

Framework for the Review of Research Programs of the National Institute for Occupational Safety and Health

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This is the second version of a document prepared by the National Academies Committee for the Review of NIOSH Research Programs,¹ also referred to as the Framework Committee. This document is not a formal report of the National Academies—rather, it is a framework proposed for use by multiple National Academies evaluation committees to review up to 15 National Institute for Occupational Safety and Health (NIOSH) research programs. It is a working document subject to modification by the Framework Committee on the basis of responses received from evaluation-committee members, NIOSH, stakeholders, and the general public during the course of the assessments. This version will be posted on the Web sites of the National Academies and NIOSH.

All written public comments submitted to the Committee for the Review of NIOSH Research Programs will be included in the public-access file for this activity as required by the National Academies study process. Please keep in mind that personal information that you directly disclose in your written comments may be collected and used by others.

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Abbreviations and Acronyms

ABLES	Adult Blood Lead Epidemiology and Surveillance
AOEC	Association of Occupational and Environmental Clinics
BLS	Bureau of Labor Statistics
CDC	Centers for Disease Control and Prevention
CSTE	Council of State and Territorial Epidemiologists
DOD	US Department of Defense
EC	Evaluation Committee
EPA	Environmental Protection Agency
FACE	Fatality Assessment Control and Evaluation
FC	Framework Committee
HHE	Health Hazard Evaluation
MSHA	Mine Safety and Health Administration
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
NORA1	National Occupational Research Agenda 1996-2005
NORA2	National Occupational Research Agenda 2005-forward
OSH Review Commission	Occupational Safety and Health Review Commission
OSHA	Occupational Safety and Health Administration
OSHAct	Occupational Safety and Health Act of 1970
PART	Performance Assessment Rating Tool
PEL	permissible exposure limit
RFA	request for applications
SENSOR	Sentinel Event Notification System of Occupational Risks
TMT	tools, methods, or technologies
USDA	US Department of Agriculture

I INTRODUCTION

In September 2004, the National Institute for Occupational Safety and Health (NIOSH) contracted with the National Academies to conduct a review of NIOSH research programs. The goal of this multiphase effort is to assist NIOSH in increasing the impact of its research efforts that are aimed at reducing workplace illnesses and injuries and improving occupational safety and health. The National Academies assigned the task to the Division on Earth and Life Studies and the Institute of Medicine.

The National Academies appointed a committee of 14 members, including persons with expertise in occupational medicine and health, industrial health and safety, industrial hygiene, epidemiology, civil and mining engineering, sociology, program evaluation, communication, and toxicology; representatives of industry and of the workforce; and a scientist experienced in international occupational-health issues. The Committee on the Review of NIOSH Research Programs, referred to as the Framework Committee (FC), prepared the first version of this document during meetings held on May 5-6, July 7-8, and August 15-16, 2005. This second version was finalized after the Framework Committee's May 30-31, 2007 meeting, based on feedback received on the framework from the first two independent evaluation committees, NIOSH leadership, and National Academies' staff, as well as discussions during an earlier FC meeting in April 2006.

This document is not a report of the National Academies; rather, it presents the evaluation framework developed by the FC to guide and provide common structure for the reviews of as many as 15 NIOSH programs during a 5-year period by independent evaluation committees (ECs) appointed by various divisions and boards of the National Academies. It is a working document to be shared with NIOSH and the public. This version has been modified by the FC on the basis of responses from the ECs, NIOSH, NIOSH stakeholders, and the public; and it may be modified again. It is incumbent on the ECs to consult with the FC if portions of the evaluation framework presented here are inappropriate for specific programs under review.

I.A Overview of Charge to Evaluation Committees

At the first meeting of the FC, Lewis Wade, NIOSH senior science adviser, emphasized that a review of a NIOSH program should focus on the program's relevance to and impact on health and safety in the workplace. In developing a framework, the FC considered the following elements of the charge to the ECs:

1. Assessment of the program's contribution, through occupational safety and health research, to reductions in workplace hazardous exposures, illnesses, or injuries through
 - a. An assessment of the relevance of the program's activities to the improvement of occupational safety and health.
 - b. An evaluation of the impact that the program's research has had in reducing work-related hazardous exposures, illnesses, and injuries.

The evaluation committee will rate the performance of the program for its relevance and impact using an integer score of 1-5. Impact may be assessed directly (for example, on the basis of reductions in illnesses or injuries) or, as necessary, by using intermediate outcomes to estimate impact. Qualitative narrative evaluations should be included to explain the numerical ratings.

2. Assessment of the program's effectiveness in targeting new research areas and identifying emerging issues in occupational safety and health most relevant to future improvements in workplace protection. The committee will provide a qualitative narrative assessment of the program's efforts and suggestions about emerging issues that the program should be prepared to address.

I.B Evaluation Committees

Individual ECs will be formed in accordance with the rules of the National Academies for the formation of balanced committees. Each EC will comprise persons with expertise appropriate for the specific NIOSH research program under review and may include representatives of stakeholder groups (such as labor unions and industry), experts in technology and knowledge transfer, and program evaluation. The EC will gather appropriate information from the sponsor (the NIOSH research program under review), stakeholders affected directly by NIOSH program research, and relevant independent parties. Each EC will consist of about 10 members, will meet about three times, and will prepare a report. The National Academies will deliver the report to NIOSH within 9 months of the first meeting of the EC. EC reports are subject to the National Academies report-review process.

I.C NIOSH Strategic Goals and Operational Plan

As a prelude to understanding the NIOSH strategic goals and operational plan, NIOSH research efforts should be understood in the context of the Occupational Safety and Health Act (OSHAct), under which it was created. The OSHAct identifies workplace safety and health as having high national priority and gives employers the responsibility for controlling hazards and preventing workplace injury and illness. The act creates an organizational framework for doing that, assigning complementary roles and responsibilities to employers and employees, the Occupational Safety and Health Administration (OSHA), the states, the Occupational Safety and Health (OSH) Review Commission, and NIOSH. The act recognizes NIOSH's role and responsibilities to be supportive and indirect. NIOSH research, training programs, criteria, and recommendations are intended to be used to inform and assist those more directly responsible for hazard control (OSHAct Sections 2b, 20, and 22).

