

Measuring Respirator Use in the Workplace

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Measuring Respirator Use in the Workplace

Committee on the Review of the
National Institute for Occupational Safety and Health/
Bureau of Labor Statistics Respirator Use Survey

William D. Kalsbeek, Thomas J. Plewes, and Ericka McGowan, *Editors*

Division on Earth and Life Studies
Board on Chemical Sciences and Technology

Division of Behavioral and Social Sciences and Education
Committee on National Statistics

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Preface

The mission of the National Personal Protective Technology Laboratory (NPPTL) of the National Institute for Occupational Safety and Health (NIOSH) is to prevent work-related illness and injury by ensuring the development, certification, deployment, and use of personal protective equipment and fully integrated, intelligent ensembles. This is accomplished through the advancement and application of personal protective technology standards. Like everything else about this new agency of government (founded in 2001), this is an evolving mission statement for a changing and evolving agency. While NPPTL inherited a portfolio of research into personal protective equipment technology and an extensive real-world standards-setting and certification program that impacts directly on the use of respirators in the workplace, NPPTL has been striving to seek new ground in a performance-driven environment in which there are new areas of emphasis, technologies, and responsibilities.

As part of a multifaceted look at the inherited and evolving portfolio of the NPPTL,¹ the laboratory asked the National Academies to undertake a special look at the informational underpinnings of the respirator use program in mid-2005 and to report back expeditiously with recommendations. The primary focus of the committee inquiry was to be on a landmark survey conducted by the Bureau of Labor Statistics (BLS) under the sponsorship of NIOSH in 2001—the *Survey of Respirator Use and Practices* (SRUP). The review would critique the survey and render judgment on the fitness and relevance of the survey methodology to

provide valid information that would guide respirator protection policy into the future.

Various skills were needed to approach this task in a comprehensive manner. The National Academies formed this committee to represent broadly the range of interests involved, with members drawn from industry, employee organizations, and academe according to the necessary expertise. The committee members were selected on the basis of their expertise in occupational health and safety, industrial hygiene, respirator and filter technology, survey design and methodology, and statistical data analysis. In this regard, the National Academies was fortunate to obtain the enthusiastic service of a committee of experts who were broadly representative of the many disciplines and interests that would have to pull together to ensure a successful program of respiratory protection in U.S. workplaces.

In the process of developing this report, the committee conducted two meetings to which officials of the NPPTL and BLS were invited to discuss the SRUP and other matters of concern to the agencies, and a third, closed meeting at which the committee's findings and recommendations were discussed. In addition to the formal meetings, selected committee members participated in conference calls with agency representatives to elicit more technical information.

The staff of the National Academies that supported this review was drawn from two divisions within the Academies—the Division on Earth and Life Studies, Board on Chemical Sciences and Technology (BCST), and the Division of Behavioral and Social Sciences and Education, Committee on National Statistics (CNSTAT). Dorothy Zolandz, the board director of BCST ably served as overall project director, and Constance Citro provided support and direction on the statistical aspects of the investigation from her position as director of CNSTAT. Tom Plewes of CNSTAT staff served as study director, while Ericka McGowan of BCST served as

¹The Institute of Medicine has formed a standing Committee on Personal Protective Equipment for Workplace Safety and Health to serve as a steering committee for studies to support NPPTL. The committee will provide a forum for discussion of scientific and technical issues relevant to the development, certification, deployment, and use of personal protective equipment, standards, and related systems.

research associate. Lance Hunter of CNSTAT rounded out this interdisciplinary staff as project assistant, in charge of administrative support to the committee.

Throughout the project, the staff of the sponsoring agency, NPPTL, provided sustained interest and support for the project. Senior leadership of the laboratories, including Les Boord, director of NPPTL, was supportive of the work of the committee and participated in its first and second meetings to provide both guidance and technical expertise. Throughout its work, the committee was directly assisted by NPPTL Associate Director for Science Dr. MaryAnn D'Alessandro, who in turn was ably supported by several members of the senior staff of the laboratories: Roland BerryAnn, George Bockosh, Bill Haskell, and John Kovac.

Staff of the NIOSH Division of Respiratory Disease Studies (DRDS) were also very helpful in assembling background materials, providing a unique perspective with their expertise in workplace surveillance, and otherwise supporting the work of the committee. The members of this team, Brent Doney and Mark Greskevitch, supported by Dennis Groce, were instrumental in initiating the mid-1990 investigations that determined that NIOSH would sponsor the BLS survey and played critical functions in providing context to the SRUP. Under the guidance of NPPTL, this team and others from DRDS have carried the bulk of the burden of preparing and disseminating analysis of the survey and its findings, continuing the program of exploiting survey results to this day with several pioneering statistical analytical products still in the pipeline.

Likewise, the staff of the Office of Safety, Health, and Working Conditions of the BLS, which had responsibility for the design and conduct of the SRUP, was consistently supportive of the committee. The assistant commissioner of BLS for this office, William J. Wiatrowski, and his associate, William McCarthy, developed and presented an objective discussion of the survey at the first meeting of the committee and stood ready to respond to the many questions posed by the committee and staff prior to and after that presentation. Kelly Frampton of BLS was very helpful in retrieving and forwarding documents to the committee as well.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the

National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the institution in making its report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

The committee wishes to thank the following individuals for their review of this report:

- Dr. Howard Cohen**, University of New Haven, Connecticut
- Dr. Lewis Goldfrank**, New York University School of Medicine
- Dr. James S. Johnson**, Los Alamos National Laboratory (retired), Pleasanton, California
- Dr. Timothy Johnson**, University of Illinois, Chicago
- Dr. Frank Potter**, Mathematica Policy Research, Princeton, New Jersey
- Dr. Stanley Suboleski**, Federal Mine Safety and Health Review Commission, Washington, D.C.
- Mr. Michael Wright**, United Steelworkers of America, Pittsburgh, Pennsylvania

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by **Dr. Alan Zaslavsky**, Harvard Medical School, and **Dr. Harley Moon**, Iowa State University. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests entirely with the authoring committee and the institution.

William D. Kalsbeek, *Chair*
 Committee on the Review of the National
 Institute of Occupational Safety and Health/
 Bureau of Labor Statistics
 Respirator Use Survey

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Summary

As part of a multifaceted look at the inherited and evolving portfolio of the National Personal Protective Technology Laboratory (NPPTL), the laboratory asked the National Academies to undertake a special look at the informational underpinnings of the NPPTL program to promote effective use of respirator equipment in the workplace. The primary focus of the committee inquiry was to be on a landmark survey conducted by the Bureau of Labor Statistics (BLS) and the National Institute for Occupational Safety and Health (NIOSH)—the 2001 *Survey of Respirator Use and Practices* (SRUP).

NIOSH had commissioned and collaborated with BLS to conduct a nationwide respirator survey in 2001. The purpose of this survey was to evaluate respirator use and practices in the workplace to help guide NIOSH respirator certification and research. The survey results were published in September 2003 in a report entitled “Respirator Usage in Private Sector Firms.”¹ The survey findings suggest that there may be certain aspects of respiratory protection that are not compliant or are only partially compliant with Occupational Safety and Health Administration and Mine Safety and Health Administration regulations.

SCOPE OF THE STUDY

The purpose of this review has been to critique the survey and render judgment on the fitness and relevance of the survey methodology to provide valid information that would guide respirator protection decision making into the future. The National Academies formed the Committee on the Review of the NIOSH/BLS Respirator Use Survey Program to broadly represent the range of interests involved, with

¹This report can be found on the world wide web in its entirety at <http://www.cdc.gov/niosh/docs/respsurv/pdfs/respsurv2001.pdf>.

members drawn from industry, employee organizations, and academe. The committee members were selected on the basis of their expertise in occupational health and safety, industrial hygiene, respirator and filter technology, survey design and methodology, and statistical data analysis. This review is one part of a larger, more extensive, NPPTL-sponsored review by the National Academies of several scientific and technical issues relevant to the development, certification, deployment, and use of personal protective equipment (PPE),² standards, and related systems to ensure workplace safety and health.

This review addresses the following issues:

- The adequacy and appropriateness of the survey instrument, considering both the content and the format of the instrument;
- The adequacy and appropriateness of the survey methodology, including the choice of sample, the sampling method, survey follow-up, and ultimate response rate;
- The methods of estimating the resultant survey data and the adequacy of the data to address policy concerns with respirator usage;
- The extent and adequacy of data analysis and publication;
- The appropriateness of conclusions reached from the data;
- The possibility of extending the utility of the data through additional statistical analysis; and

²PPE encompasses both protective ensembles (garments, boots, gloves, hoods, and respiratory protection) and operational equipment (equipment needed to sustain operations and provide general support during chemical, biological, radiological, and nuclear response operations). See the following web site for more information: <http://saver.tamu.edu/assessments.php?s=2&c=1>.

- The potential for obtaining additional information that is useful to NIOSH from current and future survey results.

Each of these issues was considered by the committee to constitute a task to be accomplished during its review. To the extent that information was available to it, the committee assessed each of these issues and made recommendations, when appropriate.

OBJECTIVE OF THE SURVEY

The objective of SRUP was “to provide information to develop educational interventions for specific populations and to increase the frequency and effectiveness of respirator use in the workplace.”³ The survey was designed to provide estimates of the number of establishments and employees who used respirators in a recent 12-month period by type of respirator and type of use, and to collect data on the characteristics of the respirator program at the establishment; medical fitness to wear respirators; characteristics of respirator training at the establishment; usefulness of NIOSH approval labels and respirator manufacturers’ instructions; substances protected against by the use of respirators; and fit-testing methods used for respirators. The target population of the survey was private-sector establishments with employment covered by unemployment insurance programs that were included in the 1999 Survey of Occupational Injuries and Illnesses (SOII). The data to illuminate these survey objectives had never been systematically collected before from such a large number of establishments covering so many industries and size classes.

FINDINGS

The 2001 SRUP was critiqued with the thought that the analysis and recommendations would help guide a subsequent survey of this scope and nature and that the critique would be based on published documentation provided by BLS and NIOSH. This was, in many ways, a landmark survey for both agencies. Although it built on the extensive sampling capacity of BLS that came with years of experience in conducting the SOII, it was experimental in its selection of questions and sample units.

Finding 1: The survey was an important first step in collecting respiratory protection data from a probability sample. As such, it was a worthwhile learning experience for both NIOSH and BLS.

It soon became obvious to BLS management that the survey suffered from inadequate funding for its scope and

³Bureau of Labor Statistics and National Institute for Occupational Safety and Health; Respirator Usage in Private Sector Firms, 2001; Washington, D.C., 2003, p. 1.

size. One casualty of the lack of funding was the inability of BLS to follow up with a full set of documentation.

Finding 2: There was insufficient documentation and detail for the committee to reconstruct key aspects of the methodology and to fully understand the survey design and implementation.

The lack of documentation was particularly true for the sample design, sample weighting, content development, and handling of missing data through a type of imputation procedure known as the “hotdeck,” in which missing lines of data are replaced by sampled complete data records. Appropriate documentation and access to this documentation are essential to evaluating and reproducing a survey of this type.

Development of the questionnaire was a joint responsibility between NIOSH and BLS. NIOSH participated in the development of the survey questionnaire by providing BLS with direction on technical subjects such as regulations, respirator types and uses, and specific substances that require respirator use. Although the survey was appropriately subjected to cognitive experimentation and field testing, the resulting questions tended to be focused more on items that were measurable from the perspective of the employer respondents, and the questions tended to elicit information on regulatory compliance rather than respirator certification and use.

Finding 3: The survey questionnaire was not adequately related to the initial survey objectives.

The committee found that it was difficult to evaluate the adequacy of pretesting because, in general, the documentation about the details of the testing, the resulting instrument revisions, and the efficacy of those revisions were inadequate. Although the testing appears, overall, to have uncovered a large number of problems, it is difficult to determine the effectiveness of the solutions without explicit examples or results of their retesting.

The field test provided valuable insights that enhanced the survey operations. For example, the overall field-test response rate of 80 percent was fairly close to the reported survey response rate of 75.5 percent. However there were many issues with the pretesting, including the following:

Finding 4: The field test paid little attention to exploring validation procedures that might have provided information on the quality of data collected or motivated the need for a formal quality assessment of the data, and thus missed an opportunity to improve understanding of the quality of the SRUP data.

Finding 5: Many features of the survey were not user friendly or optimally designed to aid navigation.

SUMMARY

Finding 6: There were several material weaknesses in the procedures for instrument testing.

The committee observes that the SRUP was, in essence, a sample of a sample. The population sampled for the SRUP is technically the subset of the SOII target population defined by industry types. This was a potential strength of the survey. However, the opportunity was largely missed.

Finding 7: NIOSH did not set specific precision objectives for key estimates of population subgroups from the SRUP.

It is customary to establish reliability objectives for key data elements in the design of a survey. Reliability objectives are sensitive to sample size and survey operations, and, ultimately, to the cost of the survey in terms of resources and respondent burden. In the absence of such objectives it is difficult to assess the adequacy of the sample sizes for the various populations subgroups (e.g., by region, by type of business).

Several aspects of the sample design resulted in less than optimal estimation in practice.

Finding 8: The choice of stratification variables for the SRUP sample design appears to have been appropriate, since many of the survey's reported findings by type and size of industry were quite different (e.g., respirator use). The rationale for using the allocation for the SRUP sub-sample among strata was to maximize the yield of companies with higher rates of respirator usage. This allocation, which made each stratum sample proportional in size to the expected number of establishments in the stratum that use respirators, may not have been optimal to improve the precision either of overall survey estimates or of estimates for population subgroups defined by the strata, but it did serve to increase the proportion of sample companies that reported respirator use.

Finding 9: More could have been done with the characteristic of the SRUP being a subset of the SOII to build strength into the estimates in that a sample that is the second phase of a "two-phase" or "double" sample can gain power from the first-phase sample.

The first-phase sample can improve stratification or estimation in the second phase if utilized appropriately. To do so, the strata should be defined consistently (if not identically) in both phases of sampling to permit analysis of the SRUP sample as a two-phase sample. Although the documentation is not clear, there may not have been attention to the necessary consistency of stratification between the SOII (first-phase sampling) and the selection of industries for the SRUP (second phase). This oversight limits the ability of the two-phase sample to be analyzed as such, with sample weights accounting for sampling and nonresponse in both phases of

sampling and the stratification in the two phases accounting for determining the precision of survey estimates.

Finding 10: The SRUP used a basic collection design that is fairly typical of many establishment mail surveys conducted by federal agencies. However, the SRUP data collection design did not use several state-of-the-art techniques that would likely have produced a higher response rate and enhanced data quality.

Several of these techniques to be considered for use if there is another SRUP-type survey in the future include the following:

- Identifying the best-qualified survey respondent in advance of the questionnaire survey mailing;
- Sending a pre-notice letter in advance of the questionnaire mailings and thank-you or reminder postcards a week after the questionnaire mailings;
- Personalizing all mailings;
- Following the guidelines in Dillman⁴ for the format and content of the mailings;
- Using real stamps instead of "business reply" postage on the return envelopes included in the two questionnaire mailings;
- Making refusal conversion attempts on persons who refuse to participate during the nonrespondent follow-up calls; and
- Implementing measures to evaluate the quality of the data, such as assessments of response and nonresponse bias.

Finding 11: The reported overall SRUP response rate of 75.5 percent paints an incomplete picture of the impact of nonresponse on all key SRUP findings. In addition to findings on the percentage of respirator use among all companies in the sample, the survey findings focused heavily on companies with required respirator use, and the response rate among these companies is not reported.

Because of the setup of the survey questionnaire, the respondents who identified themselves as being in the group of establishments that had mandatory respirator usage were obliged to answer many more questions than those who only had voluntary use of respirators. There was a penalty for reporting mandatory use, so it is quite likely that companies having mandatory use had a higher rate of nonresponse. This would lead to a corresponding increase in the potential for nonresponse bias. Moreover, the net effect of nonresponse in a two-phase sample is the product of the response rates in the two phases, instead of just the response rate in the second

⁴Dillman, D.A. *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000.

phase corresponding here to the response outcome for the SRUP subsample.

Finding 12: *The performance of extensive machine editing and error resolution follow-up contacts showed commendable attention to resolving inconsistent and invalid responses.*

In keeping with its reputation for careful, professional work, BLS (and its contractor) did many things in processing the survey data in exemplary fashion. The care taken in resolving issues was particularly commendable. However, no assessment was made of response and nonresponse bias.

Finding 13: *Although a standard error was calculated for each estimate from this survey, these measures of error were not computed correctly. BLS used SAS Version 6.0 to produce the computations, which yielded appropriately weighted estimates but did not account for stratification in estimating the standard error of estimates.⁵ Also of concern was the finding that standard errors were not published along with the data in the main report.*

Sophisticated data users would be able to obtain the standard error estimates for every data item by requesting them from BLS, but it would have been preferable to have included them with the published tables in the report.

Finding 14: *A large number of analytical studies were conducted by NIOSH staff following the release of the initial SRUP report. However, more could have been done to disseminate survey findings and data to key stakeholders such as users, policy and decision makers, and the industrial hygiene and safety engineering communities.*

For the most part, NIOSH dissemination activities were concentrated on providing useful information to the professional PPE community. A more active outreach program to employer groups and employee organizations would have better popularized these findings.

Finding 15: *The failure to conduct the sample matching earlier in the process constituted a missed opportunity to improve the quality and richness of the data.*

The initiative to enrich the data with potentially useful analytical data from the SOII should be applauded, but it came very late in the process. Although the inability to control for differences in the data related to different time periods was recognized, different conditions in the reporting establishments rendered the results of the match somewhat speculative. This sample unit matching was conducted after

⁵Later versions of SAS account for stratification, but these versions may not have been available at the time of the SRUP analysis.

the processing of survey data was concluded and primarily for the purpose of data analysis. It is unfortunate that the sample matching did not come earlier as a planned feature in the processing cycle.

RECOMMENDATIONS

Despite these findings about the adequacy of the survey operation and concerns about the missed opportunities to fully realize the potential of this survey, the committee applauds the agencies for undertaking this pioneering data collection in order to improve understanding of respirator use in industry.

RECOMMENDATION 1: **NPPTL should continue to address and explicitly articulate data needs to evaluate and improve the respirator certification program so as to ensure the efficient availability and advancement of protective technologies for employees.**

The committee is encouraged that the NPPTL leadership continues to place appropriate emphasis on its statutory mission of respirator certification, even as it enriches its program with attention to other objectives. It is proper to maintain this emphasis even as NPPTL moves forward in other areas.

RECOMMENDATION 2: **Discussion and explicit articulation of information needs related to PPE performance and utilization should be the subject of continuous review and periodic updating by NPPTL as PPE technology evolves and the method of meeting those needs changes.**

An intensive effort of this type may be impractical to sustain on an ongoing basis, but it should be a necessary function of NPPTL's surveillance efforts. Imposing a top-to-bottom consideration of information needs in conjunction with program objectives is a hallmark of performance-based management. This is consistent with the NPPTL value creation system and government-wide performance management initiative.

RECOMMENDATION 3: **NPPTL's future data-gathering activities should seek, within a sound scientific approach, to derive explanations for observations on the use of PPE in the field.**

Beyond meeting current and emerging program objectives, however, increasing recognition of the research role of NPPTL should be embedded in the future approach to the task. NIOSH is, in essence, a research organization and should give a sharper research focus to its data-gathering activities.

RECOMMENDATION 4: **In the future, the resource-intensive data-gathering framework for NPPTL surveillance efforts should focus on the evolving mission categories of surveillance, certification, research, technology, and standards.**

The committee provides an example of such a framework in this report for consideration by NPPTL leadership. The framework is tied to NPPTL mission categories.

RECOMMENDATION 5: NPPTL should develop for implementation an ongoing survey of employer and employees whose overarching goal is to obtain needed information on the use of respirators and other PPE in the United States. To ensure the scientific quality and broad utility of this series of surveys, NPPTL should ensure that this system of periodic surveys:

1. Is sufficiently flexible to meet NPPTL's changing information needs; and
2. Attains the highest standards of current survey research by:
 - Following a responsive sample design,
 - Assuring the reporting accuracy of all of its key survey measures,
 - Widely disseminating its findings,
 - Making its data easily available to outside researchers, and
 - Documenting all of its methods in detail.

The major recommendation arising from this review is based on the conclusion that data on respirator use are best provided by employers and employees in the context of the work setting. This suggests the need for a very different approach to conducting any future survey operation. After considering several options, the committee developed a proposal for an employee-within-establishment survey.

The recommendation to conduct an employee-within-establishment survey should not be interpreted as suggesting

this as an exclusive approach to all future data collection. To the extent that qualitative indicators are needed, focus groups might suffice. It may also continue to be useful to collect information about aspects of establishment respirator program management from employers, so it would be useful to continue to conduct focused employer-only surveys periodically.

RECOMMENDATION 6: The most efficient data collection approach for the establishment survey is a mixed-mode design involving three phases: (1) an initial round of telephone screening calls, (2) a mail survey approach, and (3) telephone follow-up calls to nonrespondents.

RECOMMENDATION 7: Instead of addressing the survey to someone with unknown expertise in the area of interest, surveillance personnel at NPPTL should conduct a quick telephone screening of sampled establishments in advance of the mail survey to identify the best-qualified respondent and to learn from that person whether the establishment is eligible for the full survey (that is, required use of respirators in the past 12 months).

Telephone screening calls have the following objectives: (1) to identify and remove from the sample those establishments that are no longer in business, (2) to identify establishments that are PPE users, (3) to identify and close out as “completed” non-PPE user establishments, and (4) to make contact with the best-qualified respondent at PPE user establishments. The calls should be made by well-trained telephone interviewers in the survey contractor's centralized call center. The interviewer should ask to speak to the person most knowledgeable about possible PPE use at the establishment.

1

A Significant Undertaking

The federal agencies responsible for ensuring “safe and healthful working conditions for working men and women”¹ have long needed information to measure workplace hazards, worker exposures, and their protection from exposure to those hazards. The need for information arose from the inception of programs developed in response to the enactment of the Occupational Safety and Health Act of 1970 in recognition of the unsafe and unhealthful working conditions of the workforce and the substantial burden that employee illnesses and injuries posed as a result. Since then, information gathering in various forms of data collection and surveillance has been a major aspect of these programs. The two programs developed as a result of this act were the Occupational Safety and Health Administration (OSHA), which as a part of the U.S. Department of Labor is responsible for developing and enforcing workplace safety and health regulations, and the National Institute of Occupational Safety and Health (NIOSH) which as a part of the U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention is responsible for assuring safe and healthful working conditions for the workforce by providing research, information, education, and training in the field of occupational safety and health.² OSHA maintains large databases of compliance data and has commissioned special surveys and analyses in support of its regulatory processes. Likewise, NIOSH manages a far-reaching surveillance program that has focused mainly on hazards, outcomes (fatalities and injuries), and exposures, but has also served to inform program management.

This commitment to information gathering has extended to NIOSH’s National Personal Protective Technology Laboratory (NPPTL). Established in 2001, NPPTL has as its mission

the prevention and reduction of occupational disease, injury, and death for employees who rely on personal protective technologies. Respirator certification tasks were transferred from the Mine Safety and Health Administration when some functions of the Bureau of Mines were merged into NIOSH in 1995. Today, NPPTL is responsible for the certification for respirators and for the development of performance guidelines and standards for personal protective equipment (PPE). Respirators and other types of PPE, such as chemical-resistant clothing, hearing protectors, and safety goggles and glasses, are all technologies that provide protection for employees against occupational hazards or risks. The most concerted focus has been on respirators because they are the most regulated component of occupational safety and health programs in a variety of industries and because NPPTL manages an extensive program of certification for these devices.

Several attempts to gain valid information on workplace hazards and exposures have been made as part of a long-standing NIOSH program of workplace surveillance—some of which are discussed in this report. While each served a focused and valuable purpose, none of these surveys and data collections had taken a comprehensive look at the status of personal protection in the workplace. A comprehensive view of personal protection in the workplace requires obtaining information on hazards, exposures, use of protective equipment, performance of PPE, compliance with standards for programs of protection and how they interrelate, and identifying trends in these aspects of workplace protection.

To remedy this gap in knowledge, NIOSH commissioned and collaborated with the Bureau of Labor Statistics (BLS) to conduct a nationwide respirator survey in 2001. The purpose of this survey was to evaluate respirator use and practices in the workplace to help guide NIOSH respirator certification and research. Approximately 282,000 firms responded that they had required the use of respirators in the

¹Occupational Safety and Health Act of 1970.

²See the following web site for more information: <http://www.cdc.gov/niosh/about.html>.

past 12 months and were asked a battery of questions about respirator use practices. The survey results were published in September 2003 in a report entitled *Respirator Usage in Private Sector Firms*.³

This survey was a significant undertaking for these two agencies. It was preceded by several years of intensive preparation and followed by an analytical program on the part of NIOSH. Although the survey was a fairly massive data collection effort, it could be viewed as a beginning, not an end, to the collection of data on hazards, exposures, and protective equipment use.

To fulfill its mandate, NIOSH must develop an ongoing strategy for better understanding of respirator use in the workplace, particularly from the employee perspective. NIOSH must do this in a time of significant change—many of the programs that underpin our workplace protection systems are being fundamentally transformed in scope and approach. To accomplish its strategic plan, NIOSH needs to identify and address additional data to be gathered in both the private and the public sectors, in a format that will maximize the usefulness of the information.

To aid in this endeavor, NPPTL has requested the National Academies, through its Board on Chemical Sciences and Technology and its Committee on National Statistics, to conduct an independent review of the 2001-2002 NIOSH/BLS survey of respirator use among private firms in the United States.

This review is part of a larger, more extensive look at scientific and technical issues relevant to the development, certification, deployment, selection, and use of PPE, standards, and related systems to ensure workplace safety and health. The Institute of Medicine has formed a standing Committee on Personal Protective Equipment (COPPE) in the Workplace to steer National Academies studies to support the NPPTL. This review is under the auspices of COPPE.

This review addresses the following issues related to the Survey of Respirator Use and Practices (SRUP) and NPPTL's research agenda:

- The adequacy and appropriateness of the survey instrument, considering both the content and the format of the instrument;
- The adequacy and appropriateness of the survey methodology, including the choice of sample, the sampling method, survey follow-up, and ultimate response rate;
- The methods of estimating the resultant survey data and the adequacy of the data to address policy concerns with respirator usage;
- The extent and adequacy of data analysis and publication;
- The appropriateness of conclusions reached from the data;

- The possibility of extending the utility of the data through additional statistical analysis; and
- The potential for obtaining additional information that is useful to NIOSH from current and future survey results.

Each of these issues was considered by the committee to constitute a task to be accomplished in its review. To the extent that information was available to it, the committee assessed each of these issues and made recommendations when appropriate.

ORGANIZATION OF THE REPORT

The organization of this report reflects the approach to the task taken by the study committee. In Chapter 2, the data needs of the federal agencies with responsibility for workplace protection are examined, in recognition that these programs are in transition and that data needs are changing as a result of the transformation of the science and policies for employee protection. Prior attempts to build a base of understanding of hazards, exposures, and protections are discussed. The report summarizes three national surveys that, by virtue of their design, yielded qualitative, not quantitative, exposure and hazard information. They provided few firm data on protective practices.

Chapter 3 documents the process of selecting the survey approach and methodology employed in the SRUP. Attention is devoted to the survey objectives since the design is influenced by those objectives and the analysis is delimited by the design. The chapter documents the major survey design steps of questionnaire development, sample selection, data collection, editing and imputation, and analysis.

A critique of the survey methodology is found in Chapter 4. Based on presentations made to the committee in its fact-finding meetings and in its review of documentation provided by BLS and NIOSH, conclusions were drawn about the adequacy of the methodology utilized in addressing the major aspects of the survey design. The overall quality of the survey was assessed, in view of the purposes the survey was to have served, and consideration was given to whether the conclusions were appropriate.

Finally, in Chapter 5, future data needs and potential sources of data are considered in order to provide guidance to NPPTL on data sources and approaches to obtaining measures of the information necessary to carry out the important mission of this agency. Also alternatives are suggested to the provision of information of interest that do not involve the complexity and expense of a large-scale survey of establishments, such as the SRUP, as well as a detailed protocol for a survey that could gather the type of data NIOSH and NPPTL want and need to carry out their missions.

A list of acronyms used in the report is found in Appendix D.

³Bureau of Labor Statistics and National Institute for Occupational Safety and Health; *Respirator Usage in Private Sector Firms, 2001*; Washington, D.C., 2003.

2

A Program in Transformation

Like many other government agencies, the National Institute for Occupational Safety and Health (NIOSH) and its National Personal Protective Technology Laboratory (NPPTL) are in an era of great change. These organizations are confronting new pressures for measuring performance. These pressures are reflected in government-wide performance rating systems and in internal NIOSH initiatives to be more responsive to an increasingly complex workplace that is, in many ways, potentially more dangerous.

The potentially more dangerous workplace is manifest in a number of ways. The characteristics of the workforce are changing rapidly, with a greater mix of non-English-speaking employees in dangerous occupations. In an increasingly global economy, there is a greater risk of transmission of natural diseases. The heightened danger of terrorist activity increases the possibility of intentional release of toxic and infectious airborne biological or microbial agents into the atmosphere. The danger of accidental release of toxic industrial materials into the workplace from transportation or storage modes is also a concern.

There are new hazards and exposures in technologically changing industries. Emerging technologies are dramatically changing the way in which work is organized and production is facilitated, and in the process, technological improvements in personal protective equipment are improving the capacity to ward off the dangers of that changing workplace. Finally, the very regulatory environment that provides the basis for the NIOSH programs is changing in order to maintain relevance. To keep up with these trends, NIOSH and NPPTL are transforming their programs of respiratory protection.

HIERARCHY OF CONTROLS

In the practice of industrial hygiene, it is generally accepted that as a matter of principle, control of hazards

should be based on a hierarchy, beginning with engineering methods such as isolation, substitution, or installation of local exhaust ventilation. Second in the sequence should be administrative controls, such as job rotation, limiting the time during which a particular task is performed, and others. As a final line of defense, personal protective equipment (PPE) is recognized as a means of controlling risk. Respirators fall into this latter category. This hierarchy of controls is embedded in the Occupational Safety and Health Administration (OSHA) standards at 29 CFR 1910.1000(e) for general industry and 29 CFR 1926.55(b) for construction, which state:

To achieve compliance with . . . this section, administrative or engineering controls must first be determined and implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section. Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person. Whenever respirators are used, their use shall comply with 1910.134.

Similarly, section 1910.134 requires:

In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section.

The hierarchy of controls is intended to relegate the use of PPE to control hazards for which process change, engineering, and other control options are not feasible. The hierarchy of controls principle is based on the premise that PPE is less reliable than other approaches because of the vagaries of individual compliance with instructions for use, and that the quality and efficacy of PPE are insufficient to guarantee that exposures will be reduced.

PERFORMANCE RATING

As a federal agency, NIOSH is increasingly challenged to develop measures of performance—to set and meet goals and objectives established under the Government Performance and Results Act and to complete the periodic scorecard in the Performance Assessment Rating Tool. These performance objectives must be overlaid with NIOSH's institute-wide strategic planning effort (the National Occupational Research Agenda [NORA-2]), which calls for increased intervention research and technology transfer (i.e., research to practice, or R2P) directed at specific industry sectors. In this increasingly complex environment, NIOSH has turned to the National Academies to bring together expertise from the scientific disciplines to assist in program development and assessment.

