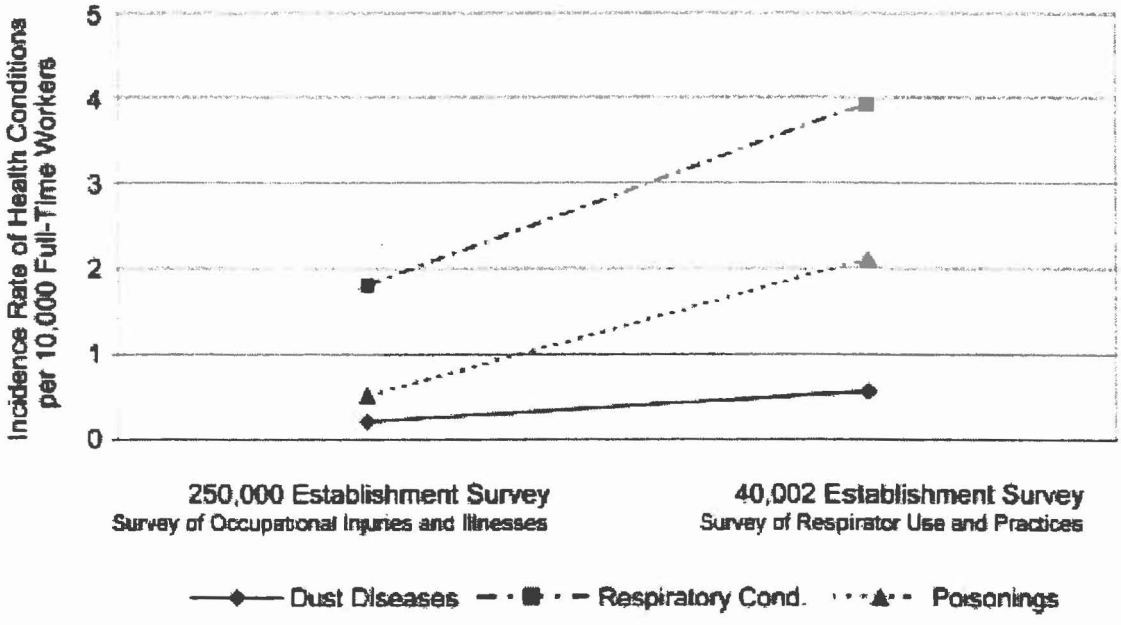

Figure 3. Incidence rate of health conditions by survey sample size.

A third limitation is that this study did not capture information about job exposures. Occupational respiratory health outcomes (e.g. pneumoconiosis) result from exposures over many years. The approaches to respiratory protection reported in the SRUP may not reflect the policies in place during the years of relevant exposure.

A fourth study limitation was the occurrence of under-reporting bias in SOII. Under-reporting by employers of occupational injuries and illnesses in the SOII and on their OSHA logs, particularly at smaller sized establishments, has been a major concern (Oleinick, et al., 1995; Okun, et al., 2001). Under-reporting offers a plausible explanation for the lower incidence of reported health outcomes at establishments with "Poor" and "Intermediate" SRUP programs versus "Good" SRUP programs (See Figure 2). Since employer reporting depends on recognition, accurate diagnosis, and full notification of occupational illnesses, there is reason to expect establishments with inadequate respiratory protection programs (i.e., "Poor" or "Intermediate" SRUP programs) would also be inefficient in reporting occupational diseases.

This study reports two key findings: 1) Only 16% of establishments with 1 – 10 employees had "Good" respirator programs, while these small establishments had the highest percentage of negative SRUP indicators (See Figures 1 and 2 and Table II). The two leading respiratory protection program deficiencies throughout all industries were the lack of a written program and the failure to evaluate program effectiveness (See Table II). These findings should be useful in developing and evaluating effective interventions at the establishment level.

The prevention of illness through effective programmatic interventions is a critical foundation for industrial hygiene. A full understanding of the relationship between respiratory protection program quality and the occurrence of illness is important, particularly to identify program factors that influence this relationship. This study highlights some of the variables that can confound the assessment of respiratory protection program effectiveness at the establishment level. Future studies in this area need to consider the accuracy and completeness of occupational illness reporting and should emphasize establishments with historically greater potential hazards and health risks. Factors that must be taken into account include establishment size, program variability among industry divisions and classes, and the relationship between the presence of workplace hazards and the resources applied to protection. Further research in this field could assist establishments in designing and implementing more effective respiratory protection programs. Innovative strategies (e.g., targeted educational materials, professional partnerships, regulatory measures) may be required to improve the quality of respiratory protection programs, particularly at smaller establishments.

CONCLUSIONS

This study found that a majority of small establishments (1-10 employees) had "Poor" respirator programs. The two leading program deficiencies across essentially all industries were the lack of a written program or an evaluation of program effectiveness. The study was unable to discern an impact of an establishment's respiratory protection program quality on the reported incidence of occupational illnesses, but the findings can help guide practical approaches for further investigations in this field.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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