Section 2b of the OSHAct describes 13 interdependent means of accomplishing the national goal, one of which is "by providing for research . . . and by developing innovative methods . . . for dealing with occupational safety and health problems". Sections 20 and 22 give the responsibility for that research to NIOSH. NIOSH is also given related responsibilities, including the development of criteria to guide prevention of work-related injury or illness; development of regulations for reporting on employee exposures to harmful agents; establishment of medical examinations, programs, or tests to determine illness incidence and susceptibility; publication of a list of all known toxic substances; assessment of potential toxic effects or risks associated with workplace exposure in specific settings; and conduct of education programs for relevant professionals to carry out the OSHAct purposes. NIOSH is also responsible for assisting the secretary of labor regarding education programs for employees and employers in hazard recognition and control.

The NIOSH mission is “to provide national and world leadership to prevent work-related illness, injury, disability, and death by gathering information, conducting scientific research, and translating the knowledge gained into products and services”. To fulfill its mission, NIOSH has established the following strategic goals:²

- **Goal 1: Conduct research to reduce work-related illnesses and injuries.**
 - Track work-related hazards, exposures, illnesses, and injuries for prevention.
 - Generate new knowledge through intramural and extramural research programs.
 - Develop innovative solutions for difficult-to-solve problems in high-risk industrial sectors.

- **Goal 2: Promote safe and healthy workplaces through interventions, recommendations, and capacity building.**
 - Enhance the relevance and utility of recommendations and guidance.
 - Transfer research findings, technologies, and information into practice.
 - Build capacity to address traditional and emerging hazards.

- **Goal 3: Enhance global workplace safety and health through international collaborations.**
 - Take a leadership role in developing a global network of occupational health centers.
 - Investigate alternative approaches to workplace illness and injury reduction and provide technical assistance to put solutions in place.
 - Build global professional capacity to address workplace hazards through training, information sharing, and research experience.

In 1994, NIOSH embarked on a national partnership effort to identify research priorities to guide occupational health and safety research for the next decade. The National Occupational Research Agenda (NORA) identified 21 high-priority research subjects (see Table 1). The NORA was intended not only for NIOSH but for the entire occupational health community. In the second decade of the NORA, NIOSH is working with its partners to update the research agenda, using an approach based on industry sectors. NIOSH and its partners are working through sector research councils to establish sector-specific research goals and objectives. The emphasis is on moving research to practice in workplaces through sector-based partnerships.

Figure 1 is the NIOSH operational plan, presented as a logic model,³ of the path from inputs to outcomes for each NIOSH research program. The FC adapted the model to develop its framework. NIOSH will provide similar logic models appropriate to each research program evaluated by an EC.

² See <http://www.cdc.gov/niosh/docs/strategic/>.

³ Developed by NIOSH with the assistance of the RAND Corporation.

TABLE 1 NORA High-Priority Research by Category

Category	Priority Research Area
Disease and injury	Allergic and irritant dermatitis Asthma and chronic obstructive pulmonary disease Fertility and pregnancy abnormalities Hearing loss Infectious diseases Low-back disorders Musculoskeletal disorders of upper extremities Trauma
Work environment and workforce	Emerging technologies Indoor environment Mixed exposures Organization of work Special populations at risk
Research tools and approaches	Cancer research methods Control technology and personal protective equipment Exposure-assessment methods Health-services research Intervention-effectiveness research Risk-assessment methods Social and economic consequences of workplace illness and injury Surveillance research methods

I.D Evaluation Committees' Information Needs

Each NIOSH program under review will provide information to the relevant EC, including that outlined in Table 2. The EC may request additional information of NIOSH as needed, and NIOSH should provide it as quickly as is practical. NIOSH should consider organizing the information listed in Table 2 by subprogram or program as appropriate and to the extent possible.

In addition to the information provided by NIOSH, the EC should independently collect additional information that it deems necessary for evaluation (for example, the perspectives of stakeholders, such as OSHA, MSHA, unions and workforces, and industry). In conducting the review, the EC should continually examine how individual projects or activities contribute to the impact and relevance of a program as a whole.

FIGURE 1 The NIOSH operational plan presented as a logic model.