The assessment starts with the NIOSH mission. Since its establishment in 1970 with the passage of the Occupational Safety and Health (OSH) Act, NIOSH has worked closely with OSHA of the U.S. Department of Labor, which has responsibility for regulating occupational safety and health in the workplace. NIOSH provides national and world leadership in preventing work-related illnesses, injury, and death by pursuing the strategic goals of coordinating and strengthening the capacities of state-based surveillance systems for major workplace illnesses, injuries, exposures, and health and safety hazards; increasing prevention activities through workplace evaluations, interventions, and recommendations; providing employees, employers, the public, and the occupational health and safety community with information, training, and capacity to prevent occupational injuries and illnesses; and conducting a focused program of research to reduce injuries and illnesses, including transmission of infectious diseases, among employees in high-priority and high-risk sectors, including mining, agriculture, construction, and health care. Although the mission has been relatively constant, the emphasis and the means of accomplishing the mission have evolved.

ORGANIZATIONAL TRANSFORMATION

In administering its programs, NIOSH has, for the last decade, focused on priority areas defined in NORA. NORA is a framework established in 1996 by NIOSH and more than 500 partners to guide the efforts of the occupational safety and health community in 21 priority research areas.

Starting in 2006, an extension of this program (NORA-2) will develop a cross-matrix of research priorities addressing opportunities for public health interventions in specific industrial sectors: agriculture, forestry, and fishing; construction; health care and social assistance; manufacturing; mining; public and private services; trade; and transportation, warehousing, and utilities. The agency also organizes its efforts along 15 cross-sector programs taking into account adverse health outcomes, statutory programs, and global efforts. Among the cross-sector programs is personal protective technology (PPT), which encompasses PPE such as respirators, chemical-resistant clothing, hearing protectors, hard hats, hazardous substance sensors, and safety goggles and glasses that provide a barrier between the employee and the occupational safety and health risk.

In 1972, responsibility for PPE was transferred to NIOSH from the Bureau of Mines. In that year, NIOSH opened the NIOSH Personal Protective Equipment Laboratory in Morgantown, West Virginia. This laboratory has a role in testing protective equipment and respirator certification. Later, the responsibility for chemical protective clothing was added. The respirator program was transferred to a new organization—the NPPTL in Bruceston, Pennsylvania—in 2001.

The mission of NPPTL is to provide world, national, and NIOSH leadership for prevention and reduction of occupational disease, injury, and death for those employees who rely on PPTs through partnership, research, service, and communication.¹ Like its higher headquarters, NPPTL organizes its programs along the lines of surveillance, research, intervention, training, and education. In addition, NPPTL develops standards and guidelines relating to PPE performance, quality, reliability, and efficiency and, as an offshoot, directs and carries out the NIOSH respirator certification program and related laboratory, field, quality, and records activities. Surveillance activities of the NPPTL have centered on understanding respirator use in workplaces; investigating ways to evaluate respirator use by mobile workforces such as construction crews; and understanding the work requirements, challenges, and PPE needs of first responders. The NPPTL organizes these activities among three major branches—Technology Evaluation, Technology Research, and Policy and Standards Development—parcel-

¹In Senate Report 106-293 Departments of Labor, Health and Human Services, and Education and Related Agencies Appropriation Bill, 2001 Filed Under Authority of the Order of the Senate January 6, 1999, Congress outlined the need for this new division: "It has been brought to the Committee's attention the need for design, testing and state-of-the-art equipment for this nation's . . . miners, firefighters, healthcare, agricultural and industrial employees . . . [also] the Committee encourages NIOSH to carry out research, testing and related activities aimed at protecting employees who respond to public health needs in the event of a terrorist incident. The Committee encourages CDC [the Centers for Disease Control and Prevention] to organize and implement a national personal protective equipment laboratory."

ing out lead responsibility to each in a cross-sectional and sectoral matrix scheme.

Another NIOSH organization has a role to play in administering the personal protection program. The Division of Respiratory Disease Studies (DRDS) provides national and international leadership toward the identification, evaluation, and prevention of occupational respiratory diseases, such as asthma, chronic obstructive pulmonary disease, and pneumoconiosis. This division conducts a program of surveillance, under which it collects, analyzes, and disseminates health and hazard information related to occupational respiratory disease. It also conducts a program of field studies to evaluate the relationship between exposures to toxic substances and disease. Of interest for the purpose of this study is that the NIOSH staff that developed the Survey of Respirator Use in Industry is now organizationally located in this division. Staff of DRDS continues to support the NPPTL in managing a program of analysis and data gathering on PPE in the workplace.

CHANGING TECHNOLOGICAL ENVIRONMENT

The technology associated with PPE has advanced in recent years and remarkably so in respirators. For example, chemical cartridge (air-purifying, gas mask) respirators are effective against a wider range of toxic industrial compounds than ever before, as well as chemical warfare agents; this is the result of new developments in sorbent technology and low-temperature oxidation catalysts. In addition, end-of-service-life indicators (ESLIs), which inform a user when to replace chemical cartridges during use against organic vapors, are under development. (These new ESLIs will complement those that are already available for mercury vapors, acid-type gases, ethylene oxide, and toluene diisocyanate.)

Technology has also influenced supplied air respirators, particularly the self-contained breathing apparatus (SCBA). For example, advances in electronics have resulted in the development of firefighter location devices, personal alert safety systems (PASS devices), which assist in locating “downed firefighters,” and heads-up displays that enable wearers to easily monitor the supply of breathable air. In addition, new polymeric compounds have found applications in SCBA components.

Overall, the aforementioned advances have had a significant impact on respirator use and have improved the level of protection provided by such devices. For example, in recent years, air-purifying respirators have been used not only in traditional industrial applications, but also by individuals in law enforcement, office personnel requiring escape from fire and terrorist activities, and those participating in the do-it-yourself market. As a result of the advances in polymeric materials, SCBAs are now confirmed to provide firefighters with high levels of respiratory protection from chemical and biological warfare agents.

Note, however, that such equipment advances have, in some instances, required increased training on their proper use, additional maintenance, and possibly, a greater initial investment or cost.

CHANGES IN THE REGULATORY ENVIRONMENT

Required practices associated with the use of respirators are defined, at the federal level, by regulation—Occupational Health and Safety Administration Standard 29 CFR 1910.134. This OSHA standard sets the framework for program administration and information gathering by establishing requirements for employers and employees. The standard requires employers to use feasible engineering controls as the primary means to control air contaminants. Respirators are required when “effective engineering controls” are not feasible or while they are being instituted.

Employers have three basic regulatory requirements: (1) respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee; (2) employers shall provide respirators that are applicable and suitable for the purpose intended; and (3) employers shall be responsible for the establishment and maintenance of a respiratory protection program.² Moreover, OSHA requires that employers select a NIOSH-certified respirator appropriate for the hazards identified in the workplace.

The OSHA standards define several major compliance and, consequently, information collection requirements. These require employers to develop a written respirator program; conduct employee medical evaluations and provide follow-up medical evaluations to determine the employee’s ability to use a respirator; provide a physician or other licensed health care professional with information about the employee’s respirator and the conditions under which the employee uses the respirator; perform periodic program evaluations; perform hazard assessments; establish a replacement schedule for chemical cartridge respirators; and administer fit-tests for employees who use negative- or positive-pressure, tight-fitting face pieces.³ In addition, employers must ensure that employees store emergency use respirators in compartments clearly marked as containing such respirators. For respirators maintained for emergency use, employers must label or tag the respirator with a certificate stating the date of inspection, the name of the individual who made the inspection, the findings of the inspection, required remedial action, and the identity of the respirator. Employers may also allow employees to wear respirators voluntarily in circumstances that do not require respiratory protection. The standard also requires employers to ensure

²See the following web site for more information: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=2275.

³Bollinger, Nancy J., and Robert H. Schutz, NIOSH Guide to Industrial Respiratory Protection, DHHS (NIOSH) Publication 87-116, Washington, D.C., September 1987, p. 87.

that sources used to supply breathing air to respirators meet the requirements for Type 1, Grade D breathing air.⁴

For metal, nonmetal, and coal mining establishments, the Mine Safety and Health Administration (MSHA) has established similar requirements. MSHA mandates that respiratory protection approved by NIOSH be available to all affected employees when an area in a coal mine has been determined to be in noncompliance with the applicable respirable dust standard. Respiratory protection is required in metal, nonmetal, and coal mining establishments when (1) engineering controls are not feasible to reduce exposure beyond threshold limit values (TLVs)⁵ established by the American Conference of Governmental Industrial Hygienists; (2) engineering controls are being established to reduce exposures below the TLV; and (3) occasional employee entry into hazardous atmospheres is necessary to perform short-term maintenance or investigations. When respirators are required, mine operators must establish a respiratory protection program.

While most of the requirements rest with the employer, the employee also has regulated responsibility under the OSHA standards.⁶ Specifically, each employee must (1) check the respirator for proper operation before each use, (2) check the respirator fit after each donning as instructed, (3) use the respirator as instructed, (4) guard against damaging the respirator, (5) go immediately to an area having respirable air if the respirator fails to provide proper protection, and (6) report any respirator malfunction to a person responsible for the respirator program.^{7,8} In turn, fulfillment of employee responsibilities depends in large measure on the effectiveness of the supervision and training provided by the employer.

The NIOSH respirator certification program is premised on the supposition that the use of respirators conforms to OSHA-MSHA requirements. Moreover, the program dictates that NIOSH-approved respirators must be used in compliance with the conditions of their approval. NIOSH transmits the conditions of approval in a label affixed to, or packed with, each approved respirator. In addition to a label with the manufacturer's name and address, the NIOSH approval number, NIOSH and Department of Health and

Human Services logos, component part numbers, and associated conditions and limitations, the manufacturer provides detailed instructions for use. The instructions are reviewed, edited, and approved by NIOSH-NPPTL for content, clarity, and accuracy.

DATA FOR PROGRAM MANAGEMENT

The Survey of Respirator Use and Practices (SRUP) was developed under the aegis of the NIOSH surveillance initiative before NPPTL was established as a separate entity. For many years, administrators of the NIOSH PPE programs had recognized a need for surveillance to fill major data gaps, particularly for managing the respirator certification program. These gaps have limited their ability to assess the relevance and effectiveness of the programs and to develop certification standards and educational interventions so as to increase the effectiveness and frequency of respirator use in the workplace.

NIOSH intramural and extramural surveillance research has directed its public health initiatives since the inception of the institute. This multilayered program consists of three components—collection of relevant facts, analysis of those facts, and effective dissemination of the facts—in an effort to both improve understanding of workplace hazards and enhance understanding of the protective measures to respond to those hazards.

From the beginning of NIOSH, surveys were an important part of the process of documenting hazards and protections.⁹ However, at the end of the twentieth century, significant information gaps still existed, including such critical information as the impact and adequacy of NIOSH respirator testing, certification, and labeling programs; how respirators are used; and what, if any, worksite programs are actually implemented by employers. In particular, NIOSH needed information on the following:

- Do employees know that NIOSH certifies respirators?
- Do they recognize that labels indicate such certification?
 - Are manufacturer's user instructions and NIOSH approval labels received with each respirator?
 - Are manufacturer's user instructions clear and useful?
 - Are NIOSH approval respirator labels clear and useful?
- Do NPPTL respirator certification protocols effectively distinguish between adequate and unacceptable respirators?
 - What changes in those protocols might improve this discrimination?

⁴See the following web site for more information: http://www.osha-slc.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=16558.

⁵TLVs refer to airborne concentrations of chemical substances and represent conditions to which it is believed that nearly all employees may repeatedly be exposed, day after day, over a working lifetime, without adverse health effects. TLVs are developed to protect employees who are normal, healthy adults. See the following web site for more information: <http://www.acgih.org>.

⁶See http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716.

⁷Bollinger, Nancy J., and Robert H. Schultz, NIOSH Guide to Industrial Respiratory Protection, Washington D.C., September 1987, p. 89.

⁸It should be noted that some programs require employees to clean and maintain the respirators themselves.

⁹Several of these surveys are summarized in this chapter.

- To what extent are manufacturers and vendors compliant with NIOSH respirator certification requirements?
- To what extent are consumers or employers confused by the lack of regulations certifying consumer use respirators and by Food and Drug Administration (FDA) approval of PPE including N95 respirators?¹⁰

In addition, NIOSH needs to have information about the existence and adequacy of employer respiratory protection programs, especially since their approach to workplace protection is premised on proper use of the equipment. To ascertain if the programs are adequate, NIOSH needs information on aspects of program management at the workplace (see Box 2.1).

To further determine whether its certification program is appropriate, NIOSH is interested in obtaining information on the process by which establishments anticipate exposures, assess risks, and determine which respirator is appropriate for the substances faced by employees (see Box 2.2).

To understand whether employers use the NIOSH-recommended method for respirator selection, NIOSH needs information on the types of programs of air sampling in the establishment as a means to determine which respirator would be appropriate to protect employees from substance(s) in the workplace and the industrial hygiene expertise of individuals involved in these decisions. Although air sampling is not required for most agents, it is considered to be an important, sometimes critical, component of an effective employee protection program.¹¹ For example, NIOSH recommends that the selection of respirators be guided by NIOSH Respirator Decision Logic. The Decision Logic indicates that respirator selection should begin with a comparison of the contaminant concentration to the exposure limit for that contaminant. The contaminant concentration can be determined by air sampling, either on the site or in a similar operation, but in many cases other techniques such as control banding¹² can be used to anticipate the magnitude of

¹⁰Surgical masks and surgical N95 respirators are regulated by the FDA. FDA evaluates the performance of these devices in areas including fluid resistance and filtration efficiency to ensure that they are at least as safe and effective as similar devices already on the market. FDA encourages manufacturers to follow specific performance standards for their masks and also requires that they be produced using good manufacturing practices. Respirators may also be certified by NIOSH in accordance with regulations in 42 CFR Part 84. When a mask is both cleared by FDA as a surgical mask and certified by NIOSH as an N95 respirator mask, FDA calls it a “surgical N95 respirator.” See <http://www.fda.gov/cdrh/ppe/masksrespirators.html> and FDA’s PPE program as described at <http://www.fda.gov/CDRH/PPE>.

¹¹Wherever OSHA sets a Permissible Exposure Limit (PEL), it is implicit that the employer must assess the risk and know whether it is above or below the PEL. This is generally done by monitoring. However, the frequency of monitoring is not specified in OSHA substance-specific standards and is therefore unknown.

¹²Control banding is a process in which a single control technology (such as general ventilation or containment) is applied to one range or band of exposures to a chemical (such as 1–10 mg/m³) that falls within a given hazard group (e.g., skin and eye irritants, severely irritating and corrosive).

BOX 2.1

Workplace Program Management Requirements

- Written program, adopted by management, to guide the manner of respirator use
- Written procedure to periodically evaluate the effectiveness of respirator use
- Training of employees to help them understand the use and limitations of respirators
- Written change-out schedule with the use of air-purifying gas or vapor cartridges and canisters
- Fit-testing for each tight-fitting respirator wearer, by
 1. Who conducts the fit-test:
 - In-house staff
 - Employees themselves
 - Respirator manufacturer’s sales or technical representative
 - Other outside party
 2. Method of fit-testing used in the establishment:
 - Saccharin
 - Bitrex
 - Irritant smoke
 - Isoamyl acetate
 - Ambient aerosol
 - Controlled negative pressure
 - Don and seal-check only
 - Other
- Assessment of the medical fitness of respirator-wearing employees
- Written procedures and a schedule for maintaining respirators
- Assessment of hazards in the workplace
- Training of employees on the hazards of substances in the workplace

SOURCE: Bureau of Labor Statistics and National Institute for Occupational Safety and Health. 2003. Respirator Usage in Private Sector Firms, 2001. Survey of Respirator Use Practices Questionnaire.

exposure for purposes of determining the degree of protection that a respirator must provide.

To help further understand the decision of the establishment to use air-purifying respirators (APRs), the basis for rejecting control options other than PPE, and whether or not the establishment used the technique of air sampling in coming to that decision, NIOSH needs to understand

BOX 2.2
**Potential Means of Determining Appropriate
 Respirator Purchase and Use**

- Employer or supervisor selection based on factors such as price or labeling
- Employee suggestion
- Local store products or salesperson
- Air sampling (monitoring) conducted at the facility
- Air sampling (monitoring) conducted at facilities with operations similar to the facility
- Respirator manufacturer's representative
- Respirator manufacturer's literature
- Material Safety Data Sheets
- Assigned Protection Factor methodology
- Hazard ratio methodology
- Other

SOURCE: Bureau of Labor Statistics and National Institute for Occupational Safety and Health. 2003. Respirator Usage in Private Sector Firms, 2001. Survey of Respirator Use Practices Questionnaire.

how employers apply the Decision Logic as it pertains to a wide variety of the potentially dangerous substances for which respirators provide protection in different organizational settings. Thus, information is required to identify whether the presence of any of 26 substances and categories of substances (e.g., arsenic, lead, biologicals, solvents)¹³ has prompted the use of APRs and whether air sampling is conducted for those categories. If air sampling had not been conducted, information is needed on whether historical and objective data were obtained from industry or trade associations' studies of businesses that are similar to the establishment's atmospheric conditions for the substance or if some other method of selecting the appropriate respirator was used. Similar data were collected to assess the extent of use of supplied-air respirators (SARs) and the testing that pertained to the SAR-protected substances.

Finally, NIOSH needs to know about important aspects of field performance. Field performance includes issues such as the following:

- Durability or expected use lifetime
- Common failures or reliability
- Total inward leakage

¹³Bureau of Labor Statistics and National Institute for Occupational Safety and Health, Respirator Usage in Private Sector Firms, 2001; Washington, D.C., 2003, Table 1, p. 269.

- User comfort, usability
- Consistent adjustment of straps and resistance to overstretching
- Ease of repair
- Effectiveness of field seal checks
- User's ability to discern the adequacy of the respirator's face seal
 - Performance or usability at extreme temperatures and when wet
 - Changes in performance with typical usage

User Focus

The importance of seeking information from users of respirators (and other types of PPE) should not be overlooked. Users respond to respirators and other PPE by accepting, not accepting, or modifying PPE to suit their use.

The human element is an important aspect in developing and assessing a respirator certification program and in PPE guidelines and standards programs. Human wearers have their own requirements that impact directly on the devices and their performance. Thus, employees should be considered a part of the system, and they should be consulted in all aspects of research and development, certification, and programs. Research on the efficacy of respirators and respirator programs should adequately assess user aspects. In the SRUP and in prior collections, the focus of attention was mainly on the devices themselves and not on the users, the tasks performed, or the work environment.

PREVIOUS ATTEMPTS TO SURVEY RESPIRATOR USAGE

The SRUP took place against a backdrop of several prior surveys that were conducted to support the series of NIOSH hazard surveillance initiatives over the years. Some of these surveys were designed to allow estimation of the extent of use of PPE. All of them were completed prior to the creation of NPPTL.

Between 1972 and 1989, NIOSH conducted three national surveys that yielded databases containing mostly information about exposures to dangerous agents. The first two surveys—the 1972 to 1974 National Occupational Hazard Survey and the 1981 to 1983 National Occupational Exposure Survey—were conducted in establishments regulated by the OSH Act. The third—the 1984 to 1989 National Occupational Health Survey of Mining (NOHSM)—was conducted in mines regulated by the Mine Safety and Health Act.¹⁴

¹⁴Boiano, James M., and R. Delon Hull, Development of a National Occupational Exposure Survey and database associated with NIOSH hazard surveillance initiatives, Applied Occupational and Environmental Hygiene 16(2):128, 2001.

*National Occupational Hazard Survey (1972-1974).*¹⁵ This first NIOSH survey effort had its origin in recommendations of a Department of Health, Education, and Welfare Hazard and Disease Task Force, formed soon after the passage of the OSH Act of 1970.¹⁶ This survey was designed to collect data to describe the health and safety conditions in the American workplace, and to collect information on potential employee exposure to all chemical, physical, and biological agents. The survey used a stratified probability sample using the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses so as to be statistically representative of the respective nonmining, private-sector industries covered by the OSH Act of 1970. Consequently, coverage was limited to establishments with eight or more employees.¹⁷ The survey covered 4,645 facilities in 66 different two-digit Standard Industrial Classification (SIC) categories in 67 metropolitan areas, selected by a two-stage process involving stratification and systematic selection procedures.¹⁸

Data were collected using a standardized questionnaire and an observational facility walkthrough by 20 recent college graduates serving as field data gatherers. This staff of field interviewers included chemical engineers, industrial hygienists, and graduates of other disciplines, following a short training program by NIOSH. The questionnaires were administered to management and elicited information on facility demographics, type of health and safety activities and resources, and use of exposure controls (including respirators). National estimates of the number of employees in each industry surveyed were calculated by using payroll information and ratio estimation techniques.¹⁹

In addition to producing a list of agents to which employees were potentially exposed, the survey was used by NIOSH as input for setting research priorities and by OSHA as a part of the regulatory-setting mechanism for control of workplace hazards.²⁰ Although no information was collected specifically on respirator use, the survey helped identify target industries and sites at which a respirator use survey should be focused.

¹⁵National Institute for Occupational Safety and Health, *National Occupational Hazard Survey, Volume III, Survey Analysis and Supplemental Tables*, No. 78-114, Cincinnati, OH, 1978.

¹⁶Griefe, Alice, Randy Young, Mary Carroll, W. Karl Sieber, David Pederson, David Sundin, and Joe Seta, *National Institute for Occupational Safety and Health general industry occupational exposure databases: Their structure, capabilities, and limitations*, *Applied Occupational Environmental Hygiene* p 264, 1995.

¹⁷Sieber, W. Karl, David S. Sundin, Todd M. Frazier, and Cynthia F. Robinson, *Development, use, and availability of a job exposure matrix based on National Occupational Hazard Survey data*, *American Journal of Industrial Medicine* 20:163, 1992.

¹⁸Sundin, David S., *The National Occupational Hazard Survey: A difficult quest for a reliable data base*, *Occupational Health and Safety* May/June: 21, 1978.

¹⁹Sieber et al., op. cit., p. 166.

²⁰Frazier, Todd, *NIOSH Occupational Health and Hazard Surveillance Systems*, *Journal of Clinical Toxicology* 21(1&2):203, 1984.

*National Occupational Exposure Survey (1980-1982).*²¹ This survey dealt with employees in nonmining industries and was conducted at a representative sample of 4,490 workplaces in 39 different SIC categories. The survey was similar in design and scope to the 1972-1974 survey and, like that survey, was conducted by a team of 15 field interviewers. In a modification of the 1972-1974 survey, it collected data by gender and obtained information regarding respirator use. However, information about respirator use was only observational—if the field interviewers saw respirators in use at the time of the walk-through, the observation was recorded. Consequently, the survey did not permit thorough estimates of respirator use in industry. The survey did not collect any information on the existence of written respirator programs or fit-testing in establishments.²² The methodology did not permit an independent assessment of the quality of the data collected.

*National Occupational Health Survey of Mining (1986).*²³ This survey addressed the mining workforce. NIOSH conducted field surveys for the NOHSM from May 1984 through August 1989. The main objective of NOHSM was to identify the health-related agents found in the U.S. mining industry, per the U.S. Federal Mine Safety and Health Amendments Act of 1977. NOHSM included a total of 491 mines (60 coal mines and 431 metal and nonmetal mines) that employed 59,734 miners, representing 66 mineral commodities. The mines were selected from a total of 2,131 mines that employed 297,322 miners. Although NIOSH surveyed only a representative sample of mines in each mineral commodity, the data were projected over all of the mines in each of those commodities.²⁴

Each mine's survey included a questionnaire and a worksite visit. The data obtained during the questionnaire described company information, including four questions concerning PPE usage, programs, and corrective measures for refusal or failure to properly wear PPE. It obtained information on respirator use by respirator type and derived published projections of the number of iron and copper miners working with respirators. The projected results indicated that about 13 percent of workplaces in mining required PPE. The database that was generated associated PPE with potential exposures recorded during the worksite visits, including chemical substances, trade name products, physical agents, musculoskeletal overload conditions, welding-related prod-

²¹National Institute for Occupational Safety and Health, *National Occupational Exposure Survey, Volume I: Survey Manual*, Cincinnati, OH, 1987.

²²For information on use obtained during this survey, formal testing of the quality of that information was conducted.

²³Greskevitch, Mark F., Shib S. Bajpayee, Janet M. Hale, Dennis W. Groce, and Frank J. Hearl, *Results from the National Occupational Health Survey of Mining*, Technical Report No. 96-136, National Institute for Occupational Safety and Health, Cincinnati, OH, 1996.

²⁴*Ibid.*, p. xiii.

ucts, abrasive grinding materials, and bulk dust.²⁵ However, an evaluation of this study concluded that the NOHSM was incomplete in that it was not allowed, due to funding constraints, to complete resolution of the ingredients of many of the trade name substances that were identified.²⁶ Furthermore, it does not have any information on the existence of written respirator programs or fit-testing in establishments, nor was any formal investigation conducted about the quality of the information gathered.

*Survey of Existing Data and Economic Overview of the Respirator Industry (1982).*²⁷ The early NIOSH surveillance studies focused on hazards and exposures and only incidentally collected data on control measures and use of protective equipment. Until the late 1990s, the only study that focused on employee protection was a study that used market segment data based on respirator sales to estimate respirator availability in the workplace by industry. Using sales data provided by industry sources, this study estimated the availability of certified respirators and used those data, in combination with workforce-by-industry data, to generate a “ballpark” estimate of the number of employees using respirators of various types. Based on the estimated number of units sold in 1980 and the average useful life of the units, the study estimated the number of units in use at any time, and expanded that estimate to the number of employees (approximately 4.8 million) having access to certified respirators in 1980.²⁸

OSHA Personal Protective Equipment Cost Survey (1998). In addition to the several surveys sponsored by NIOSH to improve knowledge of hazards and respirator practices, OSHA conducted a Personal Protective Equipment Cost Survey in 1998.²⁹ This survey was conducted to support the rulemaking process leading to the development of a new Respiratory Protection Standard.³⁰ The goal of the survey was to estimate, for different types of PPE, the share of PPE costs borne by employers. Secondarily, the survey sought to estimate PPE use by type and industry.

²⁵Greskevitch, M.F., S.S. Bajpayee, J.M. Hale, and D.W. Groce, Results from the National Occupational Health Survey of Mining, Applied Occupational Health and Environmental Hygiene 12(12):924-931, 1997.

²⁶Campbell, Don, et al., Respirator Surveillance Team report to DRDS lead team, September 15, 1998, unpublished, p. 11. The incomplete identification of trade name ingredients may also have been due to the lack of an MSHA Communication Standard at the time this study was conducted.

²⁷The Granville Corporation, Draft Preliminary Survey of Existing Data and Economic Overview of the Respirator Industry, NIOSH Contract 21-81-1102, Washington, D.C., March 10, 1982.

²⁸Ibid., Exhibit 24, p. 41.

²⁹Eastern Research Group, PPE Cost Survey Final Report (Task Order 3, Contract J-9-F-0010), Washington, D.C., prepared for the Office of Regulatory Analysis, OSHA, Washington, D.C., June 23, 1999.

³⁰OSHA, Final Economic Analysis of OSHA’s Respiratory Protection Standard, 29 CFR 1910.134, U.S. Department of Labor, Washington, D.C., December 12, 1997.

TABLE 2.1 Respirator Use by Employment Size Group

Size	Percentage
Less than 20 employees	11.5
20-499 employees	23.1
More than 500 employees	56.5
All establishments	13.2

SOURCE: Doney, Brent C., Dennis W. Groce, Donald L. Campbell, Mark F. Greskevitch, William A. Hoffman, Paul J. Middendorf, Girija Syamlal, and Ki Moon Bang. 2005. A survey of private sector respirator use in the United States: An overview of findings. *Journal of Occupational and Environmental Hygiene* May:275.

The contracted survey consisted of 3,722 business establishments under OSHA jurisdiction. Some industries, including finance, real estate, insurance, and services, were excluded because the expected incidence of PPE use was believed to be minimal.

The survey sample frame (the list of all establishments in the population) was the Dun and Bradstreet business establishment database. The survey was conducted by telephone utilizing a computer-assisted telephone interviewing system and had a response rate of 47.1 percent (the response rate is computed based on the number of establishments that were available at the time of the telephone call and, thus, would be an overestimate of the survey response rate computed by today’s standards with a denominator including all eligible establishments in the sample). The survey divided establishment size into three categories—less than 20 employees, 20-499 employees, and more than 500 employees.

The OSHA survey estimated that 13 percent of all establishments (or an estimated 5.2 million employees) used respirators and that 8.3 percent of all employees wore respirators (28.7 percent of construction employees). It also found that larger establishments were associated with higher rates of respirator usage. It postulated that larger establishments are generally more complex and more likely to include operations that require respirator protection and, further, that smaller establishments may be less aware of the need for respirators (see Table 2.1).

These earlier surveys clearly served to whet the appetite of NIOSH for a comprehensive survey of respirator use that would yield not only estimates of the number of establishments and employees using respirators, but also salient facts about the characteristics of that usage. This interest led to commissioning the BLS to conduct the 2001 SRUP.

3

The Survey of Respirator Use and Practices: A Learning Experience

The objective of the Survey of Respirator Use and Practices (SRUP), as stated in the overview of the report, was “to provide information to develop educational interventions for specific populations and to increase the frequency and effectiveness of respirator use in the workplace.”¹ The survey was designed to provide estimates of the number of establishments and employees who used respirators in a recent 12-month period by type of respirator and type of use. Types of respirators were defined as powered air-purifying respirators, nonpowered air-purifying respirators, and air-supplied respirators. More detailed classifications under these three types were also to be collected—these types were defined as voluntary use, required nonemergency use, and required emergency use.

The survey also was designed to collect data on the characteristics of the respirator program at the establishment; assessment of medical fitness to wear respirators, characteristics of respirator training at the establishment, usefulness of National Institute for Occupational Safety and Health (NIOSH) approval labels and respirator manufacturers’ instructions, substances protected against by the use of respirators, and fit-testing methods used for respirators. The target population of the survey was private-sector establishments with employment covered by unemployment insurance programs that had been judged to be acceptable for use in estimation in the sample of the 1999 Survey of Occupational Injuries and Illnesses (SOII). Public-sector establishments and the self-employed were not included in the sample coverage for this survey.

The data to address these survey objectives had never been systematically collected by mail and telephone from

¹Bureau of Labor Statistics and National Institute for Occupational Safety and Health, *Respirator Usage in Private Sector Firms*, 2001; Washington, D.C., 2003, p. 1.

such a large number of establishments covering so many industries and size classes. NIOSH and the Bureau of Labor Statistics (BLS) would find that conducting this survey was a learning experience showing that successfully implementing such a survey is no easy matter.

NIOSH SURVEILLANCE STRATEGY

As stated earlier in this report, the survey was conducted under the auspices of the NIOSH surveillance initiative. In the late 1990s, NIOSH initiated several multidisciplinary initiatives to develop a hazard surveillance strategy for the agency. These initiatives included empowering an in-house team to develop options for a national hazard surveillance survey and database to update the data that had been collected in the 1970s and 1980s. The team considered three options for an ongoing hazard survey: (1) an on-site hazard survey like the previous NIOSH hazard and exposure surveys; (2) a telephone survey of management, much like a recently completed Occupational Safety and Health Administration Cost Survey;² and (3) a number of smaller hazard surveys targeted by industry or hazard.³ After considering the pros and cons of each of these options, the team recommended the comprehensive, on-site national survey option.