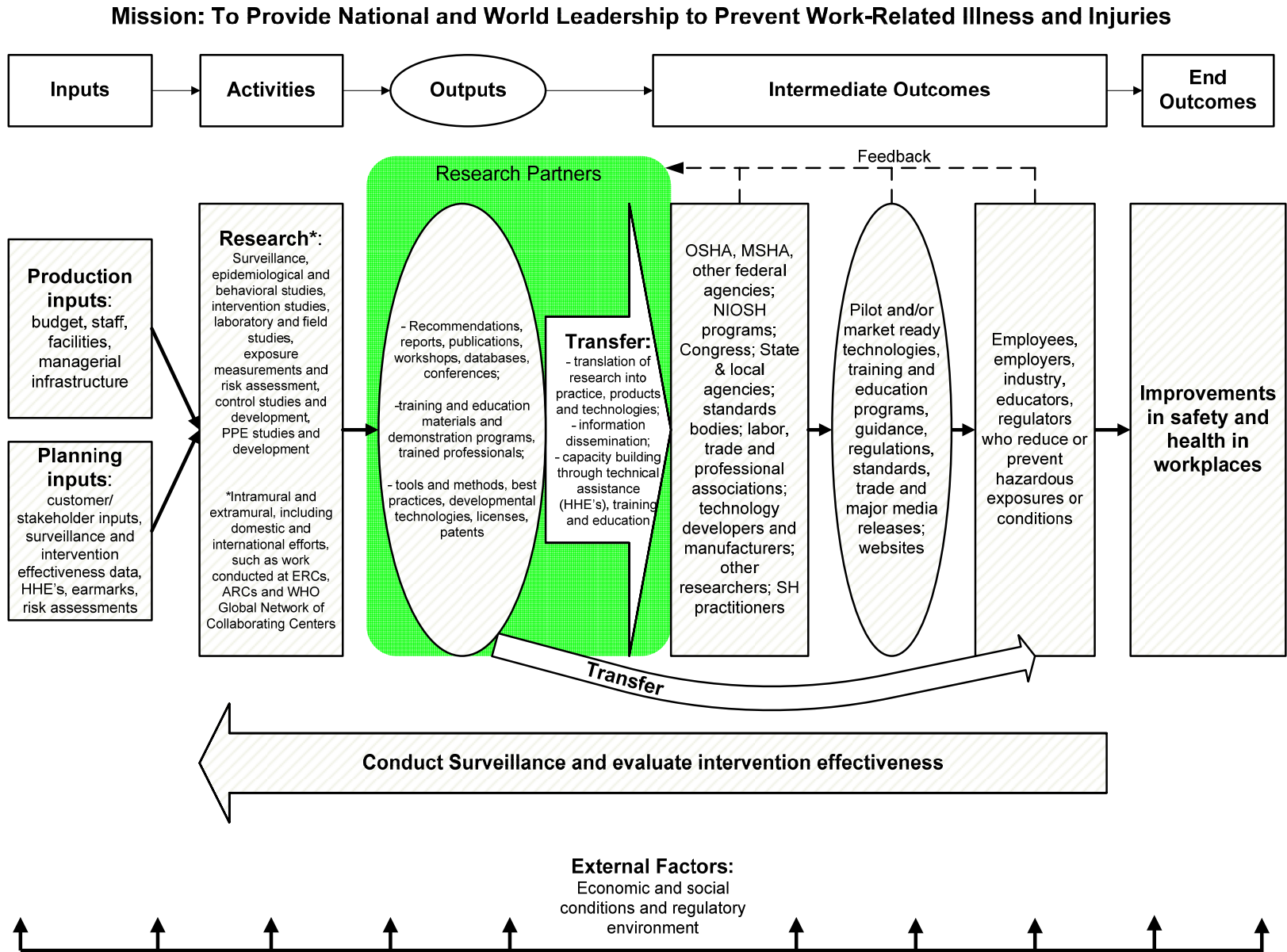


TABLE 2 Evaluation Committee Information Needs

- **Program background and resources:**
 - Program history.
 - Major program challenges.
 - Program strategic goals and objectives, past (for period under review) and current.
 - Major subprograms (if appropriate).
 - Results of previous program reviews (for example, annual review by NIOSH leadership team or external scientific program reviews).
 - External factors affecting the program.

- **Interactions with stakeholders and with other NIOSH programs:**
 - The role of program research staff in NIOSH policy-setting, OSHA and MSHA standard-setting, voluntary standard-setting and other government policy functions.
 - Interactions and working relationships with other NIOSH programs.
 - Identification of other institutions and research programs with overlapping or similar portfolios and an explanation of the relationship between NIOSH activities and those of other institutions.
 - Key partnerships with employers, labor, other government organizations, academic institutions, nonprofit organizations, and international organizations.

- **Program inputs:**
 - Program resources (also called *production inputs*)—
 - Funding by year for period under review.
 - Funding by objective or subprogram.
 - Program staffing, FTE's, and laboratory facilities, by subprogram (if indicated).
 - Percentage of program budget that is discretionary (beyond salaries).
 - Percentage of program budget that is earmarked.
 - Contributions from other agencies (in kind or funds).
 - Planning inputs—
 - Surveillance data, inputs from the Health Hazard Evaluation (HHE) or Fatality Assessment Control and Evaluation (FACE) program, or intramural and extramural research findings that influenced program goals and objectives.
 - Planning inputs from stakeholders, for example, advisory groups, NORA teams, and professional, industry, and labor groups (specify if any input from groups representing small business or vulnerable populations).
 - Related OSHA, Mine Safety and Health Administration (MSHA) strategic plans, or other input.
 - Process for soliciting and approving intramural research ideas.
 - Process for soliciting and approving program-supported extramural research activities.

- **Program activities (more details provided in Table 3):**
 - Intramural—
 - Surveillance activities.
 - Research activities (projects).
 - Transfer activities to encourage implementation of research results for improved occupational safety and health (for example, information dissemination, technical assistance, and technology and knowledge transfer).
 - Key collaborations in intramural activities (for example, with other government agencies, academe, industry, and unions).
 - Extramural funded by NIOSH—
 - Requests for applications (RFAs) developed by program.
 - Funded projects: grants, cooperative agreements, and contracts, such as
 - ◇ Surveillance activities.
 - ◇ Research activities.
 - ◇ Transfer activities.
 - ◇ Capacity-building activities.