Although the main purpose of the survey options was to produce information on exposure to hazards, plans were extended to include gaining information on worksite safety and health strategies to include personal protective equip-

²Eastern Research Group, *PPE Cost Survey: Final Report*, Office of Regulatory Analysis, Occupational Safety and Health Administration, Washington, D.C., June 23, 1999.

³Boiano, James M., and R. Delon Hull, *Development of a National Occupational Exposure Survey and database associated with NIOSH hazard surveillance initiatives*, Applied Occupational and Environmental Hygiene 16(2):129, 2001.

ment practices. These rather ambitious plans were not implemented, and only a more narrowly focused effort to collect information on respirator use bore fruit.

Respirator Surveillance Team. The overall NIOSH surveillance program turned its immediate attention to the work of an internal NIOSH team—the Respirator Surveillance Team. This team conducted a study of options for surveillance of respirator use and integration of respirator surveillance into the ongoing NIOSH program of field investigations. The team had multiple objectives for the study: to inform a fiscal year 1999 respirator surveillance project, to provide information to other program teams and the certification program, and to inform other parties interested in the use of respirators to control occupational exposures.⁴

In consultation with staff of the respirator certification program, the Respirator Surveillance Team developed a list of questions that a respirator program might answer:

- Of the total U.S. workforce, how many employees use respirators?
- Of those employees using respirators, what respirator types are used?
- For each respirator type, what hazards are they used to protect against?
- Of those employees using respirators, how many are employed by firms with a complete written respirator program, with a designated program administrator, and with a program that includes hazard assessment, fit-testing, training, and maintenance?
- Of those employees with access to a complete program, what fit-test methods are used?
- Of those employees who are fit-tested, is fit-testing conducted by in-house personnel or by a private vendor of fit-testing service?

NIOSH personnel recognized that these questions were not suitable for direct administration in a field collection instrument. These are topical questions formulated to focus on the type of information to be developed.

It was further recognized by members of the Respirator Surveillance Team that the questions identified did not address a fundamental aspect of respirator protection—the acceptance of them by employees. The team had considered including provisions for exploring respirator acceptance by including an item such as: “Provide feedback to NIOSH about any aspects of respirator design or use that could be improved to promote respirator use when engineering controls are inadequate.” However, the team elected to focus only on aspects of respirator use that could be assessed

objectively with help from the employer alone.⁵ NIOSH personnel decided to forgo direct collection from employees (i.e., respirator users) themselves, setting the stage for a significant weakness in the eventual survey.

The Respirator Surveillance Team reviewed a number of options for collecting the necessary information. These options included repeating data collections along the lines of the National Occupation Exposure Survey and National Occupational Health Survey of Mining projects; a NIOSH interdivisional survey of occupational safety and health programs; surveys in collaboration with BLS; field studies; and focus groups. Considering these options, the team recommended several future actions that would lead to a survey of respirator programs.

Development of the NIOSH-BLS Working Agreement. In the end, NIOSH selected the option of commissioning a BLS survey and elected to enter into an Interagency Agreement with BLS. It did so for several reasons, not the least of which was NIOSH recognition that BLS is an unbiased, reliable, and objective source of expertise. Importantly, BLS had laid some of the groundwork for a respirator use survey by having established respondent contacts as part of its recent (1999) collection of SOII data. Finally, BLS had the methodological infrastructure to conduct such a survey. Nonetheless, this special-purpose survey constituted a new line of business for the Office of Safety, Health, and Working Conditions of BLS.

Although it is a large, multipurpose statistical agency, BLS had some limitations in conducting surveys of this type. Although well acclimated to the conduct of the large annual SOII and other regular collections, BLS had little experience in conducting special-purpose, reimbursable surveys in this field. Importantly, the agency had methodological expertise but did not have the field infrastructure to support a data collection effort of this scope and complexity. The agency would have to contract out data collection to the National Opinion Research Center at the University of Chicago.

The interagency agreement negotiated between NIOSH and BLS translated the overall objectives into a very specific statement of requirements. Data collected from the SRUP would be used by NIOSH “to identify by industrial sector and establishment size: (1) the distribution of respirator use, (2) the types of respirators used, (3) the hazards that respirators are used against, (4) the training of respirator users, (5) the extent medical examinations are used to qualify employees for respirator use for all respirator users, (6) the extent fit testing is used to qualify employees for respirator use, (7) the conductor of fit testing by users, (8) the distribution of fit test methods, (9) the training level of respirator program administrators, (10) the characteristics of respirator programs, and (11) the usefulness of NIOSH

⁴Campbell, Don, Al Dieffenbach, Dennis Groce, Ruth Ann Jajosky, and Greg Spransy, Respirator Surveillance Team report to DRDS lead team, NIOSH Internal Document, September 15, 1998.

⁵Campbell et al., op. cit., p. 5.

certification label.”⁶ It was envisioned that the findings of the survey would permit direction and evaluation of efforts to protect employees, by providing researchers with information to develop educational interventions for specific populations to improve respirator use in the workplace.⁷ Those agreements were carried forward into the Office of Management and Budget (OMB) clearance documentation submitted to OMB by BLS.

The process of development of the questionnaire was iterative and involved both agencies. As in most survey development projects, the final design was the product of many compromises, not the least of which was the trade-off between cost and quality. BLS also had the benefit of ongoing advice during the development phase from program panels of the Labor Research Advisory Council (LRAC) and the Business Research Advisory Council. These panels meet regularly to review programs and make recommendations for program changes and improvements. Both panels included the SRUP in their purview in 2000 and 2001.

The LRAC’s Committee on Occupational Safety and Health Statistics was particularly helpful in the evolution of the survey. In its meeting on December 12, 2000, the LRAC committee critiqued the plans and the proposed questions (after the initial cognitive tests but prior to the field test), identified questions that could be eliminated, and prioritized questions that it would like added. Among the issues raised by the LRAC were (1) the prevalence of both “voluntary”

and “routine” respirator use and how these two forms of use differ in participating establishments; (2) the prevalence of both “regular” and “emergency” respirator use and how these two forms of use differ in participating establishments; and (3) the duration of respirator use once employees have put them on (e.g., how long do employees wear respirators after putting them on and when do they take them off?).

The LRAC advised BLS of its priorities for information about respirator use in the workplace. LRAC priorities were (1) emergency response, (2) duration of use, (3) knowledge of who does the training, (4) determination of when the establishment last reviewed its program, and (5) knowledge of whether employees failed medical testing in the establishment’s respirator program.^{8,9}

BLS reported back to the LRAC after the initial round of data collection in November 2001. A member of the LRAC again asked if it was possible to capture public-sector respirator use data. A public-sector frame can be constructed in about 30 states that gather public-sector data for the SOII, but not in the others. However, it was decided to continue to restrict this survey to the private sector.

In the end, the OMB survey approval request form, required for all federal data collections involving the private sector, represented that series of compromises based on trade-offs. The OMB survey plans were approved and the survey was sent to the field.

⁶BLS, Supporting Statement, Information Collection Request.

⁷Federal Register, October 27, 2000, p. 64459.

⁸BLS, Labor Research Advisory Council, Committee on Occupational Safety and Health Statistics, minutes, December 12, 2000, p. 6.

⁹In the prepublication version of this report the statement was made that BLS did not implement LRAC recommendations related to respirator use in the workplace. Subsequent information received from the sponsor proved otherwise. Therefore the statement “None of these made the final cut” and the corresponding footnote were deleted.

4

Lessons Learned

Finding 1: The survey was an important first step in collecting respiratory protection data from a probability sample. As such, it was a worthwhile learning experience for both the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS).

Some of the lessons learned came early on in the survey process. For example, by November 2001, in the midst of the survey operation, BLS officials reported to the Labor Research Advisory Council (LRAC) Committee on Occupational Safety and Health Statistics that BLS had already learned some important lessons from conducting the respirator survey:

- *Funding was inadequate.* It “was originally pegged at \$450,000, but this was underestimated by several hundred thousand dollars.”¹ For BLS, this survey was a money loser. Undoubtedly, this affected the ability of BLS to perform and complete some labor-intensive tasks, such as preparation of adequate documentation.

- *Things dragged on too long.* “There was more ‘lag time’ in reaching consensus on the questionnaire content and wording and in obtaining Office of Management and Budget (OMB) approval than originally anticipated.”²

- *Dealing with a contractor was a learning experience as well.* As a result of this survey experience, “BLS had a better idea of what duties can be done ‘in-house’ versus contracted out.”³

The lessons learned by BLS were taken into consideration in critiquing the Survey of Respirator Use and Practices (SRUP). The committee’s task of critiquing the 2001 SRUP was approached with the thought that the analysis and recommendations in this section would be designed to help guide a subsequent survey of this scope and nature, and that this critique would be based on both published documentation and that provided by BLS and NIOSH.

Finding 2: There was insufficient documentation and detail for the committee to reconstruct key aspects of the methodology and to fully understand the survey design and implementation.

The lack of documentation was particularly true for the sample design, sample weighting, content development, and handling of missing data through “hotdeck” imputation. Although a serious deficiency, the lack of documentation on several aspects of survey design and implementation did not preclude an assessment of the adequacy and appropriateness of most aspects of the survey. The specific gaps in documentation are noted below where these topics are discussed.

This critique approximately follows the OMB framework for standards and guidelines for statistical surveys.⁴ The framework includes translation of concepts and methods into a questionnaire design; collection of data; processing and editing of data; production of estimates; data analysis and review procedures; and data dissemination.

¹BLS, LRAC, Committee on Occupational Safety and Health Statistics, minutes, November 28, 2001, p. 5.

²Ibid.

³Ibid.

⁴Office of Management and Budget, Proposed Standards and Guidelines for Statistical Surveys, Federal Register, July 14, 2005, pp. 40746-40747.

Questionnaire Development

The translation of survey objectives into the design of a questionnaire to obtain the required data was a dual responsibility of NIOSH and BLS. NIOSH participated in the development of the survey questionnaire by providing BLS with direction on technical subjects such as regulations, respirator types and uses, and specific substances that require respirator use. In a departure from the usual BLS arrangements, NIOSH actually developed the initial draft of questions for the survey.⁵

Finding 3: The survey questionnaire was not adequately related to the initial survey objectives.

The questions that were developed and asked in the survey did not relate to the original objectives for performing the survey. The survey became focused more on items that were measurable from the perspective of the employer respondents, and the questions elicited information focused more on regulatory compliance than on respirator use.

The BLS somewhat modified the NIOSH version of the questionnaire prior to the pretests. The BLS modifications were developed using Dillman's Total Design Methods,⁶ as well as other methods emphasizing formal design principles. The pretest version of the survey used during the cognitive interviews looked vastly different from the initial version, although it retained much of the language, item structure, and content. The stated BLS goal was to test the "semantic and linguistic features" during pretesting and obtain respondent reaction to the newly redesigned respirator survey form.

Assessment of instrument testing for this establishment survey was guided by a number of general principles. Unfortunately, there is no consensus set of accepted pretesting best practices. While a number of common procedures are widely used in establishment surveys—including cognitive testing, usability testing, and various types of field tests—there is no generally accepted procedure or combination of procedures for establishment survey instrument testing.⁷

⁵Fisher, Sylvia Kay, Kelley Frampton, and Ramona Tran, Pretesting the Survey of Respirator Uses and Practices (SRUP): Cognitive and field testing of a new establishment survey, Proceedings of the Annual Meeting of the American Statistical Association, August 5-9, 2001.

⁶Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000.

⁷For an example of a comprehensive development and testing program for an establishment survey, see the following: Goldenberg, K.L., A.E. Anderson, D.K. Willimack, S.R. Freedman, R.H. Rutchik, and Z.L.M. Moy, Experiences implementing establishment survey questionnaire development and testing at selected U.S. government agencies, presented at the International Conference on Questionnaire Development, Evaluation and Testing Methods, Charleston, S.C., 2002; Willimack, D.K., L. Lyberg, J. Martin, L. Japac, and P. Whitridge, Evolution and adaptation of questionnaire development, evaluation and testing methods for establishment surveys, in Presser et al., eds., *Methods for Testing and Evaluating Survey Questionnaires*, New York: John Wiley & Sons, 2004.

Pretesting is a required step in the preparation of BLS questionnaires. In the absence of a commonly accepted template, the SRUP pretesting program involved the integration of multiple methods, including expert review, cognitive interviewing, and field testing.

Cognitive Testing

A total of 12 cognitive interviews were conducted with 11 establishments during two rounds of pretesting. Nine establishments participated in the first round of interviews, which focused on the development of a satisfactory field-test instrument. The final three interviews were completed during a second round of testing after the field-test results were analyzed.⁸

The 11 companies that participated in the cognitive interviews were divided by BLS into three groups:⁹

1. Five large companies that reported having heavy usage of respirators among their employees: these large companies included a steel firm, a utilities company, a ship repair company, a construction firm, and a paint producing and distribution company (this firm participated in two separate interviews). All five sites had one or two safety coordinators or managers and/or industrial hygienist(s) at the company who participated in the interview.

2. Four midsize companies, two of which reported minimal or occasional respirator use and one that reported moderate respirator usage: these midsize companies included a sheet metal production company, two construction companies, and a scaffolding company. All four sites had a safety coordinator or manager and/or industrial hygienist at the company who participated in the interview. Three respondents participated in the cognitive interview with one of the construction firms.

3. Two small companies, one of which reported minimal use of respirators and a second that reported a significant amount of respirator usage: one of those companies was a scrap metal company, and the other was an auto body repair and paint shop. Neither company had a safety coordinator, manager, or industrial hygienist at the company; as a result the company owner or office manager completed the interview.

⁸Fisher, Sylvia Kay, Kelley Frampton, and Ramona Tran, Pretesting the Survey of Respirator Uses and Practices (SRUP): Cognitive and field testing of a new establishment survey, Proceedings of the Annual Meeting of the American Statistical Association, August 5-9, 2001.

⁹The establishments selected for cognitive interviews were primarily large- and medium-sized firms in which interviews were generally with "safety experts with extensive training in industrial hygiene and safety issues. . . ." This may have led to some underestimation of the difficulties that actual survey respondents might be expected to experience with the instrument.

All of the interviews were conducted on-site at the establishments, with a BLS occupational health and safety expert accompanying the trained cognitive interviewer. The interviews lasted about 90 minutes and were audiotaped. During these interviews, the respondents were shown a copy of the survey form as iteratively revised from previous interviews. The interviews followed a strict protocol designed to assess respondent comprehension and ease in responding and to identify any response problems ensuing from the form. The protocol queried respondents about the following:

- Survey title, introduction, routing of survey throughout the establishment; survey completion time; initial respondent reactions; other issues
 - Definition of major terms
 - Relevant documentation at the establishment
 - Air-purifying respirators (APRs) and air-supplied respirators (ASRs)
 - Establishment's respirator program and administration
 - Respirator fit-testing

BLS reported that the cognitive interview respondents made a number of observations that were useful in refining the survey instrument and designing the data collection. One important finding that emerged was that respondents in large establishments who were most likely to have specialized training in respirator protection programs appeared to understand a large proportion of the terminology used in the survey, so it could be concluded that there was little need to define the terms. However, when the cognitive interviews were extended to small companies where respondents had little or no specialized training, were less familiar with survey terminology, did not maintain records of respirator use, and did not necessarily conduct (or even know about) fit-testing and/or air-sampling procedures, the respondents had greater difficulty understanding the definitions of many technical terms used in the survey.

The cognitive pretesting unearthed other important observations that would be carried into the field-test and final versions of the SRUP including the following:

- Respondents uniformly agreed that the topic of respirators was an important one and appropriate for a large-scale NIOSH survey.
 - There was some concern that some noncompliant respondents would not complete the survey because they would fear that the survey would trigger a visit by a regulatory body. (BLS sought to allay this concern by adding a disclaimer at the front of the final version of the survey to the effect that data collected in the SRUP would be confidential and that the results would in no way initiate any Occupational Safety and Health Administration [OSHA] inspection.)
 - Many respondents did not know that “dust masks (with two bands)” are a form of respirator—respondents in

small establishments particularly exhibited this problem, but two safety professionals were also unaware of this fact.

- Respondents offered additions to both lists of substances (some of these were added to the final version of the SRUP).

BLS concluded that respondents liked the layout and design of the respirator survey as modified. The design staff moved on to the field-testing phase of questionnaire development.

Field Testing

The field test of questionnaire development was designed to yield more information on the cognitive, linguistic, and measurement issues in the collection of respirator use data. Some 120 establishments were selected on a statistically representative basis from the sampling frame that would be used when SRUP was implemented nationally. According to BLS, the field-test sample was chosen using OSHA and NIOSH estimates of Standard Industrial Classifications (SICs) that have a greater likelihood of respirator use. There is concern that the field test did not cover many establishments that use ASRs. BLS discussed with the Statistical Methodology Group which SICs were chosen to determine if these have a higher probability of air-supplied use. The BLS suggested a telephone follow-up to establishments in the field test that use ASRs in order to gain respondent's insight into that section of the survey. The BLS stated that six to seven of the establishments that participated in cognitive interviews used ASRs and as a result the air-supplied section has been tested somewhat extensively.

In many ways, the field test served as a dress rehearsal for the eventual survey operation—respondents were mailed a questionnaire; those who failed to respond to the initial mail-out (about 58 percent of respondents) received a telephone follow-up call after the 30-day collection period had expired to obtain their data over the phone or by fax. These telephone follow-up procedures increased the collection by an additional 38 percent, so the procedures resulted in a final overall field-test response rate of 80 percent; the final response rate for the actual survey was close—75.5 percent. Unlike the actual survey operation, however, those who responded were contacted to obtain their feedback on the survey, and those who did not initially respond were asked about their opinions and why they initially failed to complete the questionnaire.

Thus, 20 percent of field-test participants refused to participate or failed to comply with mail and telephone requests to do so. Why didn't they respond? Some were just too busy. Others reported that their companies do not respond to voluntary surveys, that the form was too long, or that it did not pertain to companies in their situations. As far as it went, the field test provided valuable insights that enhanced the survey operations.

Finding 4: *The field test paid little attention to exploring validation procedures that might have provided information on the quality of data collected or motivated the need for a formal quality assessment of the data, and thus missed an opportunity to improve understanding of the quality of the SRUP data.*

Several issues that might have been targeted for attention in the cognitive interviews and field tests were identified retrospectively. Some examples, not intended to be exhaustive, include the following:

- Often the respondent is presented with a “check all that apply” format, and there is some evidence in the survey literature that this approach, rather than requiring a yes or no answer to each response option, can lead to underreporting. Such questions are often interspersed with items using identically formatted response options, but with a “check only one” instruction. These features in concert might lead to increased response error.
 - Questions are sometimes preceded by a set of complex instructions or by boxed definitions connected by arrows whose purpose is unclear.
 - Respondents are asked to refer to their answers to previous questions in order to answer a current question.
 - Respondents are asked to volunteer unfamiliarity with “language or terms” in a particular question but without a provision to indicate exactly which words the respondent is not familiar with.
 - The 12-month reporting period, especially for voluntary behaviors (where records may be expected to be less complete than for required use) may have caused significant problems.
 - Unusual response scales are sometimes used. For example, in a five-point agree-disagree scale, the midpoint is rather oddly labeled “uncertain,” rather than the more common “neutral” or “neither agree nor disagree.”

These points are illustrative, not exhaustive, but they give a sense of the types of issues that a future cognitive interview or usability protocol might address. In view of the deficiencies noted above, it is the determination of the committee that much more could have been done to make the survey more user friendly and easier to navigate.

Finding 5: *Many features of the survey were not user friendly or optimally designed to aid navigation.*

The following are some of the usability and cognitive issues that might have been explored more directly in the pretesting:

- Usability
 - Actually reading instructions
 - Actually reading definitions

- Correctly following instructions
- Correctly using definitions
- Cognition
 - Comprehension of instructions
 - Comprehension of definitions
 - Determining whether the requested information is generally available to the respondents
- Data availability
 - Are records kept about the kinds of information requested in the survey?
 - Will multiple staff be required to provide all the requested information?

Finding 6: *There were several material weaknesses in the procedures for instrument testing.*

Among the issues that deserve further exploration in the event of a follow-on survey are the following:

- There appears to be insufficient follow-up of the problems, reported in several places, experienced by small businesses. The potential for a concentration of response error among small business could have important implications for the analyses.
 - Any use of a test-retest procedure to verify that revisions were actually improvements seems to have been slight or nonexistent.
 - There is no mention of the ability of respondents to report for the 12-month period requested in many of the questionnaire items (or, more importantly, whether a shorter reporting period might have improved accuracy for some topics).
 - Although it was mentioned that sometimes only training data were available in lieu of actual data, it does not appear that consideration was given to asking for the source of data for relevant items, which may have been useful in providing more informative, detailed descriptions of the nature of the reported data.
 - There is mention of problems with definitions or following skips, but little information is provided about the extent of such difficulties or what was done to address them.
 - Where changes were made, it is sometimes difficult to determine exactly what they were (e.g., “Reducing the number of columns and other strategies were implemented to make the two tasks required in Table 12 more apparent to respondents and to minimize the potential for respondent confusion”).
 - In other cases, it is not obvious how a particular change was responsive to the particular respondent problem; for example, “Both tables for respirator types by hazard types were too complex for respondents to follow—they had difficulty figuring out what their task was. The font size was

enlarged and reverse printing was substituted by a light shade of titles.”

- While it is noted that “there were very few reports of ambiguity or confusion about terms,” without knowing more about the test protocol it is not clear how well this was determined. A reliance on volunteered comments could well produce such a result, possibly missing many such problems.

In general, the documentation about the details of the testing, the resulting instrument revisions, and the efficacy of those revisions was inadequate. Although the testing appears, overall, to have uncovered a large number of problems, it is difficult to determine the effectiveness of the solutions without explicit examples or results of their retesting.

Questionnaire Content

The questionnaire that evolved from the pretesting processes had some fairly unique and innovative characteristics:

- It collected fairly extensive information on the person who was responsible for completing the questionnaire, including whether he or she was responsible for directing and overseeing the use of respirators and the person’s education, training, and experience.
- It reduced respondent burden by eliminating those establishments in which employees had not used respirators, or had not used them in the past 12 months, from further participation after just one or two substantive questions.
- It contained photos of respirator types (including a photo of the two-string dust mask that was not considered a respirator by many of the respondents in the pretests).
- It contained many text boxes that defined technical terms, as well as bulleted subpoints that elaborated on the meaning of the questions and the proper interpretation of the “yes,” “no,” and “don’t know” answers.

The questionnaire was divided into five major sections: information about the contact person, information about respirator use and general practices, questions pertaining to APRs, questions pertaining to ASRs, and information about fit-testing practices.

Sample Design

To understand the sample design for the SRUP, it is important to first review the sample design of the 1999 Survey of Occupational Injuries and Illnesses (SOII), from which the SRUP sample was taken. According to BLS documentation,¹⁰ a two-stage selection process was applied

¹⁰Bureau of Labor Statistics, *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1999, Appendix A: Scope and Method of Survey*, Bulletin 2551, Washington, D.C., 2002. pp. 422-423.

to generate the SOII sample. The first stage was the sample selection of establishments (sample units); then from within those sample units, sample cases were selected, based on days away from work. These sample cases yielded demographics and detailed case characteristic information.

The frame for the SOII was derived almost exclusively from the Quarterly Census of Employment and Wages (QCEW), or ES-202, program. These data include all establishments¹¹ subject to state unemployment insurance (UI) laws and federal agencies subject to the Unemployment Compensation for Federal Employees program. Each quarter, the state agencies edit and process the data and send the information to BLS in Washington, D.C.

In the SOII, an independent sample was selected for each state—an accommodation of the fact that the survey is a federal-state cooperative program and the data must meet the needs of participating state agencies. The sample was selected to represent all private industries in the states and territories. BLS documentation states that the sample size for the SOII was dependent upon (1) the characteristics for which estimates were needed, (2) the industries for which estimates were desired, (3) the characteristics of the population sampled, (4) the target reliability of the estimates, and (5) the survey design employed.¹²

Establishments in each SOII stratum were selected for the survey based on the reported total number of lost workday cases. A key feature of the sample design is its use of stratified random sampling with a modified Neyman allocation¹³ of the sample among strata. The establishments were stratified by state, SIC, and employment size class. Because these characteristics are highly correlated with an establishment’s number and rate of recorded injuries and illnesses, stratified

¹¹The definition of establishment for the SRUP was based on the QCEW, which provided the sampling frame for both the SOII and the SRUP. All employers covered by state UI laws are required to submit monthly employment figures representing the number of people either working during or receiving pay for the payroll period including the twelfth of the month and the total wages paid during the quarter. An establishment is usually a single place of business, which is engaged in a single business activity and operated by a single employer. Business firms operating more than one establishment, in which the sum of employment in secondary locations totals 10 or more persons, are required to submit a separate report for each unit unless the payrolls are not maintained separately. If two or more units of a single employer are in a single physical location, but maintain separate payroll records and engage in distinct or separate business activities, then each unit is treated as a separate reporting unit. These definitions are standard for all BLS and Census establishment-based surveys. The QCEW program conducts ongoing surveys to verify and update the location and type of economic activity occurring at each establishment.

¹²*Ibid.*, p. 422.

¹³The Neyman allocation is designed to produce the minimum sample size that will provide an estimate with a fixed sampling variance. For the largest employment size classes, the allocation procedure places all of the establishments of the frame in the sample; as employment decreases, smaller and smaller proportions of establishments are included in the sample. Bureau of Labor Statistics, *Handbook of Methods*, Chapter 9: Occupational Safety and Health statistics; Available at http://www.bls.gov/pub/hom/homch9_g.htm.

sampling provides greater precision and, thus, results in the need for a smaller sample size than a comparable simple random sample of establishments.¹⁴

According to study documentation, the sample size for SOII varied by state depending on the number of estimates, desired precision, and budgetary constraints. Establishments were selected within the “target estimation industry” (TEI) strata. These strata varied by states, since states set TEIs that they are interested in publishing. The TEIs are equivalent to different-level North American Industry Classification System (NAICS) codes—a state may set some six-digit NAICS, some five-digit NAICS, and some three-digit NAICS as its TEIs. Another state may only set two-digit NAICS as its TEIs. All aggregations from the level of the TEI up are also published if they meet publication criteria. The national office sets TEIs for national estimates. No specification was given as to how this sample was chosen from the frame of eligible businesses. Most likely, stratified simple random sampling (without replacement) was used, but this can only be speculated.

Study documentation suggests that the allocation used in the SOII sample was a modified Neyman allocation that was directly related but not strictly proportional to the amount of variation in key study measurement within strata.¹⁵ No rationale for the modification or why the lost workday case (LWDC) ratio was used as the outcome measure for the allocation decision was provided to the committee. If reasonable information on within-stratum variation of the key study measures was available for each stratum, this allocation would be optimum in some sense (i.e., produce minimum variance for fixed sample size or cost) for SOII key measures but not necessarily for key outcome measures for the SRUP.

More specifically, five parameters were considered in determining the sample size for each SOII sampling stratum:

1. Target relative standard error for total lost workday cases
2. LWDC ratios (LWDCs in the set divided by total employment in the set)
3. Coefficient of variation (CV) for LWDC
4. Frame unit counts
5. Frame employment counts

For all strata involving the largest size class, all frame units were selected, and the allocation formula used in each of the remaining strata can be seen in Figure 4.1.

$$n = \frac{E \times C \times R \times \sum (E \times C \times R)}{D + \sum (E \times C \times R)^2 / N}$$

where

n = allocated sample size

E = total frame employment

C = CV of LWDC

R = LWDC ratio

N = number of frame units

D = target variance

\sum = summation over size classes 1 thru 4

FIGURE 4.1 Neyman allocation equation. SOURCE: Burdette, T., and S. Lang. 2003. Occupational Safety and Health Survey of Occupational Injuries and Illnesses, sample design. Presentation at SOII Sample Design Seminar.

A practical outcome of the Neyman allocation was that the largest employment size classes, with their greater variation in study outcome measurements, were in the sample with certainty (certainty strata), and smaller proportions of medium and small establishments with smaller variation were included in the sample. The certainty strata are usually composed of establishments with 1,000 employees or more.

SRUP Sample Frame

An ideal “target population”¹⁶ for a survey of respirator use in the workplace would have been (1) all establishments (i.e., physical locations at which one or more persons are employed) in the United States and (2) all persons working at these establishments. As quite often happens in survey operations, the sample frame turned out to be something other than the target population, for practical reasons. The frame file that was used to select the respirator survey sample consisted of units that were coded usable for estimation in the 1999 SOII. These frame units were all respondents to the 1999 survey and were familiar with BLS, and contact names from the 1999 survey were also included on the file so that respondents could be recontacted, if needed. Because of these factors, BLS had expected a better-than-usual response rate to this voluntary survey.

The SOII sampling frame exclusively used the QCEW lists. As a result, this SOII sampling frame became somewhat problematical for the SRUP because it restricted the sample coverage of the SRUP to the private sector, but not all of the

¹⁴Ibid., p. 423.

¹⁵Cochran, W.G., *Sampling Techniques*, 3rd Edition, New York: John Wiley & Sons, 1977.

¹⁶For a definition of target population, see Lessler, J.T., and W.D. Kalsbeek, *Nonsampling Errors in Surveys*, New York: John Wiley & Sons, 1992.

private sector. Although the QCEW currently covers approximately 98 percent of all employment, the major exclusions from unemployment insurance coverage—the self-employed and certain nonprofit organizations—tend to represent a significant fraction of the workforce in some sectors in which respirator use may be significant. For example, the self-employed exceed 20 percent of the construction workforce.¹⁷ Many of these self-employed construction workers may have the same occupational health and safety issues as regular employees. Some may even be misclassified as self-employed subcontractors. A recent study estimated that more than 14 percent of all construction establishments in Maine misclassified employees as independent contractors (not covered by unemployment insurance).¹⁸ Because small-employer-dominated sectors such as construction are associated with high risks, high rates of respirator use, and generally poor compliance, targeted surveillance may be necessary to evaluate the adequacy of such a sampling frame. Other uncovered employee groups—such as temporary employees, employees of very short-lived establishments, and informal sector employees—are also likely to be missed when the unemployment insurance list is used as a frame. Of course, consumers using respirators at home are also missed. (Presumably these are outside the scope of where the National Personal Protective Technology Laboratory [NPPTL] should be directing research).

SRUP Sample Size

The overall sample size for the SRUP was determined as follows. First, note that the supplemented subsampling frame for the SRUP (i.e., the set of SOII respondents) had been reduced to 40,002 private industry establishments for the SRUP by an iterative process in which design considerations were tempered by cost constraints. Considering that few historical data were available, BLS statisticians made some assumptions about needed standard errors of SRUP and thereby determined sample sizes for various sample designs. It was established that a sample of 23,400 establishments would produce industry division estimates with a 5 percent relative standard error (RSE), and that 48,750 sample units would produce estimates at the two-digit SIC level with a 10 percent RSE. The 40,002 figure was a compromise between the two designs and was determined with cost in mind.

Finding 7: NIOSH did not set specific precision objectives for key estimates of population subgroups from the SRUP.

¹⁷Hipple, Steven, Self-employment in the US: An update, Monthly Labor Review July:21, Table 7, 2004.

¹⁸Carre, Francoise, and Randall Wilson, The Social and Economic Costs of Employee Misclassification in the Maine Construction Industry, Construction Policy Research Center, Harvard Law School and Harvard School of Public Health, Cambridge, MA, April 25, 2005.

In the absence of clear precision goals it is therefore difficult for the committee to assess the adequacy of sample sizes for the overall population and for various population subgroups (e.g., by region, by type of business), since the only known precision constraint (used in determining the overall sample size) was set by BLS staff.

SRUP Stratification and Sample Allocation

The sample of establishments chosen for the SRUP was stratified in much the same manner as the SOII, and the overall SRUP sample size was strategically allocated among strata. The SRUP sampling strata were constructed by cross-classifying by the following two-digit industry codes and size classes:

- The following industries, classified based on the 1987 SIC Manual, were included in this survey: agriculture, forestry, and fishing, SIC 01-09; metal mining, SIC 10; coal mining, SIC 12; oil and gas extraction, SIC 13; sulfur mining, part of nonmetal mining, SIC 14; construction, SIC 15-17; manufacturing, SIC 20-39; railroad transportation, SIC 40; transportation and public utilities, SIC 41-42 and 44-49; wholesale and retail trade, SIC 50-59; finance, insurance, and real estate, SIC 60-67; and services, SIC 70-87 and 89.
- The five size classes were size class 1 = 1-10 employees; size class 2 = 11-49 employees; size class 3 = 50-249 employees; size class 4 = 250-999 employees; and size class 5 = 1,000 and more employees.

This sample was supplemented by sample units for SIC 10, 12, 14, and 40, which were not in scope for the 1999 survey. These sample units were provided to BLS by the Mine Safety and Health Administration and the Federal Railroad Administration.

While the stratum variables for the SOII and SRUP are the same, it should be noted that the strata formed for the SRUP were not precisely the same as those used in choosing the SOII sample. BLS modified the SRUP strata to conform to two-digit SIC codes and size classes.

Sampling stratification is used to improve the precision of overall estimates aimed at the target population; it may also be used to disproportionately increase the sample size of small, but important, population subgroups that can at least be partially isolated by sampling strata.¹⁹ While the rationale behind forming the sampling strata for SRUP (i.e., defined by the SIC and the number of employees) was not explicitly indicated, it appears that their main practical utility was to define population subgroups for which estimates (e.g., the number of industries using respirators) would later be produced for the SRUP report of findings. This is an appropriate strategy, for which the BLS sample designers are to be commended.

¹⁹Kish, Leslie, Survey Sampling, New York: John Wiley & Sons, 1965.

The sample for the SRUP was allocated to its sampling strata based on OSHA estimates of the percentage of establishments using respirators. The expected number of establishments that used respirators in each stratum was based on the OSHA Personal Protective Equipment Cost Survey, conducted in 1998-1999.²⁰

Finding 8: The choice of stratification variables for the SRUP sample design appears to have been appropriate, since many of the survey's reported findings by type and size of industry were quite different (e.g., respirator use). The rationale for using the allocation for the SRUP subsample among strata was to maximize the yield of companies with higher rates of respirator usage. This allocation, which made each stratum sample proportional in size to the expected number of establishments in the stratum that use respirators, may not have been optimal to improve the precision either of overall survey estimates or of estimates for population subgroups defined by the strata, but it did serve to increase the proportion of sample companies that reported respirator use.

SRUP Sample Selection

Within each SRUP stratum, the subsample of establishments was selected using an adaptation of the probability-proportional-to-size systematic sampling method. The purpose of the adaptation was to minimize variation in selection probabilities (and thus the sample weights used for analysis) within each stratum. This was accomplished by selecting each member of the sample in each stratum by using its final adjusted SOII sample weight as its “size” measure. Sample selection in this manner was accomplished using a BLS in-house selection software package called the Sample Unit Extract sampling algorithm.²¹

Implications of the SRUP Two-Phase Sample for Analysis

An advantage of the two-phase or double sampling that was used for the SRUP is that the SRUP sample is a subsample of the SOII respondent sample, implying that survey data from the SOII could be linked to each SRUP respondent record. Moreover, these linked data could have been used to produce potentially more precise SRUP estimates.

Finding 9: More could have been done with the characteristic of the SRUP being a subset of the SOII to build strength into the estimates in that a sample that is the second phase of a “two-phase” or “double” sample can gain power from the first-phase sample.

The first phase in a two-phase sample can improve stratification or estimation in the second phase, if utilized appropriately. To do both, the strata must be defined consistently (if not identically) in both phases of sampling, to permit analysis of the SRUP sample as a two-phase sample. It was not clear from the documentation of the SRUP sample if stratum consistency in this way was attempted. Inconsistency between the SOII and SRUP strata limits the ability of the two-phase SRUP sample to be analyzed as such. For instance, it is not clear if the use of ancillary data from the SOII was considered to improve the precision of SRUP estimates through regression or ratio estimation.²²

Data Collection

Overall Assessment

Finding 10: The SRUP used a basic collection design that is fairly typical of many establishment mail surveys conducted by federal agencies. However, the SRUP data collection design did not use several state-of-the-art techniques that would likely have produced a higher response rate and enhanced data quality.

Overview of the Data Collection Process

Because BLS lacked a field infrastructure to conduct this survey, it engaged the National Opinion Research Center (NORC) to perform a number of functions for this survey. Most basic survey functions were contracted out, including mail-out, check-in of questionnaire, data entry, nonresponse mailing, and nonresponse callbacks. In turn, NORC subcontracted the survey mail-out, check-in, data entry, and nonresponse mailing functions to Data Service Solutions (DSS) of Plainfield, Illinois.

The survey was mailed to sampled employers in August 2001 by DSS. The subcontractor conducted a nonresponse mailing in October 2001. This nonresponse mailing consisted of resending the original questionnaire to the nonrespondents.

Telephone nonresponse callbacks were performed by NORC from December 2001 through February 2002. At the start of telephone nonresponse callbacks, the response rate was 48 percent. The final response rate for the respirator survey was 75.5 percent. In essence, this means that the collection mode for two-thirds of the survey respondents was mail and for one-third of the respondents was telephone.

Survey Respondent

The questionnaire was addressed to a named individual in each sampled establishment—the person who responded

²⁰See Chapter 2.

²¹This generalized BLS sampling system has subsequently been replaced by a system specific for occupational safety and health.

²²Cochran, W.G., *Sampling Techniques*, 3rd Edition, New York: John Wiley & Sons, 1977.

to the 1999 SOII survey. Addressing the questionnaire to a specific person in the establishment has been shown to produce higher response rates,²³ especially when, as in the case of the SRUP, the contact person has participated in a prior BLS survey. However, while the 1999 SOII respondent may have known whether or not the establishment used respirators, it was often likely that this person was not the desired respondent, defined as “the person most familiar with the use of respirators at the Reporting Site.” Thus, it was necessary to rely on the initial questionnaire recipient to forward the questionnaire to someone else who fit that description, which made follow-up contacts more difficult and less effective. Also, there was a risk that the initial questionnaire recipient would not forward the questionnaire and, instead, would provide an uninformed response to the survey or no response at all.

Identifying the best-qualified respondent in advance of the questionnaire mailing has been shown to be an important contributor to data quality and high response rates.²⁴ This approach would have offered several advantages:

- It would have removed businesses that had not used respirators in the past 12 months, or had used them only on a voluntary basis, from further involvement, thus allowing the mail survey to focus on the establishments of interest (i.e., those that had required respirator use in the past 12 months). Had this approach been used in the SRUP, it would have eliminated 84 percent of the sample establishments.²⁵

- It would likely have improved the accuracy of the data collected because the data source would have been prescreened knowledgeable respondents.

- Response rates to the mail survey would likely have been higher because the advance telephone contact with the respondent would have helped establish rapport, and the short telephone interview followed by the longer mail questionnaire would have benefited from the “foot in the door” phenomenon (i.e., getting respondents to perform a large task by first asking for their help with a smaller task).²⁶

²³Paxon, M.C., D.A. Dillman, and J. Tarnai, Improving response to business mail surveys, in B.G. Cox, D.A. Binder, B.N. Chinnappa, A. Christianson, M.J. Colledge, and P.S. Kott, eds., *Business Survey Methods*, New York: John Wiley & Sons, 2000, pp. 303-315.

²⁴Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000; Paxon, M.C., D.A. Dillman, and J. Tarnai, Improving response to business mail surveys, in B.G. Cox, D.A. Binder, B.N. Chinnappa, A. Christianson, M.J. Colledge, and P.S. Kott, eds., *Business Survey Methods*, New York: John Wiley & Sons, 2000, pp. 303-315.

²⁵In the 2001 SRUP, 72 percent of the sample did not use respirators and answered only two introductory questions. Another 12 percent used respirators on a voluntary basis only or used them on a required basis but not in the past 12 months. These establishments answered the four introductory questions and only one or two questions in Section 1 of the questionnaire.

²⁶Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000.

While this approach would have added the cost of a round of telephone calls to all establishments prior to the start of the mail survey, it would have greatly reduced the size of the mail survey and nonresponse telephone follow-up, with attendant savings in labor, postage, telephone, and related costs, and would have likely resulted in a higher response rate and enhanced data quality.

Number and Types of Contacts

The data collection protocol included a questionnaire mailing, a replacement questionnaire mailing to nonrespondents about six weeks later, and a telephone contact to remaining nonrespondents two to four months after that. This is a basic design that is fairly typical of establishment mail surveys conducted by federal agencies. Use of the telephone as the final contact is an effective method for increasing response rate and is particularly appropriate for surveys such as the SRUP that have a high ineligibility rate.²⁷

Although the SRUP approach is typical of federal establishment surveys, research has shown that more contacts generally produce faster response and higher response rates.²⁸ Also, the timing of the replacement questionnaire mailing and the nonresponse follow-up calls was not ideal. Had the SRUP rigorously followed the Tailored Design Method advocated by Dillman,²⁹ generally recognized as the premier authority on mail surveys, the design would have included the following:

- Sending a brief pre-notice letter a few days in advance of the questionnaire mailing (this could have been omitted if the advance telephone screening call had been made, as described above);

- Sending a thank-you or reminder postcard a week after the questionnaire mailing;

- Sending the replacement questionnaire mailing two to four weeks after the initial questionnaire mailing; and

- Making the nonresponse follow-up calls beginning one week after the replacement questionnaire mailing. (If the advance telephone screening call had been made, the sample size would have been greatly reduced and would have allowed for fairly prompt completion of the nonresponse follow-up calls.)

²⁷Ibid.

²⁸Dillman, D.A., *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley & Sons, 1978; Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000; Paxon, M.C., D.A. Dillman, and J. Tarnai, Improving Response to Business Mail Surveys, in B.G. Cox, D.A. Binder, B.N. Chinnappa, A. Christianson, M.J. Colledge, and P.S. Kott, eds., *Business Survey Methods*, New York: John Wiley & Sons, 2000, pp. 303-315.

²⁹Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, New York: John Wiley & Sons, 2000.

Response Rate

The final response rate for the survey was reported to be 75.5 percent³⁰—somewhat higher than the 70 percent anticipated response rate that was projected in the OMB clearance documentation for the survey. According to a presentation made by BLS to the committee,³¹ the response rate was computed as follows:

- 40,002 total sample
- 37,989 viable (eligible)
- 28,682 responses
- 28 unusable
- 28,654 clean
- 75.50 percent response rate.

The committee notes that there are two problems with the computation of the response rate in this manner:

1. Most (84 percent) of the 28,682 responses were from establishments that did not use respirators, or used them only on a voluntary basis. These establishments only completed up to four introductory questions. The focus of an important part of the analysis of SRUP data was on establishments that used respirators on a required basis in the past 12 months. The response rate for this group could have been computed using information on respirator use collected during establishment contacts as part of nonrespondent follow-up, but it was not reported. The response rate for respirator users would have provided another useful indication of the effect of nonresponse on SRUP findings.

2. The calculation that produces the 75.5 percent response rate just includes the SRUP and does not consider nonresponse to the SOII. Since the SRUP is actually a sub-survey of the SOII survey respondents, a more appropriate response rate for the SRUP would be the product of the response rates at each phase.

Finding 11: The reported overall SRUP response rate of 75.5 percent paints an incomplete picture of the impact of nonresponse on all key SRUP findings. In addition to findings on the percentage of respirator use among all companies in the sample, the survey findings also focused heavily on companies with required respirator use, and the response rate among these companies is not reported.

Although the published response rate as computed in the manner described above met the expectation of the survey

managers, the response rates might have been better. The SRUP did not use several data collection procedures that have been shown to increase mail survey response rates. According to Dillman's Tailored Design Method, the SRUP would have benefited from the following:

- Make an advance telephone screening call to identify the best-qualified respondent and eliminate ineligible establishments (i.e., those that have not required use of respirators in the past 12 months).
 - Send a pre-notice letter (this can be omitted if an advance screening call is made) and a thank-you or reminder postcard, for a total of five contacts.
 - Follow Dillman's recommendations cited above concerning the timing of the contacts.
 - Personalize all mailings (address the questionnaire recipient by name). Print the transmittal letters on a NIOSH or BLS letterhead. Include a date and a signature. Include a toll-free phone number to call if the respondent has questions (a phone number was included in the initial questionnaire transmittal letter, but it was not toll free). Use a different, stronger appeal in the transmittal letter that accompanies the replacement questionnaire mailing to nonrespondents (the SRUP simply remailed the original letter or questionnaire). Follow Dillman's guidelines for the format and content of the mailings.
 - Use real stamps instead of "business reply" postage on the return envelopes included in the two questionnaire mailings.

Nonresponse Follow-up

BLS trained NORC telephone nonresponse callback personnel in types of respirators, background of the survey, background of the BLS sample, and an interactive test on respirators (similar to the one NIOSH provided BLS). Because NORC has a great deal of experience in procedures for survey nonresponse callbacks, BLS did not conduct training in this area. During the telephone nonresponse callback, employers who responded that they had not used respirators in the past 12 months had study data collected during the call and keyed into a data set that NORC delivered to BLS. Employers who responded that they had used respirators for required emergency or nonemergency use in the past 12 months were prompted to send in their questionnaire, and the data were keyed into a data set and delivered to BLS. (This prompting was done because the length of the questionnaire made it difficult to collect all items over the telephone.) For employers who did not mail back a questionnaire after responding "yes" during nonresponse callback, data were imputed from usable similar responses in the sampling strata.

Nonresponse callbacks were made by experienced NORC telephone interviewers, following training on the survey content by BLS staff. Case management software was used to schedule calls and control the caseload, and

³⁰Bureau of Labor Statistics and National Institute for Occupational Safety and Health, *Respirator Usage in Private Sector Firms*, 2001, Bureau of Labor Statistics, Supporting Statement Survey of Respirator Use and Practices, 2003, p. 258.

³¹Wiatrowski, William, and William McCarthy, *BLS Survey of Respirator Use and Practices*, 2001, Powerpoint presentation, December 1, 2005, Slide 42, p. 21.

a computer-assisted telephone interview application was used to guide the telephone contact and capture the data collected.

In reviewing the SRUP protocol, the committee observed that there was no provision for a follow-up contact of refusals; if the person contacted refused to provide the requested information, the case was coded out as a final refusal. This is surprising because a conversion attempt by another telephone interviewer, often a specially trained telephone “converter,” is a fairly standard component of many federally funded telephone surveys. It should have been possible for an experienced converter interviewer to obtain answers to the screening questions regarding respirator use for a significant percentage of refusal cases. This would have resulted in a completed interview for non-respirator-using establishments, thereby increasing the overall response rate. It would also have helped identify additional respirator use establishments among the nonrespondents, which would have helped inform the post-data collection imputation process. This would also have contributed to determining a response rate for the target population of respirator use establishments.

Data Processing Errors

The data processing stage of a survey is another potential source of error. The most common types of processing errors can occur at the data entry and editing stages of the survey. With responsibility for overall data collection, the NORC subcontracted the survey mail-out, check-in, data entry, and nonresponse follow-up functions to DSS. There is no indication that there were any quality issues with the data entry stages of the survey. Indeed, with quality management techniques, key entry is not a very error-prone operation.³² The survey questionnaire data were double-keyed to minimize the potential for data entry keying errors. This is an appropriate quality-enhancing measure.

More substantial errors can arise in data editing, since this step is susceptible to errors in the specification of models for identifying which data should be flagged for editing and in the procedures for dealing with them once they are identified. In this stage, BLS identified 161 levels of potential error and set up protocols for deciding which responses needed a follow-up action. When inconsistent or potentially invalid responses were identified, trained BLS personnel recontacted the respondents for clarifications. Training for BLS personnel responsible for these callbacks was extensive. This training consisted of background information on the survey, identifying respirator types (including an interactive test similar to the one provided to BLS by NIOSH), a complete review of the questionnaire, and training to conduct effective telephone interviews (including role playing).

Although there is evidence that these careful procedures were followed, there was no systematic compilation of the

results of the edits and recontacts, so it is not possible to assess the adequacy of these measures. A compilation of the results of the edits and recontacts could have been analyzed to see what could be learned about the reasons for the edit problems. Before conducting a similar survey in the future, it would be informative to analyze the changes made in the SRUP as the result of the editing process (i.e., compare the original keyed data with the final cleaned data set) to identify the frequency and types of edit problems encountered and problems with the questionnaire content or format that may have contributed to the edit problems.

Finding 12: The performance of extensive machine editing and error resolution follow-up contacts showed commendable attention to resolving inconsistent and invalid responses.

The committee is concerned that no assessment was made of response and nonresponse bias. The following are some measures that could have been taken to address data quality, but were not employed in this survey:

- Select a sample of respondents who said they did not have respirators and call them back. Explain that BLS is conducting a quality check and ask the persons how certain they are that the company does not use respirators. If the person is uncertain, ask to speak to someone who would know this information. This is an example of a “true value re-interview” study to estimate response error³³ or a “response analysis survey” toward the same end.³⁴
- Select a sample of “final” nonrespondent establishments and call them back. Ask to speak to the person most knowledgeable about respirator use (who may or may not be the person to whom the mailings were addressed) and explain that BLS is conducting a quality check and just needs to know if the company uses respirators. This would have enabled BLS to estimate the response rate among companies that use respirators (which could be considerably different from the overall response rate) and would have provided an important indication of the potential for nonresponse bias among companies using respirators.
- As a related point, ancillary information from the SOII might also have been used to assess the effect of bias due to unit nonresponse, since there would have been SOII substantive data (i.e., related to the purpose and key measurement outcomes of the study) that would be available for SRUP respondents and nonrespondents (since the SRUP sample was selected from a subset of SOII respondents).

³³Biemer, P.P., and R.S. Fecso, Evaluating and controlling measurement error in business surveys, in B.G. Cox, D.A. Binder, B.N. Chinnappa, A. Christianson, M.J. Colledge, and P.S. Kott, eds., *Business Survey Methods*, New York: John Wiley & Sons, 1995.

³⁴Dippo, C.S., I.C. Young, and J. Sander, in B.G. Cox, D.A. Binder, B.N. Chinnappa, A. Christianson, M.J. Colledge, and P.S. Kott, eds., *Business Survey Methods*, New York: John Wiley & Sons, 2000.

³²Federal Committee on Statistical Methodology, op.cit., p. 7-2.

When one has substantive data for both respondents and non-respondents, it is possible to directly estimate nonresponse bias,³⁵ at least for SOII key outcome measures, which would have given BLS an indication of the effect of nonresponse on the SRUP data.

Weighting and Estimation

While BLS seems to have followed industry standards in producing sample weights for SRUP data, the weighting process appears to have been poorly documented (based on materials available during the course of the committee's assessment). Little documentation was available from BLS regarding the weighting approach followed. Moreover, no rationale or detailed formulas (to provide a complete assessment of the approach) were available.

More specifically, weighting in a two-phase sample should account for sampling and nonresponse in each phase, with final calibration of the nonresponse-adjusted weights to the target population (defined here as those businesses in the SOII frame that meet the eligibility requirements for inclusion in the SRUP). It appears that the final adjusted SRUP sample weights account for Phase 2 sampling rates and nonresponse, with calibration to the SRUP target population somehow (the source(s) of calibration data are not indicated). Thus, it appears that Phase 1 sampling and nonresponse may not have been directly accommodated in computing the weights.

Adjustment for Unit Nonresponse

Compensation was made for two levels of nonresponse in this survey. The first level was establishment (i.e., unit) nonresponse adjustment. For each sampling stratum—two-digit industry and size class—a nonresponse adjustment factor was computed as the sample count of the study-eligible establishments in the stratum divided by the corresponding number of usable establishments in the stratum. Sample establishments that were out-of-business or post office returns from both mailings were considered ineligible. Usable questionnaires were responses that had no outstanding level 1 or 2 edits that caused the schedule to be unusable in final estimates. If a sampling stratum did not have any usable questionnaires, the stratum was combined with all other size classes in the two-digit industry, and nonresponse adjustment was computed for those strata at the two-digit industry level.

Unit nonresponse in population samples often leads to unplanned imbalance in the sample due to differential rates of nonresponse in the selected sample. The degree and nature of this imbalance in SRUP is not known, since the final response rate of sample businesses is not given and findings from an assessment of patterns of response rates to indicate

the degree of sample imbalance due to unit nonresponse were not conducted. An assessment of patterns of nonresponse typically precedes the calculation of a weight adjustment to compensate at least partially for the biasing effects of this sample imbalance.

For stratified establishment samples, this weight adjustment for any responding establishment is computed by multiplying the inverse of the establishment's selection probability by the inverse of its estimated response propensity (i.e., the inverse of the response rate among all study-eligible establishments in its stratum). This approach is called a weighting class adjustment for nonresponse,³⁶ where the "weighting classes" are the sampling strata for the SRUP. If the variables used to define SRUP strata are highly correlated with key study measures for the SRUP (presumed) and response rates differ among SRUP strata (unknown), then this adjustment will successfully reduce (but rarely eliminate) the bias due to unit nonresponse.

Calibration Adjustment

The final adjustment of sample weights is typically a multiplicative adjustment to adjust the existing weights so that the distribution of the final set of weights matches the corresponding distribution of the target population with respect to variables that are thought to correlate with key study variables. This calibration process, also called "post-stratification," or an adaptation known as "raking" is done to improve the precision of survey estimates and to adjust for other factors that may lead to biased or imprecise estimates (e.g., time differences between when the frame was constructed and when sample data are obtained, differentially incomplete frame coverage).

The SRUP sample was apparently calibrated to population frequencies from the BLS Covered Employment and Wages, or ES-202, program.³⁷ A benchmark factor was computed for establishments and for employees. The final weight used for respirator survey establishment and employment estimates was the final sampling weight multiplied by the nonresponse adjustment factor times the benchmark factor for establishments.

Effect of Variable Weights

Previous research has shown that variable weights can increase the variance of survey estimates (and thus reduce their statistical quality) in an amount that is directly related to how variable the weights are.³⁸ No indication of the

³⁵Lessler, J.T., and W.D. Kalsbeek, *Nonsampling Errors in Surveys*, New York: John Wiley & Sons, 1992.

³⁶Bureau of Labor Statistics and National Institute for Occupational Safety and Health, *Respirator Usage in Private Sector Firms, 2001*, Bureau of Labor Statistics, Supporting Statement Survey of Respirator Use and Practices, 2003, p. 258.

³⁷Lessler and Kalsbeek, op. cit.

³⁸Kish, Leslie, *Survey Sampling*, New York: John Wiley & Sons, 1965.

extent of weight variation is provided, although the use of what appears to be a step to trim (or reduce the variation of) weights (an “outlier adjustment factor”) seems to indicate that the adjusted weights were in fact deemed sufficiently variable that a separate trimming step in the weighting process was in order (although it is not specifically mentioned in the appended technical documentation to the SRUP report of its findings). Again, without details on the formulas and rationale for the statistical step, there is no basis for any assessment beyond conjecture based on apparent computational steps. The usual approach for dealing with variable weights is to trim them or to otherwise control the size of the largest weights or adjustments.³⁹

Statistical Efficiency of Estimation Strategies

Little documentation is given to determine how estimates from SRUP data are prepared. Weights are available and used in the analysis. It should be assumed that SRUP data analysts knew how to use them and in fact did use them in all analyses. The section on “final weights” in the SRUP report of findings seems to suggest this for estimated totals in the SRUP findings monograph at least.

Variance Estimation

It is generally viewed as good survey practice to produce measures of the quality of survey estimates along with the estimates themselves. Some of the common quality measures are variances, standard errors, and margins of error of survey estimates.⁴⁰ BLS traditionally computes an estimate of variance using a balanced repeated replication technique. In this case, the agency applied SAS Version 6.0 to accomplish this task.

The standard error is used to define a range (confidence interval) around the estimate. BLS typically uses a 95 percent confidence interval—the estimate plus or minus 1.96 times the standard error. For example, the 95 percent confidence interval for an estimate of 50,000 establishments using respirators with a relative standard error of 1 percent would be 50,000 plus or minus 2 percent (2 times 1 percent), or 49,000 to 51,000. The total estimate for respirator use in the last 12 months of 281,776 establishments has an estimated relative standard error of less than 1 percent (see Table 4.1 for standard errors found in the SRUP report of findings).

³⁹Potter, Frank J., Survey of procedures to control extreme sampling weights, Proceedings of the American Statistical Association, Section on Survey Research Methods, 1988, pp. 453-458; Potter, Frank J., A study of procedures to identify and trim extreme sampling weights, Proceedings of the American Statistical Association, Section on Survey Research Methods, 1990, pp. 225-230; Potter, Frank J., The effect of weight trimming on non-linear survey estimates, Proceedings of the American Statistical Association, Section on Survey Research Methods, 1993, pp. 758-763.

⁴⁰Lohr, S., Sampling: Design and Analysis, Pacific Grove, Calif.: Duxbury Press, 1999.

TABLE 4.1 Standard Errors for Numbers of Establishments and Employees That Required Respirator Use in the 12 Months Prior to the SRUP, by Industry Division

Respirator Use	Number of Establishments Using Respirators	Number of Employees Using Respirators
Private industry	196	2,677
Agriculture, forestry, and fishing	156	2,026
Mining	17	564
Construction	162	3,743
Manufacturing	34	613
Transportation and public utilities	144	2,026
Wholesale trade	167	2,914
Retail trade	153	1,186
Finance, insurance, and real estate	547	1,610
Services	457	5,749

SOURCE: U.S. Department of Labor. 2002. Respirator use and practices, United States Department of Labor News, 2002, Appendix B.

Finding 13: Although a standard error was calculated for each estimate from this survey, these measures of error were not computed correctly. BLS used SAS Version 6.0 to produce the computations, which yielded appropriately weighted estimates but did not account for stratification in estimating the standard error of estimates.⁴¹ Also of concern was the finding that standard errors were not published along with the data in the main report.

Although standard errors for the numbers of establishments and employees that required respirator use in the 12 months prior to the survey, by industry division, did find their way into the BLS press release, they were available only on request for the bulk of the data that appeared in the SRUP report of findings.

Dealing with Item Missing Data

In addition to adjustment for unit nonresponse, BLS used imputation for item nonresponse. The need for imputation arises from the fact that the survey had missing data on some items among the questionnaires that were completed by responding establishments.

There are a number of reasons for item nonresponse. Missing data arise when respondents refuse to answer a question; when they answer that they “do not know”; when the respondent terminates the survey mid-interview; or when the respondent has skipped an item in error.

Several options are available for dealing with item nonresponse in surveys such as the SRUP. BLS could have produced estimates using fully responding establishments

⁴¹Later versions of SAS account for stratification, but these versions may not have been available at the time of the SRUP analysis.

only or using respondents who completed the key items used for analysis. The agency could also have weighted complete cases to make up for missing cases. The agency chose to impute values of missing items using a common technique called the hotdeck imputation method.

The hotdeck imputation method uses reported data based on responses from usable schedules in the same sampling strata to impute missing data. In this method, matching criteria within that strata are used to find a donor respondent. The matching criteria form a “model” for the missing data value. The model employed by BLS was to randomly select replacement data based on the prevalence of responses to the item in the strata. All told, 795 out of a possible 805 units were “hotdecked,” or 2.1 percent of the survey variables.⁴²

The hotdeck method assumes that data are missing at random, where being missing is related to other observed values. An imputation is “good” if it provides unbiased estimates of the variable being evaluated (mean, variance), corrects for potential distributional differences between respondents with missing data and those with reported data, and maintains relationships among associated variables.⁴³ Multiple sets of imputed values are often computed for each missing item to account for the statistical error arising out of the imputation process. It is not clear that this use of multiple imputations was followed.

In addition to serving as a method of imputing values to missing data items, an imputation method can also serve as a check on the quality of the responses by providing an indication of the type of item “missingness.” This measure was not employed—it would have been a useful tool for assessing the quality of the data collection protocol followed for the SRUP.

Assessment of Findings

In this section, the committee comments on (1) the appropriateness of conclusions reached from SRUP data and (2) the utility of SRUP data and findings to the user constituency of the SRUP. These elements of the charge to the committee are considered together. Appropriateness is related to the quality of the application of statistical methodologies and techniques in all aspects of the design and implementation of the survey. The committee summarizes its findings on the quantitative measures of appropriateness that are discussed above. This is followed by a more subjective evaluation of the usefulness of SRUP analysis, presentation of its findings, and release of its data, which are also aspects of the appropriateness of conclusions.

⁴²Wiatrowski and McCarthy, *op. cit.*, p. 45.

⁴³Davern, Michael, Lynn Blewett, Boris Bershadsky, and Noreen Arnold, Possible Bias in the Census Bureau’s State Income and Health Insurance Estimates, University of Minnesota School of Public Health, presented to the Housing and Household Economic Statistics Division, U.S. Census Bureau, Washington, D.C., October 31, 2001.

Appropriateness of the Conclusions. An assessment of the appropriateness of conclusions considers the quality of the data; that is, the accuracy, timeliness, and reliability of survey results. There are generally two broad methods used to interpret data quality: validation, a process whereby data are analyzed before their release to avoid gross errors and eliminate poor-quality data, and sources-of-error studies (sometimes referred to as error profiles), which provide quantitative information on the specific sources of errors in the data.⁴⁴

There is evidence that BLS paid due diligence to the task of validating the data to avoid gross errors. The survey employed elaborate editing and data clarification to identify invalid and inconsistent data and, as discussed above, utilized data clarification routines that should have insured against processing and other types of errors. However, there has not been a systematic sources-of-error study to evaluate coverage errors, nonresponse errors, measurement errors, processing errors, and sampling errors.⁴⁵ This review considered many of the elements that are normally considered in a sources-of-error study, but by no means with the systematic rigor that a statistical agency could apply. In conducting this assessment, the committee did not learn of any field studies or other separate error component investigations that would suggest NIOSH’s intention to conduct a sources-of-error study in conjunction with the SRUP.