TABLE 2 Evaluation Committee Information Needs (continued)

- **Outputs (products of the research program—more details provided in Table 4):**
 - Intramural—
 - Peer-reviewed publications, agency reports, alerts, and recommendations.
 - Databases, Web sites, tools, and methods (including education and training materials).
 - Technologies developed and patents.
 - Sponsored conferences and workshops.
 - Extramural (to the extent practical).
 - **Intermediate outcomes:**
 - Standards or guidelines issued by other agencies or organizations based in whole or in part on NIOSH research.
 - Adoption and use of control or personal protective technologies developed by NIOSH.
 - Evidence of industry, employer, or worker behavioral changes in response to research outputs.
 - Use of NIOSH products by workers, industry, occupational health and safety professionals, health care providers, and so on (including internationally).
 - NIOSH Web-site hits and document requests.
 - Unique staff or laboratory capabilities that serve as a national resource.
 - Other intermediate outcomes.
 - **End outcomes:**
 - Data on program impact on rates and numbers of injuries and illnesses and exposures in the workplace (including trend data, if available).
 - Documentation of workplace risk reduction (quantitative, qualitative, or both).
 - **Description of current processes for setting research priorities and identifying emerging issues in the workplace.**
-

I.E Prior Evaluations

Several NIOSH programs have already been evaluated by internal and external bodies. The evaluations may have been part of an overall assessment of NIOSH, such as the 2005 Performance Assessment Rating Tool (PART) review,⁴ or the evaluation of specific research program elements, such as any external scientific-program review. NIOSH should inform of, and the ECs should review, all prior evaluations of the program under review as an aid to understanding the evolution of the program and its elements. The EC evaluations, however, are independent of prior reviews and evaluations.

II SUMMARY OF EVALUATION PROCESS

The ECs will assess the relevance and impact of NIOSH research programs. In conducting their evaluations, the ECs should ascertain whether NIOSH is doing the right things (relevance) and whether these things are improving health and safety in the workplace (impact).

⁴ The PART focuses on assessing program-level performance and is one of the measures of success of the budget and performance integration initiative of the president's management agenda (see CDC Occupational Safety and Health at <http://www.whitehouse.gov/omb/budget/fy2006/pma/hhs.pdf>).

II.A The Evaluation Flowchart (Figure 2)

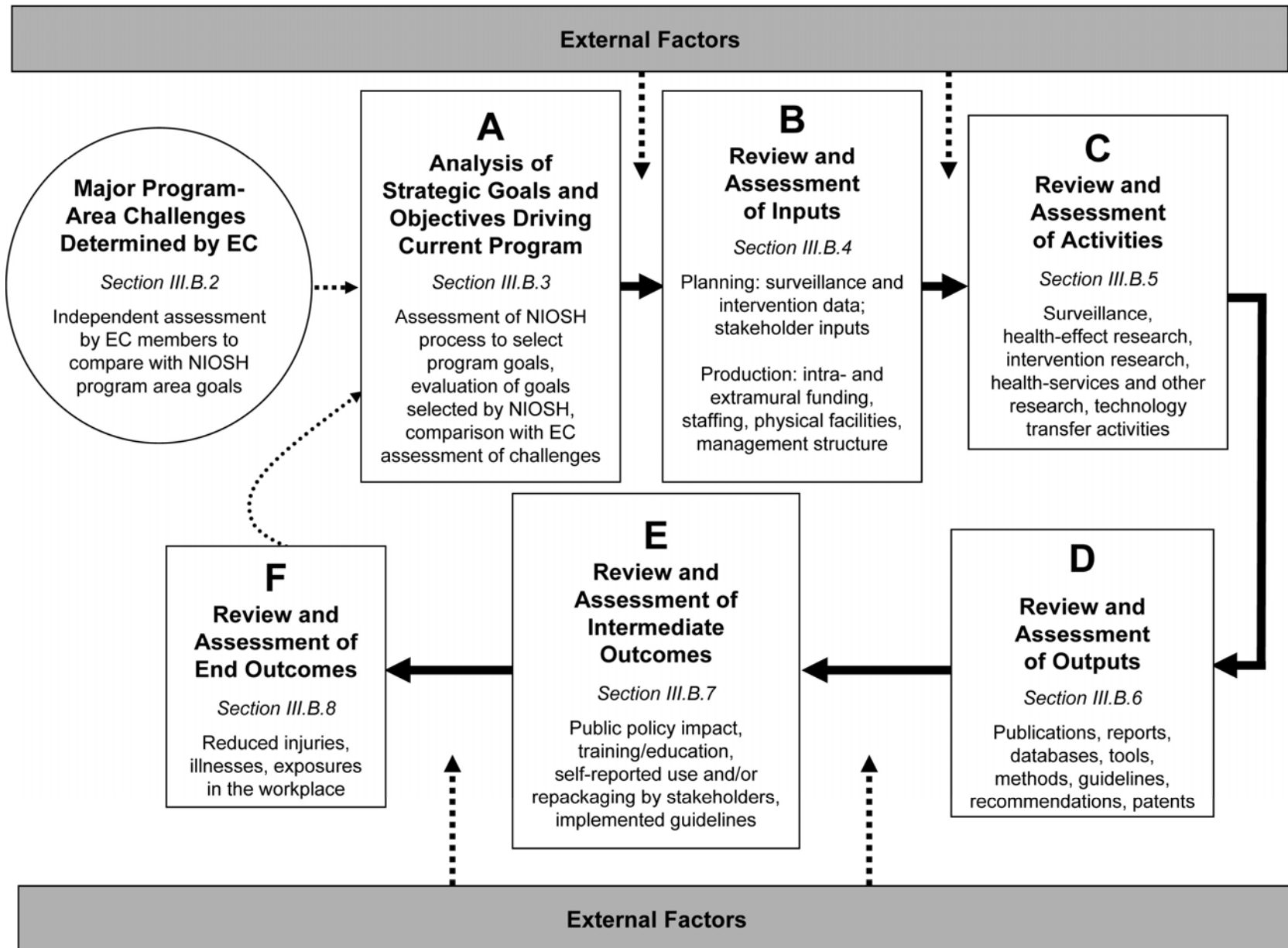
To address its charge, the FC simplified the logic model of Figure 1 into a flowchart (Figure 2) that breaks the NIOSH logic model into discrete, sequential program components to be assessed by the EC. Each component of Figure 2 is addressed in greater detail in the indicated section of this document. The FC understands that the activities of any research program will not be as linear as presented in either Figures 1 or 2. The major components to be evaluated are