The several indications of shortcomings in the design and implementation of the SRUP outlined in this chapter give the committee pause in being able to pronounce that the survey’s conclusions are fully appropriate. They were made from data and estimates based on a reasonably sound survey design and field operation, but where no clear attempt was made to measure the quality of the survey measurements needed for both. Estimates of the use of respirators in the workplace provided by employers in establishments selectively represent establishments that might be expected to use respirators based on responses to the Survey of Occupational Injuries and Illnesses and other sources. To that basic extent, the conclusions are appropriate. The sources and sizes of the nonsampling errors in the estimates on which these conclusions are based are unknown, however.

⁴⁴A useful description of these methods is found in Statistics Canada, Statistics Canada Quality Guidelines, 4th Edition, Catalogue No. 12-539-XIE, October 2003, p. 57.

⁴⁵A more complete discussion of the subject of sources of error measurement can be found in Lessler, J.T., and W. D. Kalsbeek, *Nonsampling Errors in Surveys*, New York: John Wiley & Sons, 1992; Groves, Robert, *Survey Error and Survey Costs*, New York: John Wiley & Sons, 1989; Federal Committee on Statistical Methodology, *Measuring and Reporting Sources of Error in Surveys*, Statistical Policy Working Paper 31, Office of Management and Budget, Washington, D.C., 2001.

Utility of Data and Findings

Data Release. Timeliness of release of findings is an aspect of data utility, and the agencies succeeded in this aspect of survey operations. Findings from the SRUP report were disseminated in a timely manner in the form of BLS and NIOSH press releases and, soon after, in several analytical articles. The survey data collection was begun in August 2001, with data pertaining to the 12-month period occurring between August 2000 and January 2001. Within less than a year of the time of collection, in March 2002, BLS provided the initial tabulated data from the survey to NIOSH.

The first public release of these findings was in the form of a BLS press release entitled “Respirator Use and Practices” (USDL 02-141), which was issued on March 20, 2002. NIOSH followed the BLS release with its own release two days later. The release, entitled “Findings of Survey Co-developed by NIOSH Will Help Respirator Research, Recommendations” was issued as a *NIOSH Update* on March 22, 2002.

In September 2003, BLS and NIOSH published a 280-page, 103-table report of the survey results entitled *Respirator Usage in Private Sector Firms, 2001*. This report comprises the official record of the methodology and survey results. The selection of data presented in the 103 tables reflects the emphasis of the survey and of the NIOSH users. Most of the tabulations were presented by industry division, although several tables presented the cross-tabulations by employment size group. In a departure from usual BLS practice and in contrast to the procedures for publishing data from the SOII, for example, the publication did not present information on the statistical precision of the estimates. Tabular footnotes stated that “a measure of sampling variability for each estimate is available on request.”

Summary of the Findings. The voluminous data published in the NIOSH-BLS report clearly provided “a greater level of detail than any previous study of job-related respirator use.”⁴⁶ The major findings of the study addressed two levels of data: (1) the number of establishments and employees using respirators, by type of respirator and type of use, and (2) the characteristics of the respirator program at the establishment level.

As for the number of establishments, the SRUP estimated that respirators were used for voluntary or required purposes in about 620,000 (or 10 percent of) workplaces—a number somewhat smaller than previously estimated. This estimate of the total number of establishments in which employees used respiratory protection equipment differed from estimates previously published. The OSHA Final Economic Analysis estimated that approximately 1.3 million

establishments, or about 20 percent, had employees who use respirators, while the personal protective equipment cost survey estimated 684,000 reported respirator use.

The number of employees who used respirators for required purposes totaled 3.3 million in the 281,800 workplaces estimated to have required use. (Because of the construction of the questionnaire, it was not possible to obtain an estimate of the total number of employees who used respirators both voluntarily and as required.) Again, this number was substantially different from three previously published point estimates of the population of respirator users—each with differing sources of input data and employing very different means of estimation:

1. The number of employees “wearing or having access to certified respirators” was in the ballpark of 4.9 million (1980) based on an extrapolation of units sold to employees in mining, manufacturing, and construction.⁴⁷
2. About 5 million employees in general industry, construction, and shipyards were estimated to use respirators as of 1997.⁴⁸ This translated to an estimate that approximately 5 percent of employees in these industries were wearing respirators at any one time.
3. In 1999, it was reported that the number of “employees using respiratory protection (other than nontoxic dust mask)” was about 8.7 million.⁴⁹

Previous estimates of users and establishments varied markedly from the SRUP estimate. The earlier estimates were derived from a variety of sources, each requiring the development of modeling techniques and assumptions that could be challenged, while the SRUP results are direct sample-based estimates but of unknown quality.

Other major findings regarding the total number of establishments and employees using respirators (for both required and voluntary purposes) addressed size of firm and industry. However, the bulk of the data collected and all other published details pertained only to establishments requiring respirator use. Thus, although the survey produced a few estimates of the total prevalence of respirator usage, they are derived from the less than one-half of the firms that required use. Those firms requiring use tended to be larger and somewhat more concentrated in the service-producing sector than in mining, construction, and manufacturing. Interpretation of the details regarding workplace practices and programs should be made with these limitations in mind.

⁴⁷The Granville Corporation, Draft Preliminary Survey of Existing Data and Economic Overview of the Respirator Industry, NIOSH Contract 21-81-1102, Washington, D.C., March 10, 1982.

⁴⁸OSHA, Final Economic Analysis of OSHA’s Respiratory Protection Standard, 29 CFR 1910.134, Office of Regulatory Analysis, U.S. Department of Labor, Washington, D.C., December 12, 1997.

⁴⁹Eastern Research Group, PPE Cost Survey Final Report (Task Order 3, Contract J-9-F-0010), Washington, D.C., Prepared for the Office of Regulatory Analysis, OSHA, June 23, 1999.

⁴⁶Bureau of Labor Statistics and National Institute for Occupational Safety and Health, *Respirator Usage in Private Sector Firms, 2001*, September 2003, p. 1.

Descriptive Analysis. The press release and the large volume of tables were followed by more focused analytical work. Most of the analysis of the SRUP data was conducted and published by a team of NIOSH surveillance experts. Several of these NIOSH researchers had been involved with this survey since its inception. The team has continued its work in the form of a steady series of articles and poster sessions.

The most comprehensive of these NIOSH articles appeared in the May 2005 *Journal of Occupational and Environmental Hygiene*.⁵⁰ In addition to reporting on the survey methodology and the primary findings, the article was enriched with analysis of respirator use with program characteristics. The results focused on the relationship between the designation of a program administrator and program effectiveness factors. For example, 70 percent of establishments with a trained program administrator reported a written procedure for maintaining respirators, and 55 percent of them reported written procedures for periodic evaluations of effectiveness. The reported written procedures for establishments without a trained administrator were 23 percent and 11 percent, respectively.

These findings were an informative aspect of this survey. In essence, those establishments that were reporting no written procedures were admitting noncompliance because written procedures are a matter of compliance with regulations. A number of reasons could be posited for the fact that the reporting establishments so readily indicated they were out of compliance with regulations: perhaps they were comfortable with the BLS pledge of confidentiality; they might have been unaware of the legal requirements; maybe they were confident that the probability of enforcement was minimal or that the probable penalties were insignificant; or they could simply have failed to understand the questions. Since there was no sources-of-error study addressing this matter, it is not possible to give a reason for the apparent reporting of activities for which a citation could be issued.

Several other possible violations of OSHA regulations were noted. Establishments reported that 51 percent of employees in places where respirators were required were not assessed for medical fitness to wear respirators, despite OSHA regulations that the employer must provide a medical evaluation. The study concluded that a “large number of employers do not follow NIOSH recommendations for the selection and use of respirators.”⁵¹ It went on to comment that employers either are unfamiliar with the regulatory requirements or are not applying appropriate resources to meet regulatory requirements. Since NIOSH explicitly administers its respirator certification program with the

assumption that regulations are being followed, this should be a subject of future investigation at NPPTL, as to whether such compliance is actually necessary for respirators to be effective at protecting employees.

This study introduced, but only briefly, the notion of Indicators of Potentially Inadequate Respirator Programs. The analytical staff identified 15 questions in the survey that could be considered indicators of potentially inadequate programs, depending on how they were answered (Box 4.1). If these indicators are representative, respirator program administrators have a difficult problem on their hands. More than 90 percent of establishments requiring respirators had at least one indicator of potentially inadequate programs, and 54 percent had at least five.

The selection of these particular indicators was quite subjective and seemed to give weight to “don’t know” answers, which may indicate confusion rather than lack of programs. Still, this was a useful attempt to turn statistical data into surveillance intelligence, but it was only a start. This path of inquiry gives an indication of the direction that future research efforts could fruitfully pursue. Even if NIOSH continues to use the information only as indicators of “potentially inadequate” programs, the analysis appears to provide a useful path of inquiry.

In the fall of 2003, the NIOSH team produced an analysis of the substances that prompt the use of respirators.⁵² The survey had collected information as to whether any of 26 listed substances or categories of substances had prompted the establishment to use APRs and whether exposure assessment by air sampling had been conducted for those categories.

Some of the reported survey results were quite unsettling. For example, a large number of respondents reported that they used disposable dust masks as protection for gas or vapor substances, although, for the most part, disposable dust masks protect only against particulate substances.⁵³ The survey yielded an estimate of about 36,000 establishments, with some 193,000 employees using dust masks in these dangerously inappropriate ways. It would be useful (in future studies) to be able to assess the validity of these responses and, if valid, to identify why the apparently inappropriate protection was being used; was it lack of training, failure to read the labels, or what?

A third significant piece of analysis addressed a key administrative aspect of the NPPTL certification program—the clarity and understandability of the respirator manufacturer’s user instructions to users and of the NIOSH

⁵⁰Doney, B.C., D.W. Groce, D.L. Campbell, M.F. Greskevitch, W.A. Huffman, P.J. Middendorf, G. Syamlal, and K.M. Bang, A survey of private sector respirator use in the United States: An overview of findings, *Journal of Occupational and Environmental Hygiene* 2(5):267-276, May 2005.

⁵¹Ibid.

⁵²Doney, B.C., B.M. Greskevitch, P. Middendorf, and D. Groce. Which substances prompt respirator use? *Journal of the International Society for Respiratory Protection* 20, 2003.

⁵³Some disposable respirators look like dust masks, but have activated charcoal embedded in the facepiece. These disposable respirators provide suitable protection, so some of the responses may be legitimate.

BOX 4.1
Indicators of Potentially Inadequate Respirator Programs

1. No written change-out schedule for establishments with the use of air-purifying gas or vapor filters
2. Improper method of setting air pressure to control airflow on airline respirators, or don't know which method is used
3. No written procedures to periodically evaluate the effectiveness of respirator use, or don't know if such procedures exist
4. No written program for deciding how respirators are used
5. Airline respirator hose couplings are compatible with couplings for other air or gas supply lines, or don't know about compatibility
6. No written procedures and schedule for maintaining respirators, or don't know if such procedures exist
7. No assessment of the medical fitness of respirator-wearing employees, or don't know if assessment is done
8. No training for employees regarding respirator use and limitations
9. No specific respirator training for program administrator
10. Use of dust masks (disposable) to protect against gases or vapors
11. No one assigned to be responsible for directing and overseeing the use of respirators
12. Didn't know which method was used or who was responsible for assessing employee's medical fitness or didn't know what method was used to fit-test employees
13. Didn't know if air sampling was conducted for substances during jobs requiring the use of either air-purifying or air-supplied respirators
14. Not familiar with respirator terms or language use in at least two of nine questions regarding respirator selection, types of respirators or hazards, and fit-test methods
15. No fit-testing for each tight-fitting respirator wearer, or don't know if fit-testing was done

SOURCE: Bureau of Labor Statistics and National Institute for Occupational Safety and Health. 2003. Respirator Usage in Private Sector Firms, 2001.

approval labels.⁵⁴ Instructions and labels are an important part of the certification program in that they are intended to transmit information about the mechanics and proper use of the respirator and the approved conditions of use.

On the positive side, the survey found that the instructions and labels had reportedly been received with the equipment and were understood by employees. Nonetheless, a careful reading of the survey results points to a potentially serious inadequacy in application of those instructions and labels in the workplace. The analysis identified a failure of establishments to provide appropriate airflow controls and hose couplings for airline respirators as called for in the instructions. This could result in a dangerous situation for wearers of airline respirators if the devices were inadvertently connected to a line that contained a substance other than breathing air. Based on this information, NIOSH issued a Safety and Health Information Bulletin describing

the dangers and recommending actions to prevent fatalities associated with this hazard.

At the time this report was prepared, NIOSH staff were preparing several additional draft manuscripts that were in various stages of review and release.⁵⁵ These additional studies expand the analysis into the chemical, transportation, and mining industries. The publications continue to be directed mainly to an audience of occupational health and safety professionals.

⁵⁴Doney, B., W. Hoffman, D. Groce, and M. Greskevitch, Usefulness of respirator manufacturer user's instructions and NIOSH approval labels, *Journal of the International Society for Respiratory Protection*, 21(Spring/Summer), 2004.

⁵⁵(a) Doney, B., M. Greskevitch, and D. Groce, Respirator use and practices by National Demolition Association Members, abstract American Industrial Hygiene Conference and Expo, Chicago, May 15-18, 2006.

(b) Doney, B., M. Greskevitch, and D. Groce, Respirator use in the chemicals and allied products manufacturing industry, *Chemical Health and Safety*, in press.

(c) Doney, B., D. Groce, M. Greskevitch, and K.M. Bang, Respirator use among ARTBA member companies, *Transportation Builder*, in press.

(d) Syamlal, G., B. Doney, K.M. Bang, M. Greskevitch, D. Groce, S.J. Ganocy, and W. Hoffman, Medical fitness assessment for respirator users, *Journal of Occupational and Environmental Medicine*, in press.

(e) Greskevitch, M., Groce, D., and B. Doney, A survey of respirator use in the U.S. mining industry, *Mining Engineering*, 2006.

Beyond these sponsor-prepared analytical works, other uses of the data were found. One important application deserves mention. The data were used by OSHA in developing the preliminary economic and regulatory flexibility screening analysis (required by Executive Order 12886 and the Regulatory Flexibility Act), which addresses issues related to costs, benefits, and economic impacts of OSHA's proposed Assigned Protection Factors rules.⁵⁶ OSHA based its estimates of the number of employees using respirators and the corresponding number of respirator-using establishments on the 2001 SRUP. For the purpose of this regulation, OSHA found useful the breakouts by type of respirator (filtering facepieces, half-masks and full facepieces, non-powered air-purifying, powered air-purifying, and supplied-air). This was the only documented use of the NIOSH-BLS survey data outside of NIOSH.

Finding 14: A large number of analytical studies were conducted by NIOSH staff following the release of the initial SRUP report. However, more could have been done to disseminate survey findings and data to key stakeholders such as users, policy and decision makers, and the industrial hygiene and safety engineering communities.

If a survey is to effectively contribute to the quality of decision making, its findings must get into the hands of the right people. It is difficult to measure the impact of any particular data source in terms of policy impact or impact on public understanding. This review has described a couple of examples of the survey results finding their way into public decision making: Where a potentially dangerous condition was identified (e.g., the lack of controls where air hoses connect to the compressed breathing source), a widely disseminated NIOSH bulletin was issued, and OSHA used the information in preparing the economic analysis of the proposed APR regulation. These uses may or may not have justified the expense of the survey. In the end, only the survey sponsor can determine the ultimate cost-benefit of a survey.

However, there are several areas in which marginally increased expenditures of time and analytical resources could have added to the utility for the survey. Certainly, expanding dissemination was an avenue that could have increased the impact of the results. In the case of SRUP survey data, except for BLS and NIOSH press releases, most dissemination has been to NIOSH or the industrial hygiene community through articles in occupational health and safety journals and poster sessions at conferences. There were some attempts to enlarge the dissemination in the form of displays at industry meetings and an article or two in industry journals. However, the focus on release of tabular data and in the selection of dissemination venues limited the potential usefulness of the survey findings.

⁵⁶OSHA, 29 CFR Parts 1910, 1915, and 1926, Docket No. H049C, June 6, 2003, pp. 34071-34091.

Another factor that undoubtedly limited the extent of analysis was the fact that, mainly as a result of BLS confidentiality rules, the NIOSH sponsors were not able to directly access survey microdata. The need to rely on laborious and time-consuming requests for special tabulations to support their analysis projects undoubtedly limited the reach of the research and analysis. Despite these obstacles, the NIOSH analytical team has arranged for an additional tabulation of the survey data, matching the respirator responding establishments with their 1999 BLS annual SOII responses for dust diseases of the lungs, respiratory conditions due to toxic agents (e.g., pneumonitis, pharyngitis, occupational asthma), and poisonings. At the time of this report, these data were being analyzed by NIOSH and had not yet been released.

Missed Opportunity. The late-coming initiative to enrich the analytical potential of the data by enriching it with matched data from the SOII should be applauded. There may yet be issues with the use of matched data. The inability to control for differences in the data related to different time periods as well as different conditions in the reporting establishments renders the potential of the match somewhat speculative at this point.

The importance of sample unit matching when possible should not be underestimated. This particular match was conducted late in the survey operation and primarily for the purpose of data analysis. It is unfortunate that the sample matching did not come earlier and as a planned feature in the processing cycle.

Finding 15: The failure to conduct the sample matching earlier in the process constituted a missed opportunity to improve the quality and richness of the data.

As mentioned earlier in this chapter, a matched file could have helped enrich the quality and efficiency of the estimation process. For example, sample matching, if conducted as part of the estimation process for production of the original findings from the SRUP, could have had important ramifications for the quality of the survey data in that SOII results could have been used to improve the estimates obtained from SRUP data. SOII data could have been used in a number of ways for estimation (e.g., ratio, regression, and difference estimators).⁵⁷ There is no indication that these alternative and potentially superior approaches were considered or used in producing any of the SRUP findings. If not, this is a potentially important limitation of the SRUP findings, especially since the use of these estimation approaches could have improved the quality of estimated totals (of respirator use) that is a key finding of the SRUP.

⁵⁷See Kish, Leslie, *Survey Sampling*, New York: John Wiley & Sons, 1965; and Cochran, W.G., *Sampling Techniques*, 3rd Edition, New York: John Wiley & Sons, 1977, for the use and statistical utility of these approaches in estimating population means and totals.

Ultimate Impact of the SRUP

If a survey is to be effective, its findings must get into the hands of the right people. It is difficult to measure the impact of any particular data source in terms of policy impact or impact on public understanding. However, patterns of dissemination may be illustrative. In the case of SRUP survey data, except for BLS and NIOSH press releases, most dissemination has been to NIOSH or the industrial hygiene community through articles in occupational health and safety journals and poster sessions at conferences. Where a poten-

tially dangerous condition was identified (e.g., the lack of controls where air hoses connect to the compressed breathing source), a widely disseminated OSHA bulletin was issued. Also, MSHA used the information in preparing the economic analysis of the proposed APR regulation.

Were these uses sufficient to justify the expense of the survey? Only the survey sponsor can determine the ultimate cost-benefit of a survey. However, several areas in which marginally increased expenditures could have produced additional information have been pointed out in this chapter.

5

Planning for the Future

In the years since the objectives and the methodology of the Survey of Respirator Use and Practices (SRUP) were developed, and since the results of the survey were made available, the approach of the federal government to personal protective equipment (PPE) technology has changed rather dramatically. As the principal agency with responsibility for PPE technology, the National Personal Protective Technology Laboratory (NPPTL) has come of age. In recent years, the NPPTL has forged new directions and adopted new statements of emphasis, reflected in the new National Institute for Occupational Safety and Health (NIOSH) NPPTL strategic objectives outlined in the NPPTL Strategic Plan.^{1,2} In light of these changes, NPPTL's changing informational needs were considered. In this section, the committee answers the questions: What should the future data-gathering activities agenda for NPPTL be, and what should the process be for determining what these activities are and how they should be conducted?

ESTABLISHING INFORMATIONAL NEEDS

NPPTL is a new agency, and directions for the agency were formulated well after the goals and objectives of the SRUP had been established in the late 1990s. Future data collection objectives and methods should be developed keeping in mind this evolving environment and the unique focus of PPE expertise at NPPTL.

¹NPPTL, NIOSH'S National Personal Protective Technology Laboratory: Providing Personal Protective Technology Innovations for the 21st Century, NIOSH Publication No. 2004-111, May 2004.

²NPPTL, Options for Future Surveys and NPPTL Surveillance Strategy, December 1, 2005.

FOCUS ON OUTCOMES

A key to developing a plan for future data gathering is to accommodate the new NIOSH-NPPTL focus on outcomes. This new focus is depicted in the Value Creation System adopted as part of the NPPTL Strategic Plan (see Figure 5.1). The system provides architecture for defining, measuring, and improving the performance of the organization and focuses on outputs, intermediate outcomes, and public benefit outcomes:

- Outputs are products and services that are the direct results of NPPTL activities; these include measurable activities such as peer-reviewed publications, protective equipment standards, and respirator certification approvals.
- Intermediate outcomes are benefits that occur in the process of developing outputs, to include partnerships with NPPTL technology developers and suppliers.
- Public-sector outcomes are defined to include certified PPE and PPE ensembles that provide more reliable and higher levels of employee protection and a subsequent reduction in occupational illnesses and injuries.

It is in this context that NPPTL will measure program effectiveness in the future. This will require assessing two difficult-to-measure public benefit outcomes that were specifically identified in the NPPTL Strategic Plan: (1) reductions in the incidence of work-related injury and illness related to PPE use (a real measure of the efficacy of respirators and respirator programs), and (2) reductions in economic, human, and lost opportunity costs from work-related injury and illness.

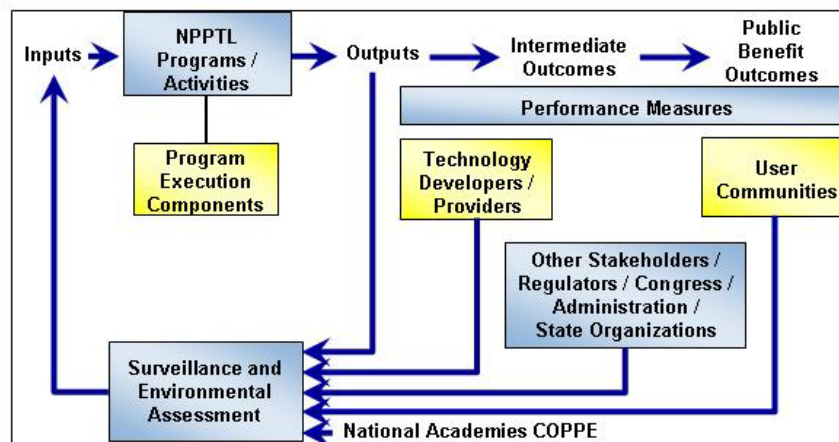


FIGURE 5.1 NPPTL Value Creation System.

SOURCE: NIOSH NPPTL Strategic Plan, May 2004, p. 11.

SECTORAL APPROACH

In considering a data collection program for the future, the fact that NPPTL is aligning its activities along the sectoral divisions adopted by NIOSH was also considered. The NIOSH program portfolio has been organized into eight National Occupational Research Agenda (NORA) sectors that are rough approximations of industry sectors: agriculture, forestry, and fishing; construction; health care and social assistance; manufacturing; mining; services; transportation, warehousing, and utilities; and wholesale and retail trade.

In addition, NIOSH has organized its efforts along 15 cross-sector programs, selected to emphasize health outcomes, statutory programs, and global efforts. These programs include two of direct relevance to formulating a PPE data-gathering program for the future: personal protective technology and respiratory diseases.

As described in Chapter 3, these initiatives are under the umbrella of NORA. Through NORA, NIOSH is reaching out to a community that includes public interest, employer, and employee groups as it develops its approach to a research agenda for the future. In the summer of 2006, NIOSH was hard at work to develop a baseline of occupational safety and health information used and disseminated by business associations, professional associations, and labor unions within the eight NORA industrial sectors. The goal of this project is to develop and administer a survey of business associations, professional associations, and labor organizations in the eight NIOSH industrial sectors to determine (1) occupational safety and health (OSH) information presently being disseminated by these associations and unions to their members; (2) channels of communication within the associations and unions used to disseminate OSH information; (3) their needs for specific types of OSH information, especially those needs not presently being served; (4) sources of OSH

information presently used by business associations, professional associations, and labor unions; (5) OSH concerns of the associations and labor unions; (6) awareness and perception of the associations and labor unions; (7) use of NIOSH information services (web site, printed publications, 800 number, etc.); (8) usefulness of NIOSH information to address their OSH concerns; and (9) credibility of NIOSH as a trusted source of OSH information.³ The results of this information gathering could be used by NPPTL to sharpen its research focus and develop a more effective information dissemination program.

Ultimately, NPPTL's data needs for the future have increasingly become tactically focused on program objectives. They are more in alignment with NIOSH and NPPTL agency policy directions and more reflective of the new emphasis throughout the government on measurability, in sharp contrast to the focus on generalized public health surveillance issues of interest in the NIOSH work that preceded the SRUP (see Chapter 2). The data needs will focus more on outcomes that will inform NPPTL's regulatory or certification and research priorities.

As it adopts this new emphasis, it is expected that NPPTL data collection will extend beyond basic research, embodied in the SRUP, which provides important baseline data focused on employer respiratory protection programs. Likewise, while NPPTL may make recommendations to the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) based on SRUP data to assist in enforcement targeting or regulatory changes to improve employer respiratory protection program compliance, enforcement data are unlikely to constitute the principal focus of future NPPTL data collec-

³Communication with Maryann D' Alessandro, NPPTL, July 14, 2006.

tion. Indeed, NPPTL might more appropriately partner with other NIOSH divisions or extramural partners to evaluate issues related to respiratory protection programs within the context of the organization of work and management systems or programs.

NEW INFORMATION NEEDS

In this environment, the emerging information-gathering objectives have been stated with a programmatic emphasis.⁴ Some of the emerging objectives address issues that can be resolved in a survey-based data collection, reminiscent of the objectives that underscored the 2001 SRUP, but most require a new approach.

RECOMMENDATION 1: NPPTL should continue to address and explicitly articulate data needs to evaluate and improve the respirator certification program so as to ensure the efficient availability and advancement of protective technologies for employees.

RECOMMENDATION 2: Discussion and explicit articulation of information needs related to PPE performance and utilization should be the subject of continuous review and periodic updating by NPPTL as PPE technology evolves and the method of meeting those needs changes.

It is impractical to mount and sustain an intensive effort such as that devoted to this review on an ongoing basis. However, NPPTL's surveillance efforts necessitate a continual review and updating of data needs to support the agency's program objectives. Imposing a continuous program of top-to-bottom consideration of reliable indicators of program objectives is a hallmark of performance-based management.

The continuous review of current and emerging program objectives should be conducted with recognition of the increasing research role of NPPTL. NIOSH is, in essence, a research organization and it should approach the development of program management data with that in mind. NPPTL data-gathering activities in the future should place a sharp focus on meeting the needs of the research program, not on making findings that would inform OSHA and MSHA on the adequacy of compliance programs. Several research questions are postulated in this section and summarized in Table 5.1 in an effort to give some substance to a research agenda that focuses on the use of PPE in the field.

RECOMMENDATION 3: NPPTL's future data-gathering activities should seek, within a sound scientific approach, to derive explanations for observations on the use of PPE in the field.

Furthermore, there should be a consistent framework within which these needs are considered. This framework should be aligned with the core mission of NPPTL as described above. There are many possible ways to depict this framework; however, the following is recommended:

RECOMMENDATION 4: In the future, the resource-intensive data-gathering framework for NPPTL surveillance efforts should focus on the evolving mission categories of surveillance, certification, research, technology, and standards.

To assist NPPTL in evaluating the various options for data collection in light of the aforementioned mission categories, the committee considered the kinds of data that would provide a useful tool for measuring program performance and guide the NPPTL research agenda. Among these data elements are the following:

Surveillance

- How often is PPE used?
- What is the motivation for its use or nonuse?
- Is PPE used in its intended way?
- Are training programs adequate?
- Is information about PPE adequate?
- Does the use of PPE interfere with job performance?
- What kinds of jobs are performed while wearing PPE?
- Are the correct types of PPE being used?
- How important are economics in the selection of PPE?

Certification

- Is the certification program adequate?
- How does certification testing match real-life job demands?
- What significance is paid to certified products in actual use?
- Should products be recertified?
- Can certification testing be extended to best use instead of just protection?
- Should certification testing be extended to best use instead of just protection?
- Are there minimum protection factors that can be assigned to specific pieces of PPE?

Research

- How does PPE affect employee productivity?
- Are there better ways to train employees?
- What physical or physiological burdens are associated with PPE use?
- Can computer modeling be used to predict employee response to PPE?
- Do combinations of PPE types affect employees differently?

⁴D' Alessandro, Maryann, Emerging NIOSH approaches to PPE, presentation at the meeting of the panel, open session, March 23, 2006.

- What should physicians look for in a candidate for PPE wear?

Technology

- Are there improved filter technologies?
- Can PPE be designed for specific types of tasks?
- What defines a better material?
- How can respirators be fully integrated with other items of PPE and with the wearer?

Standards

- How specific should standards be?
- Do standards restrict the introduction of new technologies?
- What information is necessary before a new standard can be written?
- Should the standard lead technology or vice versa?
- Are present NIOSH standards adequate?

Based on this assessment, Table 5.1 was prepared to reflect a sense of the information sources associated with these mission-related data requirements. This is an initial effort. The illustrative list of categorized data needs displayed in Table 5.1 lends itself to periodic reexamination and to prioritization within the context of the emerging strategic plans of NIOSH and the NPPTL. Table 5.1 contains a more detailed list of data that needs to be collected to achieve NIOSH and NPPTL missions, including the aforementioned broader list of data needs.

The columns of Table 5.2 indicate (by an “X”) suggested types of data-gathering options available to collect the types of information indicated in the rows of Table 5.1. The options include probability surveys, administrative records, and qualitative methods. Description and comments on the most likely of these data-gathering options are presented in the next section. However, a quick reading of the table indicates that data gathered from individuals in a probability survey and from focus groups yields data representative of most data sources.

POTENTIALLY USEFUL INFORMATION-GATHERING APPROACHES

With this new emphasis, at the request of NPPTL, a number of information-gathering options were identified for meeting future information needs on PPE use (Table 5.2). These options included the following:

- Follow-on employer survey utilizing the 2001 SRUP design
- Redesigned SRUP employer survey
- Employee-within-establishment survey
- Combined employer and employee survey
- Focus groups
- Combined survey and focus group approach

- Household survey
- Compliance data
- Use of existing administrative data sources
- Alternative means of data collection

FOLLOW-ON EMPLOYER SURVEY UTILIZING THE 2001 SRUP DESIGN

Repeating a survey in the same manner in which it was originally conducted is not recommended, even though a follow-on survey based on the same survey design as the 2001 SRUP would have the benefit of providing some trend information on employer respirator programs and practices and would permit sharpening some of the concepts and making methodological improvements based on lessons learned in the original survey.⁵

There are a number of reasons for the committee’s lack of enthusiasm for this option. Most notable among them are numerous shortcomings in the 2001 SRUP (see Chapter 4), although many of these could potentially be avoided in a repeat application of the SRUP design (see discussion of the redesigned SRUP employer survey). Another drawback is that the survey was quite inefficient. A fairly large proportion of the data collection effort was spent on collecting information from industries in which there was relatively little respirator use, and consequently, the report had a significant number of “blank” data cells. While this shotgun approach permitted development of an estimate of total number of establishments and employees in the private sector using respirators of various types and information about the risks and respirator programs of the companies, the approach is too expensive and too limiting for assessing the new NPPTL programmatic issues.

REDESIGNED SRUP EMPLOYER SURVEY

Employer or establishment surveys are useful instruments for examining workplace issues. For an employer survey following the basic SRUP design concept, NPPTL may wish to identify other groups at risk for targeting research interventions to prevent occupational injury and disease that were not covered by the SRUP—the informal workforce, the self-employed (now more than a quarter of the construction workforce), and temporary and personnel leasing agencies employing persons in high-risk occupations such as construction. Increasing attention should be paid to the impact of workforce trends on the PPE research agenda, such as increased employee turnover rates in many industry

⁵The utility of trend information will be somewhat diminished by the fact that the Bureau of Labor Statistics converted the industrial classification scheme from the Standard Industrial Classification used in the SRUP to the North American Industrial Classification System for subsequent Surveys of Occupational Injuries and Illnesses. Other changes include changes in the occupation coding system and changes in population weighting based on more recent counts of employment.

TABLE 5.1 Potential Sources of Information to Meet Specific Information Needs

		Potential Information Sources					
	Information Needs	Employees or Individuals	Employers	Manufacturers of PPE	Researchers (academia, AIHA)	Educators (individuals that develop training programs and train employees)	Practitioners (e.g., CSP, CIH, consultants)
	Leadership or Culture						
1	Do executive management and supervisors strongly support the proper use of PPE?	X	X				X
2	Are there any disciplinary actions that take place should an employee not use the assigned PPE?	X	X				X
3	Do supervisors, etc. wear the same PPE as employees reporting to them? Are supervisors and employees able to communicate when wearing PPE? How are communication challenges addressed?	X	X				X
4	Are supervisors required to comply with the same use requirements? Are productivity and safety performance given the same relative weights?	X	X			X	X
	Surveillance						
5	How frequently is PPE used?	X	X			X	X
6	What is the motivation for use or any nonuse (e.g., cost, comfort, reduced productivity)?	X	X		X	X	X
7	Is PPE used in its intended way?	X	X		X	X	X
8	Is information about PPE adequate (e.g., proper fit, donning, limitations, inspection criteria)?	X	X	X	X	X	X
9	Does the use of PPE interfere with job performance?	X			X	X	X
10	What tasks are performed while wearing PPE?	X	X				X
11	Are the correct types of PPE being used?	X	X		X	X	X
12	How would you rate wearability and comfort?	X	X		X		X
13	How compatible is the equipment with work tasks? What is a typical learning curve for new users?	X	X				X
14	Do you believe that the PPE device provides adequate protection against the hazard?	X	X		X		X

continued

TABLE 5.1 Continued

	Information Needs	Potential Information Sources					Practitioners (e.g., CSP, CIH, consultants)
		Employees or Individuals	Employers	Manufacturers of PPE	Researchers (academia, AIHA)	Educators (individuals that develop training programs and train employees)	
15	Are there instances in which its level of protection is so high, that PPE must be removed to perform a task (e.g., hearing protection must be removed to hear instructions)?	X					X
16	Are there instances in which the PPE is so uncomfortable or cumbersome that it must be removed to perform a task?	X					X
17	What is the duration and frequency of use?	X	X				X
18	How frequently does equipment have to be replaced?	X	X	X	X	X	X
19	Do employees ever share PPE? Are they aware of issues of cleaning and contamination?	X	X				X
20	Are training programs adequate (e.g., simply read manufacturer's literature, hands-on training)?	X	X		X	X	X
21	Is retraining on PPE conducted periodically (e.g., annually, when process(es) change, when determined that an employee has insufficient training)?	X	X		X	X	X
22	Are there better ways to train employees?		X		X	X	X
23	Does the company measure the effectiveness of its training program(s)?	X	X				X
24	Are PPE maintenance, cleaning, storage, and other program components implemented and effective?	X	X				X
	Selection						
25	Are hazard and risk analyses performed before deciding which PPE is necessary?		X		X		X
26	Who selects the supplier? Do employees get to choose between various brands or suppliers?	X	X				X
27	What is the most important criterion in the selection of PPE (e.g., cost, style, level of protection, availability)?	X	X	X			X
28	What weight is given to certified products in actual use?	X	X	X	X	X	X

TABLE 5.1 Continued

	Information Needs	Potential Information Sources					Practitioners (e.g., CSP, CIH, consultants)
		Employees or Individuals	Employers	Manufacturers of PPE	Researchers (academia, AIHA)	Educators (individuals that develop training programs and train employees)	
29	Do you have a designated person in each department who helps employees with reviewing their equipment and purchasing what they need or want?	X	X				X
30	Is the adequacy of selected PPE validated with monitoring or observation?	X	X				X
	Certification						
31	Is the PPE certification program adequate to distinguish reliably between respirators providing adequate protection and those that do not?			X	X	X	
32	How does PPE certification testing match with real-life job demands?			X	X	X	X
33	Should products be recertified on a periodic basis?			X	X	X	
34	Can certification testing be extended to best use instead of just protection (e.g., recommended conditions of use and use life, storage and shelf life)?				X	X	X
35	Are there minimum protection factors that can be assigned to specific pieces of PPE?			X	X	X	X
36	Should manufacturers' labeling be standardized to facilitate communication and comparisons? What about symbolic information?	X	X	X	X	X	X
37	What are the impacts of overlapping government approvals (e.g., Food and Drug Administration for surgical N95 respirators)?		X	X			X
38	What are the impacts of gaps in certification (e.g., no regulation for consumer use respirators)?	X	X	X			X
	Standards						
39	How specific should standards be?			X	X	X	
40	Do standards restrict introduction of new technologies?			X	X		

continued

TABLE 5.1 Continued

	Information Needs	Potential Information Sources					
		Employees or Individuals	Employers	Manufacturers of PPE	Researchers (academia, AIHA)	Educators (individuals that develop training programs and train employees)	Practitioners (e.g., CSP, CIH, consultants)
41	What information is necessary before a new standard can be written?			X	X		X
42	Should the standard lead technology or vice versa?			X	X		X
43	Does conformance with the standards significantly reduce exposures or improve employee safety and health?			X	X	X	X
44	How is conformance verified or confirmed?			X	X		X
45	Does the standard improve consistency of performance across sites or manufacturers?			X	X		X
46	Does the standard facilitate performance comparisons across sites or products?		X	X			X
47	Do instructions, labeling, or design increase ease of use or reduce the learning curve for conforming products?	X	X				
48	Are conforming products easier to fit, do they retain fit better, or do they provide better fit for difficult-to-fit subpopulations?	X	X		X		X
	Research						
49	How does PPE affect employee productivity and the learning curve for new users?	X	X		X	X	X
50	What physical or physiological burdens are associated with PPE use?	X	X	X	X	X	X
51	Can computer modeling be used to predict employee response to PPE?			X	X		X
52	Do combinations of PPE types affect employees differently?	X	X	X	X	X	X
53	What are some of the human factors that should be taken into consideration by physicians and other health professionals in assessing the protection afforded by PPE?			X	X	X	X
54	What are the most common causes of equipment failure? Are these failures easily repairable in the field application?	X	X	X	X		X

TABLE 5.1 Continued

		Potential Information Sources					
	Information Needs	Employees or Individuals	Employers	Manufacturers of PPE	Researchers (academia, AIHA)	Educators (individuals that develop training programs and train employees)	Practitioners (e.g., CSP, CIH, consultants)
55	How compatible is the equipment with work tasks?	X	X				
56	How durable is the equipment? How long is the shelf life?	X	X	X			X
Advances in Technology							
57	Are there improved filter technologies?			X	X		
58	Can PPE be designed for specific types of tasks? Can task-based performance be assessed?			X	X		
59	Material advances for PPE applications (sorbents, catalysts, antimicrobial materials, polymeric)			X	X		
60	How can PPE be fully integrated with other items of PPE and with the wearer?			X	X		X
61	Are technical advances in PPE driven or inhibited by the standards and certification process?			X	X		

NOTE: AIHA = American Industrial Hygiene Association; CIH = Certified Industrial Hygienist; CSP = Certified Safety Professionals.

TABLE 5.2 Comparison of Information-Gathering Methods by Data Sources

Data Sources	Probability Surveys			Records	Qualitative Methods	
	Establishment	Individual (e.g., employee, household)	Employee Within Establishment	OSHA Compliance Data	Focus Groups	Observation
Employees		X	X		X	X
Establishments	X		X	X	X	
Manufacturers	X				X	
Researchers		X			X	
Educators		X			X	
Practitioners		X			X	

sectors; decreased establishment lifetimes; increased multi-employer worksites with subcontracting and outsourcing, including virtual establishments where essentially all of the production work is outsourced; and increased immigrant employees. These all present surveillance challenges. Our national data collection systems can no longer assume long-term employment; stable establishments operating in the location where production occurs; establishments that directly employ individuals rather than subcontracting, leasing, or using temporary agencies; establishments that perform work in a single industry code; establishments that exist long enough to collect data rather than project-based limited-liability corporations; and establishments that have land line telephones rather than usually unlisted cell phones and Internet phones.

In redesigning the SRUP, NPPTL should consider limitations for specific respirator user subpopulations in the survey design. Respirators and other PPE are appropriately used where other control options are not feasible or while those controls are being implemented. Therefore, they tend to be used in higher-risk and less controlled work environments. These high-risk subpopulations (firefighters, health employees, miners, and construction employees) are an appropriate focus of NPPTL research. With limited resources, surveillance that allows reliable estimates of use in every industry sector may not be necessary. Preliminary targeted data collection such as focus groups or surveys of high-risk or heavy users of specific products may provide sufficient information for some program management purposes. Targeted assessments might also identify specific surveillance challenges where the definition of establishment based on unemployment insurance and payroll locations is not descriptive of employer, worksite, or work risks or tasks. Single employers that are multiple establishments, mobile employers, project-based limited-liability corporations, personnel services, and virtual employers present challenges in national surveillance that might be addressed in targeted settings.

Clearly, NPPTL should take care to avoid the methodological shortcomings of the 2001 SRUP. In selecting a sample frame, NPPTL should consider the entire workforce, not simply those employed in establishments covered by unemployment insurance laws. To the extent feasible, any future SRUP sample frame of establishments should include those sectors that are specifically excluded from federal OSHA regulatory oversight, including the self-employed, informal-sector employees who are paid cash, and domestic employees. Others who may be covered by regulation plans but not by OSHA or MSHA including railroad and airline employees, seafarers, longshore and harbor employees, and public employees should also be covered. For example, self-employed construction workers constitute approximately one-quarter of the construction workforce and are very likely a high-risk population with a high rate of respirator use. Similarly, firefighters and police are likely to have high

rates of respirator use but were excluded from the SRUP. This exclusion would be particularly inappropriate given NPPTL's expanded mandate related to PPE for chemical, biological, and radiological hazards and the concentrated use of these devices by public-sector first responders, the military, and other public employees.

Recent changes in Bureau of Labor Statistics (BLS) survey coverage have permitted consideration of expansion of the survey to firefighting, corrections, public-sector waste management, and other key service sectors in the 28 states that collect their own Survey of Occupational Injuries and Illnesses (SOII) data. At the time of the SRUP, BLS had not surveyed the public sector because there was no OSHA recordkeeping requirement that would elicit a sampling frame. However, BLS is now testing its ability to use the public-sector establishments in the Longitudinal Data Base (LDB).⁶ NIOSH and BLS are conducting a survey of U.S. workplaces to evaluate employers' perspectives regarding policies, training, and other related issues on workplace violence prevention, including risk factors associated with workplace violence and prevention strategies. The public-sector firms in the LDB are being sampled for this survey. It is hoped that this experience will determine if it is possible to extend coverage to the public sector in all states in future special surveys.⁷

NPPTL may wish to more selectively target future data collections to emphasize sectors of interest:

- *Agriculture, Forestry, and Fishing.* The use of respiratory protective equipment in wildland firefighting is a significant issue in this sector. Wildland firefighting crews are subject to inhalation hazards from combustion by-products and carbon monoxide, and there is a perceived reluctance on the part of the wildland firefighting community to accept the need for respiratory protection. The National Fire Protec-

⁶The LDB is the universe from which BLS draws the Current Employment Statistics survey sample. The LDB contains data on the approximately 8 million U.S. business establishments covered under the Unemployment Insurance System, representing 97 percent of all employers in the U.S. economy. There are a few sections of the economy that are not covered, including the self-employed, unpaid family employees, railroads, religious organizations, small agricultural employers, and elected officials. Data for employers generally are reported at the worksite level. The Quarterly Census of Employment and Wages program collects data from employers, on a quarterly basis, in cooperation with state employment security agencies. The LDB contains employment and wage information from employers, as well as name, address, and location information. It also contains identification information such as Unemployment Insurance account number and reporting unit or worksite number.

⁷A recent study has estimated the extent of respirator use in the U.S. Postal Service and among state and local governments. In support of a recent rulemaking, OSHA made estimates based on respirator use patterns in "like" private-sector establishments. Extrapolating the 2001 SRUP results, OSHA estimated that more than 1,000 establishments in the Postal Service and nearly 6,900 establishments in state and local governments had respirator users. OSHA, 29 CFR Parts 1910, 1915, and 1926, Assigned Protection Factors: Proposed Rule, Federal Register, June 6, 2003, pp. 34073-34074.

tion Association has considered a performance standard for wildland firefighting respirators.

- *Service Sector.* A great deal of work has gone into understanding the hazards and PPE protection requirements for emergency response personnel in the development of chemical, biological, radiological, and nuclear (CBRN) improvements after September 11, 2001, and some of that work has focused attention on the problem of inhalation of combustion by-products during initial fire knockdown and cleanup. Other issues are associated with exposure to respiratory hazards, such as smoke, soot, and airborne particles following the use of self-contained breathing apparatus. In the firefighting sector, there are some alternative sources of information that can be evaluated, including International Association of Fire Fighters and other firefighter data. Employees in waste management and remediation experience exposure to inhalation hazards; those in correctional institutions are exposed to biological particulate and aerosol threats from inmates and detainees; and ambulance service personnel are exposed to sick and contaminated persons during treatment and transport.

- *Mining.* The issues involved with respirator use in mining are somewhat more complex than in most other sectors. Mining is generally acknowledged to have the most advanced programs supporting respirator and breathing apparatus usage and the highest compliance rates. Yet current data indicate that the mining industry is associated with the highest rates of pneumoconiosis mortality. This introduces the complication of measuring respirator use in an environment in which mortality rates are the result of past exposures rather than current practices. Other issues are unique to mining. The tragedy at the Sago Mine in West Virginia that occurred in January 2006 underscored the importance of training and emergency preparedness, as well as the ready availability of PPE in mines. Additional details about self-contained self-rescuers in mining are also of interest, questions such as how many, where they are located, their capacity, their condition, their frequency of use, and their use in-place within the mine as opposed to use in escape.

- *Construction.* The NIOSH strategic goal with regard to construction is to enhance surveillance to support identification of emerging technologies and associated hazards, evaluation of intervention effectiveness, and identification of future priorities for protecting construction employees. Based on a peer review of construction surveillance conducted in 2004,⁸ NPPTL has adopted the approach of bringing together focus groups and targeting interventions rather than wide-scale survey operations for this industry. The focus groups are yielding valuable information about respirator usage from the perspective of the user, as well as the companies. The uniqueness of construction compounds the difficulty of obtaining valid information on respirator usage in a survey operation. For example, there is considerable

movement of employees between employers in construction. Except in the case of a hiring process managed in a controlled environment such as a union hiring hall, this turnover vitiates direct association of a particular company's respirator program characteristics with individual protection outcomes. High employee turnover and intermittent employment also present challenges for medical clearance for respirator use, training, and other aspects of effective respirator programs.

- *Manufacturing.* The manufacturing sector continues to present a variety of challenges for respiratory protection research. The approach of NIOSH to this industry relies on exploiting data from existing programs, such as the Sentinel Event Notification System for Occupational Risks (SENSOR) program, and focusing on specific identifiers available in the NIOSH Employee Health Chartbook to better identify risks in manufacturing. Emerging new hazards, such as those that may be associated with nanotechnologies, require vigilance in adapting surveillance systems to meet changing demands.

- *Health Care.* In health care, the requirement for respiratory protection is most often associated with protection from infectious diseases, important for both the health care provider and the patients. In addition, there is concern with smoke and fumes generated in the operating rooms of hospitals. The risk is evidenced by the estimate that the proportion of health care employees using respirators was higher than in all industries except mining, construction, and manufacturing.⁹ Additionally, NPPTL has identified risks in emergency departments to be of special interest. Parallel approval mechanisms for surgical N95 respirators by the Food and Drug Administration (FDA),¹⁰ which may be confused with NIOSH-NPPTL approval but are intended to protect patients, should be the subject of a scientific assessment that would compare the rigor and implications of the two systems of approval and certification. The fact that FDA approval is based on test data submissions by PPE manufacturers also offers an opportunity for public policy comparisons.

Given the strategic goals of NPPTL to consider possible interference within PPE "ensembles" and the requirement to consider ensembles for CBRN, the new survey should also consider other types of PPE. In particular, PPE that may interfere with respiratory protection should be considered including hearing protection, eye and face protection, and hoods or helmets intended to be used simultaneously. Ideally this surveillance will assist in defining future research priorities related to evaluating ensembles.

⁸NIOSH, NPPTL, Peer Review of Construction Surveillance, 2004.

⁹BLS/NIOSH, Respirator Usage in Private Sector Firms, 2001, Table 7, pp. 26-27.

¹⁰See <http://www.fda.gov/CDRH/PPE/>.

EMPLOYEE-WITHIN-ESTABLISHMENT SURVEY

In the final analysis, the measure of successful application of the NIOSH-NPPTL respirator use strategy is proper use of the respirator by the individual employee. There are many aspects to proper use—understanding the risks, understanding the importance of wearing the respirator, being properly screened for medical conditions, the variety of sizes and types of PPE purchased by employers to ensure correct selection and fit, making sure the respirator fits properly, and most significantly, being willing to wear the respirator when danger lurks. Some of these elements can, indeed, be measured by asking employers and their representatives questions about the respirator program.

Ultimately, however, some of these critical pieces of intelligence can be ascertained only by asking the employees themselves.¹¹ The ultimate question for NPPTL is, Are employees better protected because of the work of NPPTL? The answer to that question can be learned only by asking employees the following questions:

- Do they understand the kinds of risks and when they are at risk?
- How do they check fit or seal?
- Do they know how to correctly interpret the label?
- Do they really wear the respirator according to instructions?
- Do they understand the limitation(s) of the respirator?
- What are the barriers or conflicting demands that discourage use?
- Under what circumstances does PPE commonly fail?
- Are PPE maintenance, cleaning, storage, and other program components implemented and effective?

There are several possible means of collecting information from employees themselves. Among the methods that may be considered are establishment and employee surveys, household surveys, and focus groups. More details on these methods follow immediately below, as well as in the design for the future survey recommended by the committee.

COMBINED EMPLOYER AND EMPLOYEE SURVEY

Since the incidence of respirator usage varies so significantly by industry and establishment size, the most efficient means of identifying employees is to first sample establishments and then employees in order to interview the employees themselves. This is a difficult undertaking, requiring bringing together the rudiments of conducting a valid establishment survey operation (developing a sampling

frame, designing the survey, developing and cognitively pre-testing the questionnaire, and field-testing the survey) with the additional challenging task of identifying and sampling employees within the establishment. The task of surveying employees within establishments requires an unusual degree of cooperation on the part of employers and, in turn, unusual steps in soliciting and managing survey response.

NIOSH is now designing such a survey to collect descriptive data on hazards and exposures, practices, perceptions, and exposure controls. Called the National Exposure at Work Survey (NEWS), this proposed survey is designed to be a self-administered employee and management questionnaire that has now been subject to pilot testing in the health services sector, specifically in two Department of Veterans Affairs medical centers. The employee questions cover perceptions, job characteristics and demands, and hazard modules targeted by occupation. Employers are asked about policies and practices, and requirements for PPE, among other things. The pilot tests are designed to evaluate two modes of self-administered questionnaires (paper and web based) and to obtain feedback on questionnaire clarity, layout, and acceptance. It can be envisioned that if successful, the NEWS approach can be used to collect information in a controlled employer-employee environment on a sector-by-sector approach.

FOCUS GROUPS

The focus group methodology has moved to the front and center of the NIOSH approach to gathering information about PPE use. As the agency has directed its attention to a sector-by-sector approach, the surveillance staff has selected the focus group methodology as the primary means of investigation. It is unusual for a federal agency to use focus groups as the primary means of learning about the needs and behaviors of populations such as employees. NIOSH should be aware that the formal statistical standards of most, probably all, federal statistical agencies (e.g., National Center for Health Statistics, Bureau of the Census, National Center for Educational Statistics) would not select focus groups as their primary means of investigation. Between 2000 and 2004, NIOSH has conducted 21 focus groups in three construction industry sectors selected because of frequent respirator use and perceived hazards: protective coatings, road and transportation building, and demolition. In each of these construction sectors, NIOSH teamed with industry associations: the Society for Protective Coatings, the American Road and Transportation Builders Association, and the National Demolition Association, respectively.¹² The focus group discussions were conducted with both management and union employee groups in various locations around

¹¹Sargent, E., and F. Gallo, Use of personal protective equipment for respiratory protection, *ILAR Journal* 44(1):52-56, 2003.

¹²Doney, Brent, Protocol for Respiratory Protection Program Interventions in the Road and Transportation Building Industry, draft, NIOSH, April 2005.

BOX 5.1
Results from Focus Groups—Barriers to Respirator Use

Administrative

- Hard to get employees to wear respirators
- Requirements for maintenance of records for training and fit-testing
- Requirements for maintenance and storage of respirators
- Air monitoring
- Use of tobacco products
- Facial hair and other fashions
- Enforcement of rules
- High employee turnover rate and high mobility of work sites make it difficult to train and test
- Non-English-speaking employees

Design

- Interference with eye protection
- Filter resistance
- Reduced peripheral vision with supplied-air hoods
- Difficulty in exiting containment structures
- Straps annoyingly tight
- Paper dust masks stick to face due to moisture and have poor seals

Economic

- Administration of respirator program is costly (questionnaires for fitness to wear respirators and physical exams)
- “Fitness-to-wear” questionnaires and exams mean time away from work
- OSHA respirator regulations are perceived as written for large factories with medical personnel on-site, not for small companies

SOURCE: Doney, Brent. 2005. Protocol for Respiratory Protection Program Interventions in the Road and Transportation Building Industry, draft. NIOSH, April 2005, pp. 5-6.

the country. In the focus group sessions, information was obtained on respirator use; respirator program characteristics; exposure agents, controls, and suggested solutions; and reported barriers to respirator use.

Due to the unique nature of these management and employee focus groups, it was possible to get some very broad qualitative indications of barriers to effective respirator use—information that was not collected in the 2001 SRUP, although it could have been. These barriers (see Box 5.1) were classified as administrative, design, and economic.

While focus groups are useful to compile inventories of such barriers, the methodology does not provide information about how widespread the identified barriers are and under what conditions or in which industries they may be most serious. Moreover, as efforts are made over time to reduce the presence or impact of the identified barriers, focus groups are unsuitable to determine whether such efforts produce measurable changes in behaviors.

As a result of these focus groups, NIOSH identified possible solutions to the barriers. It was concluded that some of the design issues could be resolved by the selection of respirators with current advanced technologies or by the development of new respirator designs and that other barriers, such as employee turnover, education, training, medical evaluation, and language, are best addressed by the development of improved program administration tools.¹³

According to an American Statistical Association report,¹⁴ focus groups are useful tools for gathering a wide range of information in a relatively short time and do not require complex sampling techniques. They are flexible, in

¹³Doney, Brent, Mark Greskevitch, and Dennis Groce, NIOSH Reports on Respirator Use, ARTBA Focus Group Results, NIOSH, November 3, 2004.

¹⁴See the following web site for more information: <http://www.whatisasurvey.info/>.

that a trained moderator can explore related but unanticipated topics as they arise in the discussion. However, the results obtained from focus groups must be considered with some caution. They are limited because the sample is neither randomly selected nor representative of a target population, so the results cannot be generalized to the general population and the data cannot be treated statistically as would a survey sample. For example, the selection of management and union member employees from the three construction industries may have biased the results because the focus members were not representative of the bulk of employees in construction. The results of the focus groups should be taken to represent only the participants of the group.

The quality of the data is further influenced by the environment for the group and by the skills and motivation of the moderator. The results are also subject to the influence of the make-up of the particular focus group. Volunteer respondents may very likely have more interest in a topic and perhaps more knowledge about it.

Focus groups are useful methods for identifying topics and issues that should be examined with more statistical rigor, particularly when policy decisions are at issue. Nonetheless, focus groups have their place in a repertoire of tools for understanding the use of PPE in the workplace.

COMBINED SURVEY AND FOCUS GROUP APPROACH

Yet another approach to gathering information of use in guiding NIOSH programs is represented in the NIOSH approach to evaluate the impact of the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) and the effects of the FFFIPP recommendations and information products that are periodically distributed to the nation's 30,000 fire departments.¹⁵ This study examined career and volunteer, large and small size, and urban and rural fire departments to determine the extent to which firefighter reports, recommendations, and other information products are being implemented by fire departments. This evaluation also measured the effects of FFFIPP on the knowledge, behavior, attitudes, and safety practices of fire department management.

The survey combines a fire department survey (Tier 1) and focus groups (Tier 2). The fire department survey used a cross-sectional design with restricted random sampling¹⁶ to include 215 fire departments where there had been an investigation of a fatal incident. The survey included a random sample of 300 fire departments where there has not been any such investigation and, with certainty, the 10 largest fire departments. The random selection of additional fire departments was designed to balance various factors such as

the number of volunteer versus career, or rural versus urban firefighters, and other considerations.

The evaluation team qualitatively supplemented findings from the Tier 1 survey with a series of six focus groups with firefighters from across the country in order to explore ways in which FFFIPP may have affected firefighter knowledge, attitudes, behaviors, and safety practices.

Focus groups are also used as an important tool in the development of questionnaires and other facets of the design of population surveys. For instance, they might be used during the planning phase of a survey to identify questionnaire content, to develop and test survey questions, or to understand respondent reluctance to participate.

HOUSEHOLD SURVEYS

While not exactly a "rare" population, the 3.3 million employees¹⁷ who would be likely to use respirators for required purposes are a very small proportion of the overall workforce—just 3 percent of all private-sector employees. Finding them in a large-scale household survey would be a daunting and expensive undertaking. The survey operation would have to screen out 97 employees to identify the 3 who are in the population of interest. The likelihood of finding the employees themselves, so that information about respirator use can be obtained directly (self-response), adds a further dimension of difficulty to the possibility of employing a household-type survey for this data collection. Thus, a stand-alone household survey of employee respirator use would be inefficient and probably cost-prohibitive. Nonetheless, the allure of gathering data that may be crossed by other characteristics of interest generally gathered in household surveys (occupation, demographic characteristics, employment status, and hours worked) suggests that it might be fruitful to explore the possibility of adding a brief set of questions about employee respirator use onto an existing household survey, particularly if the screening can plausibly be conducted by telephone.

Another approach would be to screen the sample from a large existing health survey for affected employees. One survey that commends itself to service as the collection vehicle for a supplementary set of inquiries about respirator usage is the National Health and Nutrition Examination Survey (NHANES). Conducted annually by the National Center for Health Statistics, NHANES gathers data from a nationally representative sample of about 5,000 persons each year to assess the health and nutrition status of adults and children in the United States. The survey is quite unique in that it combines interviews with physical exams. The interviews have questions regarding the demographic, socioeconomic,

¹⁵<http://a257.g.akamaitech.net/7/257/2422/06jun20041800/edocket.access.gpo.gov/2004/04-28609.htm>.

¹⁶Restricted random sampling is the arrangement of sample units within blocks or clusters.

¹⁷As estimated by the SRUP. This estimate, however, omits public-sector and other types of employees who would be accessible in a household survey and increase the percentage of eligible households, although it is unknown by what amount.

and health status of the population. Although the limited size of the sample limits its utility in addressing the prevalence of respirator use in the workplace, the possibility of collecting information on respirator usage, and occupational exposure, in conjunction with demographic and health information, recommends this survey for consideration.

A shortcoming of employing an existing survey to collect data on employees who use respirators is that the sample designs will not be efficient for providing a good representation of employees from industries of particular interest. It would not be possible to oversample selected industry sectors. This would limit the amount of possible subgroup analyses. If such a survey were used, it might best be done in conjunction with the special surveys focused on particular industries (described above). If it were possible to collect reliable data from a household-type survey, it would be useful to extend those data by linking household or individual data to an employer survey. A complex but interesting example might be the way the National Health Interview Survey and the Medical Expenditure Panel Survey interlink several surveys including household, insurer, and health care provider. Other large household surveys that might be screened in this way would be the Behavioral Risk Factor Surveillance System survey, the Current Population Survey, and the American Community Survey.

If the objective of the survey of households were simply to screen and identify a population that is likely to represent employed workers in respirator-using industries, another technique would be to use a data collection mechanism developed by the National Center for Health Statistics known as the State and Local Area Integrated Telephone Survey (SLAITS). Designed to provide in-depth state and local health care information, this mechanism uses the sampling frame from the National Immunization Survey, an ongoing telephone survey that screens nearly one million households per year to produce estimates of vaccination coverage levels among children. SLAITS provides a mechanism, using a random digit dial telephone design, to collect data quickly on a broad range of topics at the national, state, and local levels. A partial list of examples of research areas includes health insurance coverage, access to care, perceived health status, utilization of services, and measurement of child well-being.¹⁸

In the United Kingdom, the Health and Safety Executive conducted a Workplace Health and Safety Survey of households in 2005. The survey was administered by telephone, with households selected by random digit dialing and a respondent selected randomly from household members who worked at some time in the 12 months prior to interview. The survey collected information on the number of employees exposed to different workplace hazards and employee's concerns, training levels, and view of trends in risk. Although the survey collected information on exposure to dust and

fumes, and about training and information on these hazards, no information was collected about the use of respirators or other PPE. The results from this survey are based on responses from 10,016 British employees, a response rate of only 26 percent.¹⁹

USE OF OSHA COMPLIANCE DATA

It is fitting to consider the administrative data collected as a result of the OSHA compliance program as a potential source of information on respirator use in the workplace. After all, most of the questions posed in the various statements of purpose for the NIOSH-BLS survey pertained to whether or not the employers were compliant with OSHA regulations. It would seem that an ideal way to measure compliance would be to use the results of compliance inspections. The data in the OSHA Integrated Management Information System reflect that from October 2004 through September 2005, the agency issued more than 4,500 federal citations for respiratory protection (Table 5.3). The year before, citations issued by OSHA for violation of the 1910.134 respiratory standards were the fifth highest on the list of 378 different types of violations.²⁰ Special emphasis programs at the area office or regional level might also allow narrow targeting.

Unfortunately, for a number of reasons the use of OSHA compliance data is not a very promising avenue of approach to illuminate issues of respirator use in the workplace. The 1998 NIOSH Respirator Surveillance Team concluded as much when it stated that OSHA compliance data regarding respirators are too limited to be of significant utility in addressing the issues detailed in Chapter 3. For one thing, much like BLS data, OSHA compliance data do not address respirator use per se. The inspections reflect the faithfulness of the establishment's implementation of a program in compliance with the regulation.