- Major program *challenges*.
- Strategic *goals and objectives*.
- *Inputs* (such as budget, staff, facilities, the institute's research management, the NIOSH Board of Scientific Counselors, the NORA process, and NORA work groups).
- *Activities* (efforts by NIOSH staff, contractors, and grantees, such as hazard surveillance; surveillance for injury, illness, and biomarkers of effect; exposure-measurement research; safety-systems research; injury-prevention research; health-effects research; intervention research; health-services research; and technology and knowledge transfer activities).
- *Outputs* (NIOSH products, such as publications, reports, conferences, databases, tools, methods, guidelines, recommendations, education and training, and patents).
- *Intermediate outcomes* (responses by NIOSH stakeholders to NIOSH products, such as public or private policy change, training and education in the form of workshop or seminar attendance, self-reported use or repackaging of NIOSH data by stakeholders, adoption of NIOSH-developed technologies, implemented guidelines, licenses, and reduction in workplace hazardous exposure).
- *End outcomes* (such as reduction in work-related injuries or illnesses or hazardous exposures in the workplace).

The flowchart summarizes the FC's vision of how a program evaluation should occur. In evaluating each program or major subprogram, the EC must collect, analyze, and evaluate information on items described in each of the boxes of Figure 2, regardless of management structure (such as linear or matrix). The FC recognizes that the components of any program will not fit perfectly in any category in Figure 1 or 2. For example, training and development programs were appropriately defined as outputs by NIOSH in the logic model (Figure 1), but the FC finds more value in focusing on the responses to these outputs as intermediate outcomes (Figure 2, Box E) in the flowchart. The committee further recognizes that matrix organizations may have little control over the input portion of the logic model and that matrix program management may have fewer resources of its own on which to base its decisions. Following the suggested evaluation procedures, however, should ensure a desired level of consistency and comparability among all the ECs.

Drawing on the program logic model, the flowchart, and EC members' expertise, the ECs will delineate important inputs and external factors affecting the NIOSH research program's agenda and the consequences of NIOSH research activities. Examples of external factors are research activities of industry and other federal agencies and the political and regulatory environment. For purposes of this review, the results of inputs and external factors are the program research activities, outputs, and associated transfer activities that may result in intermediate outcomes and possibly end outcomes.

FIGURE 2 Flowchart for the evaluation of the NIOSH research program.



II.B Steps in Program Evaluation

The FC concludes that useful evaluation requires a disciplined focus on a small number of questions or hypotheses typically related to program goals, performance criteria, and performance standards; a rigorous method of answering the questions or testing the hypotheses; and a credible procedure for developing qualitative and quantitative assessments. The evaluation process developed by the FC is summarized in Box 1 and described in detail in Section III of this document.

BOX 1 The Evaluation Process

- 1. Gather appropriate information from NIOSH and other sources** (see Table 2).
- 2. Determine timeframe to be covered in the evaluation** (see III.B.1).
- 3. Identify major program-area challenges and objectives** (see III.B.2).
All NIOSH research programs are designed to be responsive to present or future workplace safety and health issues. Each research program should have its own objectives. Each EC will provide an independent assessment of the major workplace health and safety problems related to the program under review and determine whether they are consistent with the program's stated goals and objectives.
- 4. Identify subprograms and major projects in the research program.**
Each EC must determine how to disaggregate a program to achieve a manageable and meaningful evaluation of its components, and of the overall program. A program may need to be broken down into several recognizable subprograms or major projects if an effective evaluation is to be organized. It may be advantageous for an EC to disaggregate a program into subprograms that NIOSH identifies.
- 5. Evaluate the subprogram components sequentially** (see III.B.3 through III.B.8), **using the flowchart (Figure 2) as a guide.**
This will involve a qualitative assessment of each component of the research program. ECs will use professional judgment to answer questions and follow the guidance provided by the FC.
- 6. Evaluate the research program's potential outcomes that are not yet appreciated** (see III.B.9).
- 7. Evaluate the important subprogram outcomes specifically for contributions to improvements in workplace safety and health.**
Guidance is provided with specific items for consideration (see III.B.10).
- 8. Evaluate and score the overall program for *relevance*** (see III.B.10).
Final program ratings will consist of an integer score and discussion of its rationale.
- 9. Evaluate and score the overall program for *impact*** (see III.B.10).
Final program ratings will consist of an integer score and discussion of its rationale.
- 10. Identify success in targeting priority research and emerging issues** (see III.C).
The EC should briefly discuss its assessment of the NIOSH program's process for determining priorities for research and emerging workplace issues. The ECs should also independently identify emerging workplace issues for which the NIOSH program under review should be prepared.
- 11. Prepare report by using the template provided in Section IV as a guide.**

III EVALUATION OF A NIOSH RESEARCH PROGRAM—THE PROCESS

III.A Analysis of External Factors Relevant to the NIOSH Research Program

As depicted in the logic model (Figure 1), reduction in injury and illness (end outcomes) or in exposure (intermediate outcome) is affected by stakeholder activities (external factors). Actions of those in labor, industry, regulatory entities, and others beyond NIOSH's control are necessary for the implementation of NIOSH recommendations. Implementation of research findings may depend on existing or future policy considerations.

External factors may be considered as forces beyond the control of NIOSH that may affect the evolution of a program. External factors influence NIOSH's progress through all phases of the logic model and flowchart, from inputs to end outcomes (see Figures 1 and 2). Identification of external factors by an EC is essential because it provides the context for evaluation of the NIOSH program. External factors may be best assessed on the basis of the expert judgment of EC members who have knowledge of the field of research. Information regarding external factors should also be sought from NIOSH, OSHA, and MSHA staff and from other stakeholders. The EC, however, may choose additional approaches to assess external factors. NIOSH should identify and describe external factors early in the evaluation sequence (see Table 2). Factors external to NIOSH might have been responsible for achieving some outcomes or might have presented formidable obstacles. The EC must address both possibilities.