Most importantly, OSHA compliance data are unlikely to be representative of the population of companies that should have respirator programs. OSHA targets its programmed inspections by first identifying all establishments that were in four-digit Standard Industrial Classification categories with reported lost work time injury rates above a state's manufacturing average. Then, it chooses sites randomly within this set, excluding where there are fewer than 11 employees or where an inspection was conducted in the last three years.²¹ Inspections may also be targeted based on "special emphasis programs at the area office level, or based on reported lost work time injuries" (which may

¹⁹Hodgson, J.T., J.R. Jones, S.D. Clarke, A.J. Blackburn, S. Webster, C.S. Huxtable, and S. Wilkinson, Workplace Health and Safety Survey Programme: 2005 Employee Survey First Findings Report, Health and Safety Executive, Caerphilly, UK, May 2005, p. i.

²⁰Doney, op. cit., p. 275.

²¹Mendeloff, John, and Wayne B. Gray, Inside the black box: How do OSHA inspections lead to reductions in workplace injuries? Law and Policy April:221-223, 2005.

¹⁸<http://www.cdc.gov/nchs/slaits.htm>.

TABLE 5.3 Federal OSHA Citations by SIC Division, October 2004-September 2005

No. Cited	No. Inspected	Penalty (dollars)	Industry Classification
2,449	1,104	930,785	Division D/Manufacturing
939	348	152,134	Division I/Services
592	309	231,139	Division C/Construction
206	92	78,053	Division E/Transportation, Communications, Electric, Gas, and Sanitary Services
116	50	40,173	Division F/Wholesale Trade
98	43	8,070	Division G/Retail Trade
44	16	28,063	Division B/Mining
23	8	3,750	Division J/Public Administration
22	10	3,365	Division H/Finance, Insurance, and Real Estate
15	4	2,987	Division A/Agriculture, Forestry, And Fishing

SOURCE: http://www.osha.gov/pls/imis/industryprofile.stand?p_esize=&p_stand=1910.134&p_state=FEFederal&p_type=1.

skew the source of SOII injury data). Half of all compliance inspections are initiated by a complaint from an employee or union representative about an alleged violation or hazard at the workplace, although these may not involve site visits. While these selection criteria may yield a population of great interest to OSHA, the process is designed to produce a population that is not representative of the overall population of employers; thus, the compliance data cannot be used to make generalizations applicable to the overall population of respirator-using establishment. Since these data are not collected for research purposes and OSHA inspectors are provided no training on proper coding or data quality assurance, considerable effort would be required to evaluate the reliability of this dataset.

USE OF EXISTING ADMINISTRATIVE DATA SOURCES

Several of the alternative sources of data that hold promise for illuminating the issues in respirator protection have been discussed in the proceeding sections, including sources such as the International Association of Fire Fighters surveillance data and the SENSOR program data. Many of these data sources are summarized in easily accessible form in the NIOSH Employee Health Chartbook. The 1998 NIOSH Division of Respiratory Disease Studies (DRDS) Respirator Surveillance Team report concluded that currently available sources are fragmentary and not likely to be useful for purposes of assessing respirator use in industry,²² and there is no indication that these fragmentary, and thus unrepresentative, sources have evolved since then in ways that would provide a more comprehensive view of respirator usage in the workplace. However, the DRDS team found that OSHA, MSHA, and company annual reports indicated the possibility that a special effort to obtain unpublished information that may be available from these parties would partially meet the need for assessing respirator use. The team suggested eliciting this

unpublished, nonproprietary information in focus groups or like venues.

ALTERNATIVE MEANS OF COLLECTION OF DATA

Several other possible means of data collection were contemplated. They are listed here for information only. NPPTL may wish to consider the following:

- Some form of postmarket surveillance of respirator use or performance similar to the FDA postmarket surveillance (21 CFR 822) used for medical devices, which is based on section 351 of the Public Health Service Act.²³ This sort of reporting requirement might require modification of regulations related to respirator certification.
- A database of user complaints to identify end user problems with specific respirator performance, durability, instructions, labeling, and so forth. Improved technology and software for web-linked databases would make such an effort relatively inexpensive. This would cost considerably less than end user or user establishment surveys and could provide ongoing feedback to NPPTL. The ability of NPPTL management to observe trends may be more valuable than a much more detailed survey that might not be repeated.
- Some form of user survey (include coupon or lottery cards in each box with web address and prizes for those that go to the site and fill out the questionnaire in order to enter the contest or obtain the prize). These would be inserted into boxes by manufacturers as a condition of future certifications. This would be a low-cost supplement to other surveillance databases that could be linked through a specific respirator model or certification number.
- Telephone follow-up of specific PPE users treated in emergency rooms and reported in a data collection system akin to the Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) data-

²²DRDS, op. cit., 1998.

²³See <http://www.fda.gov/cdrh/devadvice/352.html>.

base. NEISS is a national probability sample of hospitals in the United States and its territories. Patient information is collected from each NEISS hospital for every emergency visit involving an injury associated with consumer products. From this sample, the total number of product-related injuries treated in hospital emergency departments nationwide can be estimated. In this manner, follow-up information can be captured within a couple of days after emergency department visits, and detailed telephone interviews initiated. NIOSH supports the collection of work injury and employment data from a subset of these emergency departments through a memorandum of understanding with the U.S. Consumer Product Safety Commission, but PPE would have to be addressed in targeted follow-back with injured employees.²⁴ This would constitute a small sample, but it would yield potentially rich data related to acute injury.

- Collection of data from respirator users on federal contracts or procurements. This could be inserted as a contractual obligation. Mandatory response has definite advantages if the limitations or characteristics of the sample can be defined clearly.

- Analysis of PPE-specific data from Chemical Safety Board investigations of industrial disasters that often involve significant PPE use information. Using state or federal workers' compensation claims or data from large private owners involved in owner-controlled insurance plans on multiemployer sites to identify injured employees who could be asked about injuries involving the use of or failure to don PPE.

- Targeting specific large projects and/or randomly selecting and investigating every employer on a specific city block or census code. The United Kingdom's Safety Executive uses this "blitz" approach to identify small employers with some success.

- Conducting unannounced observational visits to worksites to ascertain worker practices with regard to wearing and maintaining respirators. This concept is currently the approach of an organization such as the Joint Commission on Accreditation of Healthcare Organizations. This organization no longer asks questions in advance or announces visitation in advance. Observers arrive spontaneously to actually determine what is being done. They look for gaps between what was to be done and what is done.

While these options offer the benefit of relative availability and the allure of relatively inexpensive access, it should be clearly noted that findings representative of the general population from such sources are highly unlikely, thus seriously limiting their utility in determining what is happening in the general populations of employers and employees.

²⁴The NEISS Sample, see <http://www.cpsc.gov/neiss/2001d011-6b6.pdf>.

A COMPREHENSIVE SURVEY PROGRAM FOR THE FUTURE

To meet future NPPTL information needs that are best met by gathering data from employer and/or employee surveys, it is plausible and necessary to build on experience from the SRUP and other comparable recent surveys to develop a more useful, flexible, and scientifically rigorous survey data-gathering capacity. As evident from the committee's review of information needs related to PPE use, a well-designed series of periodic surveys could provide NPPTL with most if not all of the population-based data it will need in the next several decades.

Data on respirator use are best provided by employers and employees in the context of the work setting.

RECOMMENDATION 5: NPPTL should develop for implementation an ongoing survey of employers and employees whose overarching goal is to obtain needed information on the use of respirators and other PPE in the United States. To ensure the scientific quality and broad utility of this series of surveys, NPPTL should ensure that this system of periodic surveys

1. **Is sufficiently flexible to meet NPPTL's changing information needs; and**
2. **Attains to the highest standards of current survey research by**
 - **Following a responsive sample design,**
 - **Ensuring the reporting accuracy of all of its key survey measures,**
 - **Widely disseminating its findings,**
 - **Making its data easily available to outside researchers, and**
 - **Documenting all of its methods in detail.**

Several survey design options should be considered when determining the best approach to obtaining data on PPE use from employers and employees. Employer data might be collected by mail, Internet, telephone, or in person from a sample of employers only, or from the first-stage sample of employers in a two-stage sample of employees. Employee information might be gathered from employees in the second stage in this same two-stage design. When there are significant barriers to collecting employer and employee information from the same sample, a split sample of employers might be used with one employer subsample designated for employer data gathering and the other subsample being used to collect data from employees.

The design features described below could, for example, be used as the basis for developing a series of design-related periodic surveys that provide both detailed benchmark data from large in-depth survey rounds conducted every 5-10 years and more basic trend data from smaller rounds conducted in the intervening years. Another alternative might be to use the initial cross-sectional survey of employees as

the basis for a panel design in which employees would be recontacted periodically and interviewed. While this introduces the costs and complications of panel maintenance (e.g., panel conditioning, respondent tracking, attrition), it might provide some data on change over time. It would also permit follow-up on health changes over time, a benefit not available from the other methods. If a major survey can be conducted only every 5-10 years, a panel might have some appeal.

Regardless of actual details of the final design of the system for these surveys, the underlying assumption in each periodic survey is that the information needed by NPPTL is best obtained from employers or from the employees themselves.²⁵

Two key requirements of these periodic surveys must be that (1) their designs are rigorously developed and (2) they are flexible in both design and implementation. While the basic designs can be sketched here, a number of important design issues would emerge in developing the design of these future surveys. Among them would be to rigorously answer important design questions concerning the best and most practical

- Employer or establishment frame;
- Sample size;
- Allocation of the sample among stages and strata;
- Mode or mixture of modes to collect the needed data;
- Wording of individual survey questions (particularly those used to produce the key outcome measures of interest);
- Survey instrument(s) design;
- Means to obtain high-quality measurements of PPE use;
- Estimation, reporting, documentation, and dissemination approaches; and
- Methods for assessing data quality.

Resolving these important design questions in a deliberate fashion would require a planning period of two to three years to answer these questions rigorously before regular survey implementation can commence. In real terms, this planning effort should be led by appropriate NPPTL staff, but with significant external input from sample and questionnaire design experts in survey research methods as well as outside experts in all subject matter areas that are relevant to the pur-

poses and content of these surveys. After the specific needs to be met by these surveys have been articulated, a detailed list of survey objectives would be set, and a preliminary draft of key survey questions would be developed. Activities during this planning period might include any or all of the following: statistical design studies to address sampling issues, in-depth cognitive testing of all key survey questionnaires and forms, rigorously designed and conducted field tests to resolve key survey design issues (e.g., the most accurate way to measure PPE use, alternative contact persons, what level of financial or token incentives to offer employers and/or employees), issues in using multiple modes of data collection, and large-scale field tests to act as a “dress rehearsal” for the final design plan(s). Finally, during the implementation phase of these survey designs, there should be an occasional formal assessment of both the designs and the data-gathering processes associated with them to identify and systematically resolve any unanticipated issues in conducting these surveys. In sum, the design is a project in itself. A second key requirement of the recommended periodic surveys is that they must be adaptable to changes in and evolution of NPPTL information needs over time. More specifically, the framework for selecting the sample for each round must be able to accommodate specific statistical needs at that time. For instance, if a round must focus more intensively on findings in certain work sectors, the sample must be stratified by those sectors so that larger sampling rates can be directly applied to disproportionately sample each sector of particular interest. The design must also readily allow for reasonable statistical representation of those from whom data are collected. Moreover, the data collection plan must move easily between collecting information from employers, employees, or both.

Design for a Survey of Employers Only

Sample Design

When data are sought only from employers, conventional list sampling methods are frequently appropriate. In this type of survey design there is a one-to-one link between those sampled and those observed. For surveys of business establishments, this means that a sample of employers is randomly chosen from an appropriate list frame (of employers) and that employer-level data are collected from those selected in the sample. The sample size in these and all samples should be adequate to meet clearly prespecified quantitative measures of needed statistical precision and/or statistical power for key survey estimates (e.g., relative standard error, margin of error, power to detect subgroup differences of some specified amount). Some form of stratified simple random sampling is often most useful to identify those employers from whom data will be gathered. Strata used in this way might be defined (1) by employer characteristics that are highly correlated with the key study outcome measures

²⁵More in-depth treatment of the survey methods issues and techniques mentioned in this section is given by the following: Kish, Leslie, *Survey Sampling*, New York: John Wiley and Sons, 1965; Lohr, S. *Sampling: Design and Analysis*, California: Duxbury Press, Pacific Grove, 1999; Kalsbeek, W., and G. Heiss, *Building bridges between populations and samples in epidemiological studies*, *Annual Review of Public Health* 21:1-23, 2000; Groves, R.M., F.J. Fowler, M.P. Couper, J.M. Lepkowski, E. Singer, and R. Tourangeau, *Survey Methodology*, New York: Wiley & Sons, 2004; Kalton, G., and I. Flores-Cervantes, *Weighting methods*, *Journal of Official Statistics* 19(2):81-97, 2003.

and/or (2) by the concentration of one or more population subgroups whose findings are of particular interest and thus may be disproportionately sampled. Sample allocation in a stratified sample might be proportionate or optimal (following Neyman allocation), if overall population estimates are the main priority in analysis, or disproportionate to facilitate focusing findings on important population subgroups by oversampling those subgroups. Stratification might also be used to facilitate screening down to a particular type of business establishment, such as establishments with organization of work or safety culture characteristics associated with noncompliant PPE use. For example, when focus in a round is limited to establishments whose employees actually use PPE, one might isolate those types of establishments that are most likely to use PPE and then disproportionately sample them. Stratification in this case reduces the cost of screening out those employers with employees who do not use PPE. However, it does not effectively segregate establishments that do not use respirators, but should. In a pilot sample, stratification based on other criteria, such as risk rather than respirator use, should be considered.

The quality of the business establishment frame is an important determinant of the representativeness of the sample and the utility of the findings obtained from the sample. The respondents to the SOII were used for employer sampling in the SRUP, but as this review has found, the choice of this sample frame limited coverage of some groups of interest and, importantly, limited sponsor access to the survey data due to the need to protect the confidentiality of the list of businesses. In future surveys, NPPTL should explore using other employer frame sources. These include business lists available from private vendors, such as Dun and Bradstreet and InfoUSA. If data access is not an issue, NPPTL may wish to explore contracting with the U.S. Bureau of the Census to have access to the lists maintained by that agency.²⁶ Some criteria for determining which list to use should include coverage of the targeted population of interest, availability of information on workforce size and measures used for stratification, availability of current and accurate locator information, relative ease and cost of use, and whether or not access to individual records is required. Balanced against these considerations is the potential benefit of again using the list of SOII respondents as a sample frame if it becomes possible to capture the potential benefits of correlated ancillary information (from the SOII) that can improve the precision of survey findings through the use of ratio or regression estimation.

²⁶For an evaluation of the major government and the Dun and Bradstreet lists as sample frames, see Cox, Brenda, Quality of U.S. Business Establishment Frames: Discussion, Proceedings, Survey Methodology Section, Washington, D.C.: American Statistical Association, 1997. For a comparison of the Dun and Bradstreet and InfoUSA lists, see Long, David A., and Tammy Ouelette, Private Employers and TANF Recipients, Final Report, Abt Associates, Washington, D.C.: May 25, 2004, Exhibit 5.2.

This design might be expanded to three (or more) stages if it were more practical to sample employers and employees separately within a sample of local area units such as counties or census tracts, which in this case would become the target areas for the sampling, also known as primary sampling units (PSUs). When in-person visits and/or interviews are required by the survey design, sampling area units first in this way would decrease the cost of data gathering by geographically confining the field operation and thus reducing travel costs.

Data Collection Plan

In terms of methodology, any future establishment survey should be based on a set of protocols.

RECOMMENDATION 6: The most efficient data collection approach for the establishment survey is a mixed-mode design involving three phases: (1) an initial round of telephone screening calls, (2) a mail survey approach, and (3) telephone follow-up calls to nonrespondents.

The initial round of telephone screening calls has the following objectives: (1) to identify and remove from the sample those establishments that are no longer in business, (2) to identify establishments that are PPE users, (3) to identify and close out as “completed” non-PPE user establishments, and (4) to make contact with the best-qualified respondent at PPE user establishments. The calls should be made by well-trained telephone interviewers in the survey contractor’s centralized call center. A computer-assisted telephone interview (CATI) system should be used to control the interview process, schedule calls, and manage the caseload. The interviewer should ask to speak to the person most knowledgeable about possible PPE use at the establishment.

RECOMMENDATION 7: Instead of addressing the survey to someone with unknown expertise in the area of interest, surveillance personnel at NPPTL should conduct a quick telephone screening of sampled establishments in advance of the mail survey to identify the best-qualified respondent and to learn from that person whether the establishment is eligible for the full survey (that is, required use of respirators in the past 12 months).

Once contact is made with this person, the interviewer would determine the PPE status of the establishment and, for PPE establishments, explain the survey in more detail and encourage the person to complete and return the questionnaire when it arrives.

The mail survey phase should be patterned after Dillman’s Tailored Design Method, discussed earlier. Three mailings should be used: (1) an initial questionnaire mailing, sent promptly after the advance screening call to the respondent

identified in that call; (2) a thank-you or reminder postcard mailed to all initial questionnaire recipients a week after the initial mailing; and (3) a replacement questionnaire mailing sent to nonrespondents two to four weeks after the initial questionnaire mailing. Follow the suggestions in Chapter 4 of the Dillman text concerning the content and format of the mailings and the type of postage to use. Most important, follow the precepts of the Tailored Design Method to the maximum extent possible.

The purpose of the nonrespondent follow-up calls would be to motivate the person to complete and return the questionnaire.²⁷ These calls should be made by the same telephone interviewer staff that made the initial round of advance screening calls (ideally, by the same interviewer who made the screening call to the establishment initially). Again, a CATI system should be used to control and manage the process. As noted in Chapter 4, the calls should be made beginning one week after the replacement questionnaire mailing to increase the likelihood that the respondent still has the questionnaire. When a respondent promises to complete and return the questionnaire, the interviewer should enter a follow-up date in the case management system 10 days or so hence and then call back the person if the questionnaire has still not been received at that time. Persons who refuse to participate during the nonrespondent follow-up call should be recontacted by specially trained “converter interviewers” in an effort to overcome the refusal.

Analysis and Weights

From any randomly chosen sample one can obtain estimates of population parameters of interest such as the mean, total, or proportion associated with certain employer or employee characteristics of the population targeted by the sample. Sample designs that are developed to produce these population estimates include some important statistical features, including stratification and cluster selection as well as the inclusion probabilities of individual survey respondents. From the latter feature, sampling weights are computed for each survey respondent as the inverse of their selection probability that is adjusted to account for differential frame coverage and nonresponse.²⁸ These design features are then incorporated into the analysis of the survey data. A weight would be developed for a sampling unit, whether an employer or employee.

²⁷If feasible, the interviewer should first try to complete the questionnaire over the telephone during the nonrespondent call, rather than rely on the person to complete and return it. However, the length and content of the questionnaire may make this infeasible. Determining the feasibility of this approach should be one of the goals of a pilot study.

²⁸Sample weights might also be “trimmed” to control variation in the weights, and they might be calibrated to the target population to compensate for other important imbalances that can affect the statistical bias of weighted estimates.

To compute national- or industry-level estimates from the survey data, a weight for each employee or employer in the sample would be developed. One multiplicative component of these weights is the base weight, computed as the inverse of the inclusion or selection probability, to account for disproportionality in sample selection. The remaining weight components might include some type of adjustment to correct for differential frame coverage and/or nonresponse. Some or all of the adjustment weights may be used depending on the information available to create weights and the degree of error introduced by nonresponse or non-coverage. For example, an additional weight could be used to account for instances where some records, such as specific employers, appear on the sampling frame more than once. If these were not removed prior to sampling, this multiplicity can be adjusted by using another weight to account for the number of appearances on the sampling frame.

To account for sample imbalance due to nonresponse and remaining sources, weighting class and calibration adjustments might be used, respectively. A weighting class adjustment uses available information for both respondents and nonrespondents to account for differential nonresponse across members of the sample.²⁹ Information available from the SOII on industry type could be used to create adjustment weighting classes and adjustment weights. In addition, information may be available for the entire population from BLS or other sources to calibrate the final set of weights to the study population (through poststratification or ranking ratio adjustments).

The objective of adjustment weights is to reduce bias introduced by survey nonsampling errors. The weights reduce bias but increase sampling variance. Weight trimming or truncation attempts to reduce the increased variability introduced by extremely large weights. A sensitivity analysis could be used to determine the right balance of weight trimming to adopt in the survey. The final weight associated with each survey respondent is a multiple of the base weight times each of the adjustments.

Following an analysis plan to produce the findings sought in meeting survey objectives, the final weight is then used in an analysis that accounts for all features of the sample design: stratification, cluster sampling, and sample weights. These features are generally available in software designed for analysis of survey data such as SUDAAN, STATA, and the analysis of survey data procedures in SAS Version 8.0 and beyond. A helpful comparative summary of survey analysis software appears through a link at the web page for the Survey Research Methods Section of the American Statistical Association.³⁰

²⁹Similar to a nonresponse or undercoverage adjustment, a weight might be considered to adjust for those firms that have gone out of or come into existence during the data collection period that are not accounted for in the frame.

³⁰See <http://www.hcp.med.harvard.edu/statistics/survey-soft/>.

Design for a Survey of Employees Only

Sample Design

When data in a survey round are to be collected from employees only, or from both employers and employees within the same sample design, it is prudent to sample separately at those two levels of the workforce. This implies cluster sampling in two or more stages of selection, with sampling units being employers or worksites in one stage and employees in the next (and final) stage. Two-stage sampling is the simplest application of this family of designs, where a random sample of employers or worksites serving as the PSU (i.e., the sampling unit in the first stage) is chosen and a random sample of employees is selected separately in the second stage. Frame selection issues and the notion of limiting survey data collection to a sample of area units in this design setting would be similar to those previously discussed in the employer-only design setting. In a two-stage sample of employees a stratified sample of business establishments would be chosen first. The issues related to defining strata and allocating the sample among them would also be similar to those presented for an employer-only survey. Selection of employers in each stratum in a two-stage design would best be done with probability proportional to size (PPS) if an employee sample is sought and if a suitable measure of the current number of employees is available on the employer sampling frame.

The sample of employees is chosen in the next sampling stage by separately choosing an employee sample within each participating member of the employer sample. Sampling in this stage requires a list of employees that the employer can and is willing to produce. This list must include sufficient information to stratify the employee selection (if needed, e.g., by length of employment) and to contact selected employees for study participation and data collection. Employee selection within each employer might typically utilize basic selection methods, such as simple random sampling or systematic sampling, unless employees must be disproportionately sampled (e.g., by demographics such as amount of formal education).

Data Collection Plan

As indicated above, employees can best be surveyed using a two-stage sampling design in which employers are sampled at the first stage and employees are sampled in the second stage. This approach has been used successfully to survey employees in the Department of Labor's Occupation Information Network (O*NET) project. A summary of the O*NET data collection protocol used by the contractor is presented in Box 5.2.

This model could easily be adapted for use in a PPE employee survey. The first step would be a "verification" call to the sampled business establishments to eliminate those

that are no longer in business and to identify a contact person for the establishment as before. The next step would be a screening call to the contact person to learn if the establishment uses any PPE. If the business does not use PPE, data collection is complete for the establishment at this point. For PPE users, the caller briefly explains the employee survey and tells the contact person that an information package will arrive shortly for his or her consideration.

After the screening call, the next step would be the mailing of an information package to the contact person, including a NIOSH transmittal letter, a brochure, endorsement letters, and possibly a token gift.³¹ A week or so later, a "recruiting" call would be made to confirm eligibility and enlist the contact person's agreement to participate. If the contact person agrees, the caller would ask the contact person to complete a roster of employees who use PPE and would make an appointment to call the contact person back for the sampling call.

During the subsequent sampling call the survey contractor's telephone interviewer would work with the contact person to select a sample of PPE users from the contact person's roster. The caller would inform the contact person of the roster line numbers of the selected employees and explain that a set of questionnaire packages will be sent to him or her for distribution to the sampled employees.

The next step would be the mailing of questionnaire packages to the contact person. The packages would be identified only by roster line number; the survey contractor never has the employees' names. The contact person is reminded to distribute the questionnaire packages to the sampled employees on the roster and to encourage them to complete and return the questionnaire to the survey contractor. Consideration should be given to providing a gift to the contact person to help motivate him or her to follow through with these tasks.³²

The transmittal letter to the sampled employees would encourage them to complete their questionnaires on their own time and return them directly to the survey contractor in the business reply envelope provided. The employees are assured that their data will be treated confidentially and never provided to their employer or to anyone else in a manner that would permit identification of a respondent.

At this point, the case would enter the follow-up phase. The telephone interviewers would make a series of follow-up calls to their contact persons to keep them updated on the progress of data collection from the sampled employees (which roster lines have returned questionnaires and which haven't) and to request that the contact person follow up with

³¹An example of a token gift would be a refrigerator magnet such as NIOSH's "Have your checked your seal?" or "We have you covered" magnets.

³²The O*NET project includes a framed Certificate of Appreciation from the U.S. Department of Labor in the questionnaire mailing to the point of contact.

BOX 5.2

Surveying Employees in an Establishment Survey: The O*NET Example

The Occupational Information Network (O*NET) is a system for collecting, organizing, describing, and disseminating information on occupational requirements and employee attributes. Administered by the U.S. Department of Labor, the database is designed to be the most comprehensive standard source of occupational and skill information in the United States.

The O*NET data collection program employs a two-stage design to survey establishments and employees within those establishments. The survey consists of (1) a statistical sample of establishments expected to employ employees in each specific occupation and (2) a sample of employees in the targeted occupations within each sampled establishment. The sampled employees are asked to complete one of several survey questionnaires covering various aspects of their occupation, a brief demographic questionnaire, and a short occupation-specific task inventory.

The primary stage sample of establishments is selected from lists supplied by InfoUSA (prior to October 2003) and Dun and Bradstreet (subsequent to October 2003). The establishments are selected from industries expected to employ the occupations. Up to 10 occupations are then randomly assigned to each establishment for possible data collection.

The complex data collection environment of the O*NET survey requires special, intensive data collection procedures:

- Step 1. Verification call to initial establishment contact (receptionist)
- Step 2. Screening call to possible contact person
- Step 3. Send information package to contact person
- Step 4. Recruiting call to contact person
- Step 5. Sampling call to contact person
- Step 6. Send questionnaire package to contact person
- Step 7. Send Toolkit for Business (a package of information on how to use O*NET data)
- Step 8. 7-day follow-up call to contact person
- Step 9. Send thank-you or reminder postcards
- Step 10. 21-day follow-up call to contact person
- Step 11. 31-day follow-up call to contact person
- Step 12. Send replacement questionnaires
- Step 13. 45-day follow-up call to contact person

The contractor had used this intensive methodology to survey more than 69,000 sampled establishments and 118,000 selected employees as of September 2004. The overall response rate was 70 percent for establishments and 65 percent for employees. Comparisons were made between respondents and nonrespondents on a variety of frame variables, and weight adjustments were made to compensate for the small differences found. Response rates for most questionnaire items were very high, minimizing the potential for item nonresponse bias.

employees who have not returned their questionnaires. In addition to the follow-up phone calls, thank-you or reminder postcards are sent to the contact person about a week after the sampling call, with a note requesting that the contact person distribute postcards to all of the sampled employees. After several weeks, replacement questionnaires are sent to the contact person for distribution to nonresponding employees

Analysis and Weights

The previously described principles for producing sample weights and implementing the analysis plan for any survey round would apply here as well.

Design for a Simultaneous Survey of Employers and Employees

Sample Design

If it was found that information from both employers and employees was needed at the same time (i.e., during the same survey round), two potential design strategies might be followed. One design option (Design 1) would produce two separate samples: one of employers following selection methods described for employer-only survey rounds and a second of employees chosen from a separate random sample of employers. The samples of employers for each

component sample might be chosen by randomly splitting an initial probability sample of employers. The two employer samples might also be independently selected random samples, although drawing independent samples raises the unwanted possibility (probably slight) of employer overlap in the two samples. Each of these alternative approaches has its own advantages and limitations. In particular, the independent samples permit different stratification plans for employer and employee surveys. If particular categories of employees are to be oversampled, the independent samples approach permits oversampling (by selected establishments disproportionately) without the use of (possibly) unduly large employee cluster sizes.

The other general design option (Design 2) would follow the two-stage sample design described for the employee-only survey, but data would be collected both from a contact person in the business establishment and from employees. The respondent to the employer questionnaire and the contact person to facilitate employee sampling may or may not be the same person. Since the PPS sampling of employers in the employee-only survey may not be the most appropriate here, the sampling method within the employer sampling strata may be simple random sampling with disproportionate allocation among strata. The sampling rates would be higher for employers with larger workforces. The disproportionate allocation would result in variable employee sample sizes within selected employers.

Data Collection Plan

While the employer-only and employee-only surveys described above involve somewhat different data collection protocols, they are similar in that both rely heavily on telephone and mail survey resources. Thus, some efficiency could be gained from conducting the two surveys simultaneously and from the same sample design as assumed in the Design 1 option above. For example, the same telephone staff could be used to conduct the initial telephone screening call and nonrespondent follow-up calls for the employer component of a combined survey. Other field work that would realize similar efficiencies would include screening employers for PPE use, recruiting eligible employers to participate, conducting within-establishment employee sampling, and completing follow-up calls for the employee interview component. In addition, the mail operations of both surveys could be performed by the same staff, using similar procedures. If the survey contractor has an adequate survey operations capacity, efficiencies could also be realized in staff training and supervision, common management information and survey control systems, and production operations such as mailing and processing completed questionnaires. All of these efficiencies, when taken together, would imply lower overall survey management costs resulting from a shorter performance period relative to conducting the two surveys at different times.

The employer and employee surveys described above could be combined into a single survey as described for Design 2 by modifying the employee survey protocol to include data collection from the selected employer contact person, as well as from a sample of their employees. In this setting, the contact person would complete the employer questionnaire and also coordinate data collection from the employees, as outlined above. While this design would require fewer resources than two separate surveys, it is of concern that contact persons may be reluctant to participate for fear that the employees may give a different picture of PPE usage at the establishment than that reflected in the questionnaire completed by the person responding for the employer. If this model is considered, it would have to be carefully field-tested during the planning phase to determine its feasibility.³³

Analysis and Weights

The previously described principles for producing sample weights and implementing the analysis plan for any survey round would apply here as well.

Data Quality

In any of the above design alternatives, attention needs to be given to checking the quality of implementation and the quality of the data. Among other steps that might be taken would be a reinterview program at both the screening and the main data collection stages. In these procedures, samples of establishments responding to the screener and main survey are selected and reinterviewed, with the reinterview and survey data being compared to estimate screening error rates and the reliability of reports. For the screening, a sample of firms that screened out as having no respirator use would be recontacted and rescreened. The sample might be disproportionately selected from those industry types with high respirator use. This would permit an estimate of firms that were screened out in error. For the main interview, a sample of establishments would be recontacted and administered a subset of selected items from the interview.

The reinterview approach would not be as easily done at the employee level, but other means should be explored in pilot testing to assess the quality of the employee data.

COMMITTEE COMMENT

Proper respirator use in the workplace is truly a matter of life and death. It is important to understand those practices and technologies that promote proper use, as well as those that inhibit the proper wearing of this important protective

³³The response rate concern could be ameliorated somewhat if the establishment questionnaire collected different information about PPE usage than the employee questionnaire.

equipment. While the committee applauds the initiative of NIOSH and the BLS in conducting the pioneering SRUP in 2001 in order to bring workplace practices to light, it concludes that further studies must go beyond this initial effort to discover information useful in the promotion of wear and care of respirators.

For this reason, the committee strongly recommends that future surveys elicit information from both employers and employees. The procedures for an employee-within-establishment survey have been implemented successfully

elsewhere and should be replicable for gathering this type of information from the ultimate users as well as the employers who bear responsibility for ensuring proper use. The recommendations in this report, in concert with the lessons learned from the pioneering SRUP, should enable NPPTL to mount a data collection operation that employs the most advanced and scientifically sound methods and helps augment the base of knowledge needed to advance the ultimate goal of the organization to improve health and safety in the workplace.

Appendixes

Appendix A

Statement of Task

The National Academies, through its Board on Chemical Sciences and Technology and Committee on National Statistics, will review the 2001-2002 National Institute for Occupational Safety and Health (NIOSH)/Bureau of Labor Statistics survey of respirator use among private firms in the United States, as found in the 2003 NIOSH publication “Respirator Usage in Private Sector Firms, 2001.” This review will address the following:

- The adequacy and appropriateness of the survey instrument, considering both the content and the format of the instrument;
- The adequacy and appropriateness of the survey methodology, including the choice of sample, the sampling method, survey follow-up, and ultimate response rate;

- The adequacy of resultant survey data;
- How the data obtained from the survey were analyzed;
- Conclusions reached from the data, and whether additional information is available from the data through additional statistical analysis; and
- A recommendation for additional information that NIOSH might derive from current and future survey results.

A report will be issued addressing these questions and providing recommendations for further surveys that NIOSH might undertake to obtain additional information regarding industrial and nonindustrial respirator use.

Appendix B

Biographical Sketches of Committee Members and Staff

COMMITTEE

William D. Kalsbeek (*chair*) is professor of biostatistics and director of the Survey Research Unit at the University of North Carolina-Chapel Hill. His experience includes statistical research with the Office of Research and Methodology at the National Center for Health Statistics and at the Sampling Research and Design Center at the Research Triangle Institute (RTI) in North Carolina. He is a fellow of the American Statistical Association (ASA) and a member of the American Association of Public Opinion Research and the American Public Health Association. He received his M.P.H. and Ph.D. degrees in biostatistics from the University of Michigan. Dr. Kalsbeek's research interests and areas of expertise are in biostatistics, survey design and research, spinal cord injuries, and assessment. He is well known for his work in survey methods. He was a member of the Committee on National Statistics (CNSTAT) of the National Academies from 1998 to 2004 and has served as a member of the Committee on Sampling Methodologies and the Panel on the National Health Care Survey, as well as co-chair of the Oversight Panel for the Workshop on Survey Automation.

Johnny Blair is senior survey methodologist and a principal scientist at Abt Associates. He was previously associate and acting director of the Survey Research Center, University of Maryland, and, prior to that, operations manager at the Survey Research Laboratory, University of Illinois. He has also served on the ASA Committee on Energy Statistics, advisory to the Energy Information Administration, and since 1996 on the Design and Analysis Committee advisory to Educational Testing Service for the National Assessment of Educational Progress. Over a 35-year career, he has conducted survey methodology research in a number of areas, including sample design for special populations, laboratory pretest-

ing methods, and response effects. His many publications include the book *Designing Surveys: A Guide to Decisions and Procedures*, Second Edition (with Ronald Czaja), Sage Publications.

Janice Comer Bradley is technical director of the International Safety Equipment Association (ISEA), where she directs the voluntary standards-setting activities of 13 product groups representing suppliers of safety and health equipment. She works closely with federal regulatory agencies and outside standards bodies to influence activities that affect the manufacture, use, and distribution of safety equipment, and she represents ISEA on numerous standards committees and government panels. Ms. Bradley earned a B.S. degree from the University of Dayton and a master's degree in environmental studies from Brown University. Ms. Bradley has spent her entire career in the safety and health field. Prior to her work at ISEA she was the director of environmental health and safety for the Rockefeller University in New York City, the university health and safety officer for Brown University, and the safety specialist for the Department of Veterans Affairs Medical Center in Dayton, Ohio. Ms. Bradley is a certified safety professional by the American Society of Safety Engineers and an adjunct professor at Georgetown University where she teaches a graduate-level course in the M.B.A. program that introduces future business leaders to workplace safety and health issues.

Zane Frund is manager of the Chemical Research and Analytical Services Division of Mine Safety and Appliances Co. He is responsible for the development and evaluation of designs and compounds used in a wide range of occupational health and safety equipment applications (e.g., air-purifying respirators, body armor, firefighter self-contained breathing apparatus, thermal imaging camera, solid oxygen-containing

self-rescuers). He developed a curriculum and instructed college- and university-level courses associated with occupational health and respiratory protection, materials science and engineering, forensic science, and forensic chemistry. He has also served as a peer reviewer of technical reports and manuscripts for the Centers for Disease Control and Prevention, the National Institute of Occupational Safety and Health (NIOSH), the American Industrial Hygiene Association (AIHA) *Journal of Occupational and Environmental Hygiene*, and *International Society for Respiratory Protection Journal*. He received his Ph.D. in materials engineering (currently part of chemical engineering) with a minor in occupational and environmental health in May 1998 from the University of Pittsburgh.

Arthur T. Johnson is professor of bioengineering at the University of Maryland. His research interests are effects of respirator wear on human performance, exercise physiology, and respiratory monitoring. His teaching interest is engineering related to biological systems. He is the author of more than 100 peer-reviewed publications, 3 books, and 25 book chapters. He is currently president of the International Society for Respiratory Protection. He is a fellow of the American Institute for Medical and Biological Engineering, American Society for Engineering Education, American Society of Agricultural and Biological Engineers, Biomedical Engineering Society, and AIHA.

Virginia Lesser is director of the Survey Research Center at Oregon State University, where she also serves as associate professor in the Statistics Department. Her research interests are in sampling, survey methodology, environmental statistics, and applied statistics. She has written on nonsampling error, the effects of item and unit nonresponse on nonresponse error, and multiphase sampling. She holds a Ph.D. in biostatistics from the University of North Carolina and an undergraduate degree in biology.

James Platner is the associate director of the Center to Protect Workers' Rights, which is the research and training institute of the Building and Construction Trades Department, AFL-CIO. Dr. Platner manages construction occupational safety and health research projects with a national academic consortium through a cooperative agreement with NIOSH. He has a B.S. in biophysics from Johns Hopkins, and an M.S. in radiation biology and a Ph.D. in toxicology and radiation biology from the University of Rochester School of Medicine. He is American Board of Industrial Hygiene certified in industrial hygiene. He also serves on the National Academy of Sciences standing Committee on Personal Protective Equipment for Workplace Safety and Health.

David Sarvadi is an attorney who works with clients in the areas of occupational health and safety, toxic substance man-

agement, pesticide regulation, employment law, and product safety. He represents clients before a variety of federal and state enforcement agencies in legal proceedings involving the Occupational Safety and Health Administration citations, U.S. Environmental Protection Agency Notice of Violations, Toxic Substances Control Act consent orders, Consumer Product Safety Commission Notices, Federal Insecticide, Fungicide, and Rodenticide Act Stop Sale Use and Removal Orders, and Equal Employment Opportunity Commission charges of discrimination. He works with clients in developing, reviewing, and auditing compliance programs in all of these areas, and in obtaining agency rulings on proposed or novel activities and questions, seeking interpretations of regulations as they apply to specific sets of facts. He has a background in occupational safety and health, having worked as an industrial hygienist for more than 15 years before he became a certified industrial hygienist in 1978. Prior to becoming an attorney, he was a principal in a small consulting firm and managed a corporate industrial hygiene and product safety program for a Fortune 500 company. Mr. Sarvadi received his B.S.-B.A. from Pennsylvania State University (1969), his M.Sc. from University of Pittsburgh Graduate School of Public Health (1970), and his J.D. from George Mason University (1986). Mr. Sarvadi is a member of the District of Columbia and Virginia Bars.

Bruce J. Tatarchuk is Ginn Professor of Engineering and director and founder of the Center for Microfibrous Materials Manufacturing, Department of Chemical Engineering, Auburn University, Alabama. His research involves ways to make fuel cells more efficient using microfibrous structures and the development of microfibrous structures to be used in the manufacture of respirators and other protective devices. More broadly, his research involves heterogeneous reactivity at solid surfaces.

Michael Weeks is a senior survey director at RTI. In his 35-year career in survey research he has successfully managed numerous survey projects ranging from small local studies to large national surveys. He is widely recognized as an expert project manager and has developed and taught seminars on the management of survey research projects at federal agencies, universities, private organizations, and professional conferences. He has conducted experiments on a variety of methodological issues in survey research and has reported his findings in numerous professional papers and publications. He has served on the Editorial Board of *Public Opinion Quarterly* and on two national advisory panels.

STAFF

Thomas J. Plewes (*study director*) is a senior program officer for CNSTAT of the National Academy of Sciences. He previously served as study director for the National Academies' Review of Research and Development Statistics

at the National Science Foundation. He is a fellow of the ASA. Prior to joining the CNSTAT staff, he was associate commissioner for employment and unemployment statistics of the Bureau of Labor Statistics and served as chief of the U.S. Army Reserve. He was a member of the Federal Committee on Statistical Methodology. He has a B.A. degree in economics from Hope College and an M.A. degree in economics from the George Washington University.

Ericka McGowan is associate program officer on the Board on Chemical Sciences and Technology. A native of

Baton Rouge, Louisiana, she came to the Washington, D.C., metropolitan area in 2001 to work at the National Institutes of Health (NIH). She served NIH for two years as a grants technical assistant before joining the National Academies as a research associate. She has a B.S. degree in biology with a minor in chemistry from Southern University and A&M College in Baton Rouge, Louisiana, and is currently pursuing a master of science in public health microbiology and emerging infectious diseases from George Washington University. She is also a member of the American Public Health Association.

Appendix C

Meeting Agenda

REVIEW OF THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH/ BUREAU OF LABOR STATISTICS RESPIRATOR USE SURVEY

December 1-2, 2005, The National Academies Building, 2101 Constitution Avenue, N.W., Washington, D.C., Room 250

Thursday, December 1

8:00-10:00 a.m. Closed Session

10:00 a.m.-12:00 p.m. **Open Session**
NIOSH Charge to the Committee and Overview of the NPPTL Programs
Les Boord, Director of the National Personal Protective Technology Laboratory (NPPTL)
MaryAnn D'Alessandro, Associate Director for Science

12:00-1:00 p.m. **Lunch**—Refectory

1:00-3:30 p.m. **Open Session Continues**
BLS Presentation on Design and Implementation of the SRUP
William Wiatrowski, Assistant Commissioner, Office of Safety, Health, and Working Conditions,
Bureau of Labor Statistics (BLS)
William McCarthy, Chief, Division of Safety and Health Statistics, BLS

2:00-2:45 p.m. **Summary of Research and Analysis using Survey Data**
Brent Doney, NIOSH Division of Respiratory Disease Studies

2:45-3:15 p.m. **Options for Future Surveys**
NPPTL Staff

3:15-3:30 p.m. **Break**

3:30-5:30 p.m. **Closed Session**

Friday, December 2

Closed Session

Appendix D

Acronyms and Abbreviations

APF	Assigned Protection Factor	LDB	Longitudinal Data Base
APR	Air-purifying respirator	LRAC	Labor Research Advisory Council
ARTBA	American Road and Transportation Builders Association	LWDC	Lost workday case
ASR	Air-supplied respirator	MAR	Missing at random
BCST	Board on Chemical Sciences and Technology	MEPS	Medical Expenditure Panel Survey
BLS	Bureau of Labor Statistics	MSH	Mine Safety and Health
BRAC	Business Research Advisory Council	MSHA	Mine Safety and Health Administration
CATI	Computer-assisted telephone interview	NAICS	North American Industry Classification System
CBRN	Chemical, biological, radiological, and nuclear	NEISS	National Electronic Injury Surveillance System
CDC	Centers for Disease Control and Prevention	NEWS	National Exposure at Work Survey
CNSTAT	Committee on National Statistics	NFPA	National Fire Protective Association
COPPE	Committee on Personal Protective Equipment	NHANES	National Health and Nutrition Examination Survey
CV	Coefficient of variation	NHIS	National Health Interview Survey
D&B	Dun and Bradstreet	NIOSH	National Institute for Occupational Safety and Health
DHHS	U.S. Department of Health and Human Services	NOES	National Occupational Exposure Survey
DOL	U.S. Department of Labor	NOHS	National Occupational Hazard Survey
DRDS	Division of Respiratory Disease Studies	NOHSM	National Occupational Health Survey of Mining
DSS	Data Service Solutions	NORA	National Occupational Research Agenda
ESLI	End-of-service-life indicator	NORC	National Opinion Research Center
FFFIPP	Fire Fighter Fatality Investigation and Prevention Program	NPPTL	National Personal Protective Technology Laboratory
GPRA	Government Performance and Results Act	OMB	Office of Management and Budget
IAA	Interagency Agreement	O*NET	Occupation Information Network
IAFF	International Association of Fire Fighters	OSH	Occupational Safety and Health
IMIS	Integrated Management Information System	OSHA	Occupational Safety and Health Administration

PART	Performance Assessment Rating Tool	SIC	Standard Industrial Classification
PASS	Personal alert safety system	SLAITS	State and Local Area Integrated Telephone Survey
PEL	Permissible Exposure Limit	SMG	Statistical Methodology Group
PPE	Personal protective equipment	SOII	Survey of Occupational Injuries and Illnesses
PPS	Probability proportional to size	SRUP	Survey of Respirator Use and Practice
PPT	Personal protective technology	SUE	Sample Unit Extract
QCEW	Quarterly Census of Employment	TEI	Target Estimation Industry
R2P	Research to practice	TIL	Total inward leakage
RSE	Relative standard error	TLV	Threshold Limit Value
SAR	Supplied-air respirator	UDB	Universe Database
SCBA	Self-contained breathing apparatus	UI	Unemployment insurance
SENSOR	Sentinel Event Notification System for Occupational Risks	WHASS	Workplace Health and Safety Survey

Appendix E

Interagency Agreement between CDC/NIOSH and BLS

NIOSH - FMO
ATLANTA

00-18

Interagency Agreement
between the
Centers for Disease Control and Prevention (CDC)
National Institute for Occupational Safety and Health (NIOSH)
and the
U.S. Bureau of Labor Statistics (BLS) (CONTRACT # BLS-O-263) *DWH/NWH*
(Please cite CDC Agreement # 00FED06925 when billing)

This memorandum sets forth terms of an agreement between the Bureau of Labor Statistics (BLS), Department of Labor (DOL), and the Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services (DHHS). The agreement allows BLS and NIOSH to carry out a survey of United States employers regarding the use of respiratory protective devices, with NIOSH providing the funding.

I. **Description of the Services:**

The NIOSH respirator certification and research program serves an estimated 5 million respirator wearers who are employed at approximately 1.3 million establishments. This program must assure, as best as is reasonably possible, that users are provided with correct and needed products and information so that they can be properly protected when using respirators. However, there is little reliable information available pertaining to actual respirator use and respirator programs in U.S. industries. The NIOSH respirator certification program operates under the assumption that all respirator users are using respirators in a complete respirator program. On the other hand, sources such as respirator manufacturers, state that users often wear respirators with little training and without the benefit of a respirator program. As a result, there is a pressing need to gather accurate and up-to-date surveillance information regarding respirator use in the workplace so that the NIOSH respirator certification and research program can assure that workers have needed products and are properly informed and protected. Also, the findings from this agreement will benefit workers by providing researchers with information to develop educational interventions for specific populations to improve respirator use in the workplace.

To gather this surveillance information, NIOSH has elected to enter into an Interagency Agreement (IA) with BLS because they are uniquely recognized as an unbiased, reliable, and objective source of surveillance information. Furthermore, while NIOSH has technical expertise in the area of respiratory protection, it does not have the established contacts and infrastructure in place for conducting such a survey as BLS.

This interagency agreement provides that BLS, in collaboration with NIOSH, will collect, analyze, and disseminate information regarding actual use of respirators and respirator programs (e.g., extent of written programs, expertise of program administrators, types of fit testing, types of respirators, chemical agents associated with respirator wearing) in a representative sample of all of U.S. industry in the 50 states.

For protection of participant confidentiality, NIOSH agrees that BLS will not supply the actual questionnaires or reveal the names of any respondents to NIOSH. BLS will maintain all returned questionnaires with facility identifiers for a period of 3 years to facilitate follow-up surveys of respondents. NIOSH intends to use the results of this survey to support needed changes to the Code of Federal Regulation, Title 42, Part 84, Respiratory Protective Devices, if needed. NIOSH also intends to publish results by reporting general trends and use patterns.

Responsibilities of BLS:

- a. BLS will, throughout all of the work undertaken under this interagency agreement, keep NIOSH informed of progress and difficulties by means of written reports and face-to-face meetings. The written reports will be provided to NIOSH every month for the duration of the agreement. The face-to-face meetings will occur every month, 1-2 weeks after NIOSH's receipt of the written reports, for the first six months of the agreement. Subsequent face-to-face meetings will be held as needed, at NIOSH's discretion. BLS will schedule the face-to-face meetings in consultation with the NIOSH project officer for the agreement, with the locations alternating between BLS offices in Washington, DC, and NIOSH offices in Morgantown, West Virginia. The meetings will each be chaired by BLS. BLS will prepare a timeline for the work to be conducted within this interagency agreement. The timeline will include a list of all significant tasks/events, the beginning and ending dates associated with each significant task/event, and indications of the inter-relationships of significant tasks and events. The timeline will be an evolving document, with updates and modifications made by BLS and reported to NIOSH as a part of each monthly report described above.
- b. BLS will have primary responsibility for survey sample design. The survey will collect data from about 40,000 private sector establishments by mail. BLS will design a sample based on the Standard Industrial Classification (SIC) system that will, to the extent possible, map into publishable data by the North American Industrial Classification System (NAICS) industries. The BLS design will be consistent with NIOSH's intent to obtain accurate national data for the NAICS sectors and establishment size categories listed in Appendix A. BLS will provide the design for a field test survey, the final survey, and the sample selection, along with anticipated accuracy of estimates (of numbers and percentages of workers associated with the industry/establishment size categories indicated by Appendix A) to NIOSH for comment, and will make modifications to the design based on NIOSH comments as appropriate. BLS will use the field test survey to: identify survey questions which respondents have difficulty understanding; estimate respondent burden; and assess whether respondents are able to provide accurate responses to individual questions. Results of the field test will be shared with NIOSH prior to initiation of the final survey. BLS will use the final survey data to develop estimates of the numbers and percentages of U.S. workers and establishments associated with the characteristics described in Appendix A.

- c. BLS will use a survey questionnaire drafted by NIOSH (Appendix B) for this agreement. The draft questionnaire indicates the type of information NIOSH wishes to obtain from employers. BLS will make use of its cognitive design facilities to design a survey collection form to gather the information specified in the NIOSH questionnaire. BLS and NIOSH will jointly determine what issues are to be addressed during the cognitive testing and field tests, and how to address any changes to the questionnaire or survey process suggested by the cognitive testing and field tests.
- d. BLS will conduct a field test of the survey. BLS will include provisions in the design of the field test and in the analysis of the field test results to estimate (1) the extent to which questions are understood by respondents, and (2) the extent to which respondents will accurately respond to the questions as they are understood. The field test will also provide some indications of expected response rates for the full survey. However, the sample for the field test will not be sufficiently large nor distributed across all industries and size classes to support formal response rate estimates.
- e. BLS will obtain Office of Management and Budget clearance for this the work covered by this agreement. In obtaining that clearance, BLS will make use of information from NIOSH addressing the need for the data to be developed under this agreement. BLS will keep NIOSH fully informed about any changes to the survey that arise in the discussions with OMB so NIOSH has an opportunity to participate.
- f. BLS will manage all survey operations. BLS will print the questionnaire and mail the questionnaire to the sample of about 40,000 establishments. BLS will mail follow-up letters and questionnaires to all non-respondents to the initial mailing. BLS will contact non-respondents by telephone as necessary to determine if respirators are used in the establishment and to encourage completion of the full questionnaire. BLS will strive to achieve a projected response rate of at least 70%. Beginning with the review of field test results, and through the actual survey operation, BLS will keep NIOSH informed of the expected response rate, where "response" is defined as a properly completed set of responses (i.e., not counting improper partial responses). As a part of informing NIOSH of response rates, BLS will provide NIOSH with aggregate data on the respondents and non-respondents at the conclusion of the survey. This aggregate data will include frequencies of response and non-response within each cell formed by the intersections of industry and size category strata.
- g. BLS will balance confidentiality and access to information as a part of work under this agreement, so as to maximize the data available to NIOSH for further research and analysis. BLS will pledge confidentiality of the individual answers to the questionnaire to survey respondents and therefore, will not supply the actual questionnaires or reveal the names of any respondents to NIOSH. BLS will maintain data from all returned questionnaires with facility identifiers for a

period of 3 years to facilitate follow-up surveys of respondents. After completing an Interagency Personnel Agreement, NIOSH staff may access the micro data from the survey on-site at BLS. In addition, BLS will provide as much data, in electronic format, to NIOSH for analysis and research as is possible within the constraints of protecting confidentiality. These data will be provided as ASCII and Microsoft Excel files. BLS will provide NIOSH with a list of characteristics of establishments to which BLS has access for the surveyed population. This list might include, for example, region, state, age of establishment, organized labor presence, and workers' compensation insurance rates.

- h. BLS will work with NIOSH to develop a decision logic for the analysis and reporting of data. This decision logic will address issues such as lack of response, inconsistent responses, analyses other than those listed by Appendix A, and such other issues as may become apparent during the course of the work. The need for analyses other than those listed by Appendix A is expected to be small, with no more than an additional 4 or 5 tables.
- i. BLS will analyze the survey results to make national estimates about the use of respirators in the U.S. Those estimates will be presented in a report to NIOSH that (a) describes the sampling plan and methods, (b) describes the methods of analysis and the basis of the estimates, and (c) includes estimates for each of the categories described in Appendix A of this agreement. These estimates will make use of respondent data as well as imputed data for non-respondents, based on the known characteristics of those non-respondents and data for respondents with similar characteristics.

Responsibilities of NIOSH:

- a. NIOSH will provide funding for the work covered by this agreement.
- b. NIOSH will provide a draft questionnaire (Appendix B) which BLS will use to design the survey collection form through cognitive design and field testing. NIOSH will review and approve the final survey collection form.
- c. NIOSH will comment on the design for a field test survey, the actual survey, and the sample selection provided by BLS.
- d. NIOSH will revise the questionnaire in consultation with BLS if problems with the questionnaire design are encountered during the field-test.

Shared responsibilities of BLS and NIOSH:

- a. Publication – This work may result in publications by BLS and NIOSH, either independently or jointly. If either party chooses to publish a report

independently of the other party, the report must include a credit or a disclaimer for the other party, whichever the other party determines is appropriate.

BLS and NIOSH agree to work cooperatively toward: a first joint publication of the data from this agreement; future efforts to re-analyze, review and/or renew existing data; implementation of follow-up questionnaires to meet the needs of both agencies in obtaining and disseminating information regarding working conditions of workers.

- b. Confidentiality -- In accordance with the BLS Commissioner's Order 3-93, "Confidential Nature of BLS Records," data collected or maintained by BLS under a pledge of confidentiality are treated in a manner that will assure that individually identifiable data will be used only for statistical purposes and will be accessible only to authorized persons. Authorized persons include only those individuals who are responsible for collecting, processing, or using the data in furtherance of BLS statistical purposes. A violation of the confidence placed by the respondents in BLS would endanger the ability of BLS to carry out its duties.

BLS protects the confidentiality of its data to the full extent permitted by law, and will not disclose confidential information to individuals other than authorized persons, as identified in Commissioner's Order 3-93. Under this agreement, BLS shall release only that information that BLS has determined will not disclose identifying information about its respondents. BLS shall not disclose confidential information including, but not limited to, survey materials, universe lists, survey composition information, names and addresses of respondents, and individual establishment data.

II. Duration of the agreement:

	<u>Beginning</u>	<u>Ending</u>
Agreement Period	5/1/2000	12/31/2003
Agreement Funding Periods	5/1/2000 10/1/2000	9/30/2000 9/30/2001

III. Estimated Cost:

A. FY2000: \$130,000

- Compensation and benefits: \$35,000
- Contracts (survey design^{COMMUNICATIONS} and testing) \$50,000 65,000 DWH/NIOS
- Costs paid to other federal agencies (rent, mail, Departmental charges) \$2,000 10,000 DWH
- BLS direct costs (travel, printing, supplies, training, ~~communications~~) \$18,000 3,000 DWH
- BLS indirect costs \$18,000 17,000 DWH

B. FY2001: \$273,000

- Compensation and benefits: \$110,000
- ~~ADP~~^{CONTRACTS} costs (data entry) (COMMUNICATIONS) \$4,000 2,000 DWH
- Costs paid to other federal agencies (rent, mail, Departmental charges) \$99,000 100,000 DWH
- BLS direct costs (travel, printing, supplies, training, communications) \$25,000
- BLS indirect costs \$35,000 36,000 DWH

C. FY2002: \$0

D. FY2003: \$0

E. FY2004: \$0

IV. Authority:

The authority to perform special work or services for other Federal agencies on a cost basis appears in Title 31 U.S.C. 1535-1536. This authorizes the performance of the work or service involved only to the extent that they are consistent with BLS' proper performance of its basic public duties and obligations, and the relative importance of the request to others. In addition, employment ceilings and paperwork reduction guidelines imposed by the Office of Management and Budget may impair BLS' ability to perform the work. If BLS is unable to adhere to the timing and other requirements of this agreement because of the restrictions mentioned above, BLS will obtain NIOSH approval before modifying any work requirements. This agreement is entered into pursuant to the authority of the Economy Act of 1932, as amended (31 USC 1535) and adheres to Federal Acquisition Regulation (FAR) 6.002 and other applicable Federal laws and regulations. The work requested will not place the BLS into direct competition with the private sector.

V. Travel:

Travel under this agreement is subject to allowances authorized in accordance with the Federal Travel Regulations, the Joint Federal Travel Regulations and/or the Foreign Service Regulations.

VI. Equipment:

No equipment is being provided. If equipment is procured in order to provide service, CDC will retain title to the equipment.

VII. Participating Federal Agencies' Contacts:**A. NIOSH**

Contact Person: Barbara Brown
Program Analyst
NIOSH Division of Respiratory Disease Studies
1095 Willowdale Road
Morgantown, West Virginia 26505
(304) 285-5723

Project Officer: Dennis Groce
Industrial Hygienist
NIOSH Division of Respiratory Disease Studies
1095 Willowdale Road
Morgantown, WV 2650
(304) 285-6258

B. Bureau of Labor Statistics:

Contact Person: William McCarthy
Safety and Health Program Analysis and Control
Room 3180 Postal Square Building
2 Massachusetts Ave. N.E.
Washington D.C. 20212
(202) 691-6163

Project Officer: Katharine Newman
Safety Health Program Analysis and Control
Room 3180 Postal Square Building
2 Massachusetts Ave. N.E.
Washington D.C. 20212
(202) 691-6162

VIII. Accounting Information:

The charge for services shall include both direct and indirect costs applicable to this agreement. BLS will base the final charge for this work on the actual costs incurred. When the requesting party (NIOSH) pays in advance and actual costs are less than the estimate, BLS will refund the difference. In any instance where BLS cannot complete the work within the indicated cost, BLS will notify NIOSH of this before BLS exceeds or adjusts the cost estimate.

All funds provided by CDC in this agreement must be obligated by the end of the year in which the funds expire. Any unobligated but expired funds may not be used to fund services in subsequent periods. The CDC Financial Management Office must be notified of any unobligated funds pertaining to this agreement at least 15 days before the end of the fiscal year so that the agreement can be amended to reduce the obligated amount when appropriate. The notification must be submitted to the address cited below.

When funds are provided to the performing agency in advance of services being performed or goods being delivered, the performing agency is required to provide, within 15 days of the end of each quarter, statements of obligations and expenditures made during the quarter. These statements should be provided to the address below.

Payment will be initiated by BLS through the OPAC System. ~~Payment will be made as expenses are incurred and billed by BLS.~~ CDC/NIOSH WILL BE BILLED UNDER THE U.S. TREASURY ON-LINE PAYMENT COLLECTION (OPAC) SYSTEM UPON RECEIPT OF ANNUAL SIGNED AGREEMENTS. *DCU*

Agency financial contacts and payment information for the OPAC system are as follows:

CDC/NIOSH
Att: OPAC Desk
Financial Management Office
4676 Columbia Parkway, M/S C-5
Cincinnati, OH 45226

CDC EIN No. 58-6051157
CDC Agreement No. 00-18
Common Accounting Number: 0-9277236
Cost Center :8C5D
Appropriation: 7500943
CDC ALC 75090527

(Please cite CDC Agreement # 00FED06925 when billing)

Luvanee Davis Henry
Division of Financial Planning and Management
Bureau of Labor Statistics
Room 4135 Postal Square Building
2 Massachusetts Avenue, N.E.
Washington, D.C. 20212
(202) 691-7773

ALC No. 16 01 2011

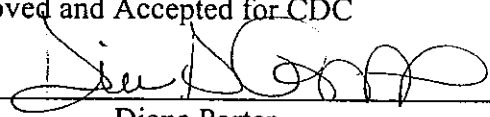
IX. Modification and Cancellation Clause:

This agreement may be canceled with 60 days written notice, whereby both parties mutually agree in the cancellation. In particular, the agencies agree that funding for 2001 is conditional upon congressional approval of the NIOSH budget and appropriate allocations of funds within NIOSH. NIOSH will reimburse BLS for orderly shut-down should the agreement be cancelled prior to the scheduled completion due to a lack of funding. If the agreement is shut down during fiscal year 2000, shut down expenses will be paid from fiscal year 2000 funds, and no charges in fiscal year 2001 will result.

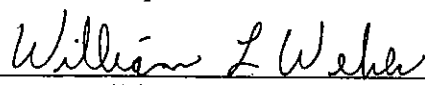
The appropriate Agency will be notified 90 days prior to agreement expiration date of any intent to continue the agreement into the next fiscal year.

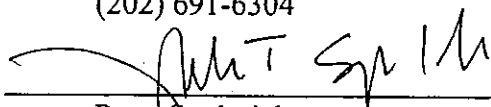
X. Approvals

Approved and Accepted for CDC

By:  5/22/00
 Diane Porter
 Associate Director for Management, NIOSH
 (404) 639-3771
 Date


Approved and Accepted for BLS

By:  7/18/00
 William Weber,
 Assistant Commissioner for Safety, Health, and Working Conditions
 (202) 691-6304
 Date

And:  7/20/00
 Peter Spolarich,
 Chief, Division of Financial Planning and Management
 (202) 691-7770
 Date

FMO BUDGET ANALYST

DATE


May 16, 2000