Some external factors may involve constraints on research activities related to target populations, methodologic issues, and resource availability. ECs might examine whether

- Projects addressing a critical health need are technologically feasible. However, a workforce of appropriate size and with appropriate duration and distribution of exposure for measuring a health effect may not exist; for example, no population of workers has been exposed for 30 years to formaldehyde at the current OSHA permissible exposure level (PEL), so the related cancer mortality cannot yet be directly assessed.
- Research is inhibited because NIOSH investigators are unable to access an adequate study population. Under current policy, NIOSH must either obtain an invitation by management to study a workplace or seek a judicial order to provide authority to enter a worksite. (Cooperation under court order may well be insufficient for effective research.)
- Research is inhibited because the work environment, materials, and historical records cannot be accessed even with management and workforce cooperation.
- Adequate or established methods do not exist for assessing the environment.
- The NIOSH contribution to a particular field of research is reduced because other institutions are working in the same field.
- NIOSH resources are inadequate to tackle key questions.

Evaluation of the impact of NIOSH research outputs on worker health and safety may require consideration of external factors that might impede or aide implementation, measurement, and so on. ECs might consider whether

- Regulatory end points are unachievable because of obstacles to regulation or because of differing priorities of the regulatory agencies. For example, there may be no implementation of recommendations for improved respiratory protection programs for

health-care workers because of enforcement policies or lack of acceptance by the health-care institution administrators.

- A feasible control for a known risk factor or exposure is unimplemented because the costs of implementation are too high or because current economic incentives do not favor such actions.
- End outcomes are unobservable because baseline and continuing surveillance data are not available. For example, the current incidence of occupational noise-induced hearing loss is not known although surveillance for a substantial threshold shift is feasible. (NIOSH conducts surveillance of work-related illnesses, injuries, and hazards, but comprehensive surveillance is not possible with existing resources.)
- Reductions in adverse effects of chronic exposure cannot be measured. For example, 90% of identified work-related mortality is from diseases, such as cancer, that arise only after decades of latency after first exposure; therefore, effects of reducing exposure to a carcinogen cannot be observed in the timeframe of most interventions.
- A promulgated regulation requires a technology that was developed but not widely used.
- Reductions in fatal traumatic injuries occur because more-hazardous manufacturing jobs are replaced by less-hazardous knowledge-based jobs.

III.B Evaluating NIOSH Research Programs by Using the Flowchart

The FC used the NIOSH logic model (Figure 1) to define the scope and stages of an EC evaluation. The evaluation of the elements in the flowchart (Figure 2) summarizes the FC's vision of how a program evaluation should proceed. FC members also identified numerous possible factors to consider in assessing the relevance of NIOSH research-program components, including

- The severity or frequency of health and safety hazards addressed and the number of people at risk (magnitude) for these hazards.
- The extent to which NIOSH research programs identify and address gender-related issues and issues of vulnerable populations. Vulnerable populations are defined as groups of workers who have biologic, social, or economic characteristics that place them at increased risk for work-related conditions or on whom inadequate data have been collected. Vulnerable populations include disadvantaged minorities, disabled persons, low-wage workers, and non-English-speakers for whom language or other barriers present health or safety risks.
- The extent to which NIOSH research programs address the health and safety needs of small businesses.
- The "life stage" of problems being addressed. As the health effects are understood, efforts should shift to intervention research, from efficacy to intervention, and to intervention-effectiveness research. Gaps in the spectrum of prevention need to be addressed; for example, research on exposure assessment may be necessary before the next intervention steps can be taken.
- The structure, in addition to the content, of the research program. A relevant research program is more than a set of unrelated research projects; it is an integrated program involving interrelated surveillance, research, and transfer activities.
- Appropriate NIOSH consideration of stakeholder input.

The ECs may consider those and other important factors that bear on relevance as they progress through each stage of an evaluation.

The following subsections are intended to guide the EC through the evaluation process and flowchart in Figure 2. Each begins with a definition of the component being evaluated, provides questions for the EC to consider during the course of its evaluation, and provides some guidance regarding the assessment of the component. The FC admittedly provides little guidance regarding the evaluation of programs that are organized in a matrix structure or programs that have large extramural research components. Because of the uniqueness of each program, each EC must determine the most reasonable way to apply the criteria established in this document.

III.B.1 Identifying the Period for Evaluation

By studying materials presented by the NIOSH research program and other sources, the EC will become familiar with the history of the research program being evaluated and its major subprograms, goals, objectives, resources, and other pertinent information. Having that information, the EC should choose the period most appropriate for the evaluation. EC efforts should focus on the impact and relevance of the NIOSH program in the most recent appropriate period. As a starting point, the ECs might consider three general timeframes:

- 1970-1995, the period from the founding of NIOSH to the initiation of NORA (pre-NORA period).
- 1996-2005 (NORA 1 period).
- After 2005 (NORA 2 period).

Those timeframes are provided as general guidance; the period chosen for review will take into consideration suggestions from the NIOSH research program under review. It is recognized that many of the intermediate and end outcomes documented since 1996 are consequences of research outputs completed before 1996.

III.B.2 Identifying Major Challenges (Figure 2, Circle)

Early in the assessment process, the EC itself should identify the major workplace health and safety challenges for the research program under review. In arriving at a list of challenges, the EC should rely on surveillance findings, including those of NIOSH investigations of sentinel events (through health-hazard or fatality-assessment programs), external advisory inputs, and its own expert judgment. The EC will then be able to compare its own assessment of workplace challenges with the NIOSH program goals and objectives. The congruence between the two will be useful during the assessment of relevance.

III.B.3 Analysis of Research-Program Strategic Goals and Objectives (Figure 2, Box A)

The research program goals and objectives should be evaluated with a focus on how each program goal is related to NIOSH's agencywide strategic goals and to the program challenges

identified in the step above (Section III.B.2). The importance or relevance of an issue may differ from the influence of NIOSH-funded research in addressing it. The EC should recognize that NIOSH research priorities may be circumstantial (for example, congressionally funded) rather than based on NIOSH's assessment of the state of knowledge.

Questions to Guide the Evaluation Committee

1. Are the strategic goals and objectives of the program well defined and clearly described?
2. How well were program goals and objectives aligned with NORA 1 priorities during the last decade?
3. How are current program strategic goals and objectives related to current NIOSH strategy, including NORA 2?
4. Are the research program goals, objectives, and strategies relevant to the major challenges for the research program and likely to address emerging problems in the research program (as determined by the EC while addressing Section III.B.2)?
 - a. Did past program goals and objectives (research and dissemination and transfer activities) focus on the most relevant problems and anticipate the emerging problems in the research program?
 - b. Do the current program goals and objectives target the most relevant problems?

Assessment

The EC should provide a qualitative assessment that discusses the relevance of the program's goals, objectives, and strategies in relation to its major challenges.

III.B.4 Review of Inputs (Figure 2, Box B)

Planning inputs include input from stakeholders, surveillance and intervention data, and risk assessments. Production inputs include intramural and extramural funding, staffing, management structure, and physical facilities.

The EC should examine existing intramural and extramural resources and, potentially, prior surveys or case studies that might have been developed specifically to assess progress in reducing workplace illnesses and injuries and to provide information relevant to the targeting of research to future needs. The NIOSH research program should provide the EC all relevant planning and production inputs (see below and Table 2 for examples).

Planning inputs

Planning inputs can be qualitative or quantitative. Sources of qualitative inputs include

- Federal advisory committees (such as the Board of Scientific Counselors, the Mine Safety and Health Research Advisory Committee, and the National Advisory Committee on Occupational Safety and Health).

- NORA research partners, initial NORA stakeholder meetings, later NORA team efforts (especially strategic research plans), and the NORA Liaison Committee and federal liaison committee recommendations.
- Industry, labor, academe, professional associations, industry associations, and the Council of State and Territorial Epidemiologists (CSTE).
- OSHA and MSHA strategic plans and other federal research agendas.

Attention should be given to how comprehensive the inputs have been and to what extent gaps in input have been identified and considered by NIOSH.

Sources of quantitative inputs include

- Intramural surveillance information, such as descriptive data on exposures and outcomes (appropriate data may be available from a number of NIOSH divisions and laboratories).
- HHEs.
- Reports from the FACE program.
- Extramural health-outcome and exposure-assessment data from OSHA, MSHA (both safety and health inspection data), the Bureau of Labor Statistics, the US Department of Defense (DOD), and the US Department of Agriculture (USDA) (fatality, injury, and illness surveillance data); state government partners, including NIOSH-funded state surveillance programs, such as Sentinel Event Notification System of Occupational Risks (SENSOR), Adult Blood Lead Epidemiology and Surveillance (ABLES), and state-based FACE; and nongovernment organizations, such as the National Safety Council, the Association of Occupational and Environmental Clinics (AOEC), the American Society of Safety Engineers, and the American College of Occupational and Environmental Medicine.
- Appropriate data from investigator-initiated extramural research funded by NIOSH.

Production inputs

For the research program under review, NIOSH should identify portions of the NIOSH intramural budget, staff, facilities, and management that play major roles in the research program. Production inputs should be described primarily in terms of intramural research projects, relevant extramural projects (particularly cooperative agreements and contracts), HHEs, and related staff. Consideration should also be given to leveraged funds provided by such partners as the National Institutes of Health (NIH) and the Environmental Protection Agency (EPA) for joint requests for applications or program announcements; and to OSHA, MSHA, and US Department of Defense (DOD) contracts with NIOSH.

Assessment of inputs should include EC consideration of the degree to which allocation of funding and personnel was commensurate with the resources needed to conduct the research and the extent to which funding for the relevant intramural research activity has been limited by lack of discretionary spending beyond salaries (travel, supplies, external laboratory services, and so on). Thus, assessments should consider the adequacy of the qualitative and quantitative planning and production inputs, given the tasks at hand.

Questions to Guide the Evaluation Committee

1. Do planning, production, and other input data promote program goals?
2. How well are major planning, production, and other program inputs used to support the major activities?
3. Is input obtained from stakeholders, including input representing vulnerable working populations and small businesses?
4. Are production inputs (intramural and extramural funding, staffing, management, and physical infrastructure resources) consistent with program goals and objectives?

Assessment

The EC should provide a qualitative assessment that discusses the quality, adequacy, and use of inputs.

III.B.5 Review of Activities (Figure 2, Box C)

Activities are defined as the efforts and work of a program's staff, grantees, and contractors. For present purposes, activities of the NIOSH program under review are divided into research and transfer activities. Table 3 is intended to guide the EC and NIOSH as to the type and organization of information required to evaluate program activities. The table may be incomplete, and some types of research activity may not be applicable to a given NIOSH program. Research activities include safety research, health-outcomes research, safety-design research, and safety-systems research. Transfer activities include information dissemination, training, technical assistance, and education designed to translate research outputs into content and formats that are designed for application in the workplace. Depending on the scope of the program under review, activities may also be grouped by research-program objectives or subprograms.

Conventional occupational safety and health research focuses appropriately on injury, illness, or death; on biomarkers of exposure; and on health effects of new technology, personal protective equipment, and regulations. A focus on surveillance research may be needed when available data inputs are inadequate. A focus on socioeconomic and policy research and on diffusion research is also needed to effect change because not all relevant intermediate outcomes occur in the workplace. NIOSH may be able to affect important outcomes farther out on the causal chain so as to influence health and safety in the workplace. Other research that might prove important in addressing NIOSH's mission includes

- Surveillance research to assess the degree of significant or systematic underreporting of relevant injuries, illnesses, and biomarkers.
- Socioeconomic research on cost-shifting between worker compensation and private insurance.
- Research on methods to build health and safety capacity in community health centers that serve low-income or minority-group workers and to improve recognition and treatment of work-related conditions.

- Transfer research to change health and safety knowledge of adolescents while they are in high school to improve the likelihood of reduced injuries as they enter the workforce.
- Community-based participatory research on differences between recently arrived immigrants and US-born workers regarding perceptions of acceptable health and safety risks so that programs can be targeted to meet the workforce training needs of immigrant workers.

TABLE 3 Examples of NIOSH Program Research and Transfer Activities

Surveillance (including hazard and injury, illness, and biomarkers of exposure or effect health surveillance and evaluation of surveillance systems)

Health-effects research (illnesses, injuries, and biomarkers):

- Epidemiology
- Toxicology
- Physical and safety risk factors (laboratory-based)
- Development of clinical-screening methods and tools

Exposure-assessment research:

- Chemical hazards
- Physical hazards
- Biologic hazards
- Ergonomic hazards
- Safety (traumatic injury) hazards

Safer-design and safety-systems research

Intervention research:

- Control technologies
 - Engineering controls and alternatives
 - Administrative controls
 - Personal protective equipment
- Work organization
- Community participation
- Policy (such as alternative approaches to targeting inspections)
- Design for safety
- Emergency preparedness and disaster response

Diffusion and dissemination research:

- Training effectiveness
- Information-dissemination effectiveness
- Diffusion of technology

Health-services and other research:

- Access to occupational health care
- Infrastructure—delivery of occupational-health services, including international health and safety
- Socioeconomic consequences of work-related injuries and illnesses
- Worker compensation

Technology-transfer and other transfer activities:

- Information dissemination
- Training programs
- Technical assistance

Transfer activities should be reviewed to determine whether the NIOSH program appropriately targets its outputs in a manner that will have the greatest impact. Ideally, information dissemination should be proactive, and strategic dissemination should be informed by research on the diffusion of new technologies, processes, and practices. Highly relevant information and technology transfer should include plans for appropriate transfer to all appropriate worker populations, including those considered vulnerable. Training should be incorporated into the strategic goals of all research fields where appropriate.

The EC should review project-level research and transfer activities (including surveillance activities) that have been completed, are in progress, or planned by the program under review. The program under review should provide a list of activities and specify whether they are intramural or extramural. For each extramural project, the key organizations and principal investigators' names should be requested, as should whether the project was in response to a request for proposal or a request for application. For each intramural project, the EC should ask NIOSH to provide a list of key collaborators (from another government agency, academe, industry, or unions).

The EC should evaluate each of the research activities outlined in Table 3 if it forms an important element of the program research. In the case of a sector-based research program (for example, mining or construction) in which health-effects research is not being reviewed, the EC should determine what research inputs influence the program's strategic goals and objective, and then assess the value of the inputs.

Questions to Guide the Evaluation Committee in Assessing Research Activities

1. What are the major subprograms or groupings of activities within the program?
2. Are activities consistent with program goals and objectives?
3. Are research activities relevant to the major challenges of the research program?
 - a. Do they address the most serious outcomes?
 - b. Do they address the most common outcomes?
 - c. Do they address the needs of both sexes, vulnerable working populations, and small businesses?
4. Are research activities appropriately responsive to the input of stakeholders?
5. To what extent are partners involved in the research activities?
6. Are partners involved early in the research process so that they could participate in determining research objectives and research design?
7. Were original resource allocations appropriate for the research activities, and do they remain appropriate?
8. To what extent does peer reviews (internal, external, and midcourse) affect the activities?
9. Is there adequate monitoring of quality-assurance procedures to ensure credible research data, analyses, and conclusions?

Questions to Guide the Evaluation Committee in Assessing Transfer Activities

1. Is there a coherent planned program of transfer activities?
2. Are the program's information dissemination, training, education, technical assistance, or publications successful in reaching the workplace or relevant stakeholders in other settings? How widespread is the response?

3. To what degree have stakeholders responded to NIOSH information and training products?
4. Is there evidence that the formats for information products were selected in response to stakeholder preferences?
5. To what extent do program personnel rely on assessment of stakeholder needs and reactions to prototype information and training projects (formative evaluation techniques)?
6. To what extent does the program build research and education capacity internally and among stakeholders?

Assessment

For this part of the assessment, the EC will provide a qualitative assessment that discusses relevance. This assessment should include consideration of the external factors identified in Section III.A that constrain choices of research projects and the relevance and effectiveness of transfer activities. The EC should consider the appropriateness of resource allocations. A highly relevant program would address high-priority needs, produce high-quality results, be appropriately collaborative, be of value to stakeholders, and be substantially engaged in transfer activities. A program may be less relevant to the extent that those key elements are not up to the mark or are missing. The discussion should cover those aspects in sufficient detail to arrive at a qualitative assessment of the activities. Assessment of the transfer activities must include considerations of program planning, coherence, and impact. The EC might also consider the incorporation of international research results into NIOSH knowledge-transfer activities for industry sectors in the United States.

III.B.6 Review of Outputs (Figure 2, Box D)

An output is a direct product of a NIOSH research program. Outputs may be designed for researchers, practitioners, intermediaries, and end-users, such as consumers. Outputs can be in the form of publications in peer-reviewed journals, recommendations, reports, Web-site content, workshops and presentations, databases, educational materials, scales and methods, new technologies, patents, technical assistance, and so on. Outputs of the research program's extramurally funded activities should also be considered. Table 4 lists examples of major outputs to be considered by the EC. The NIOSH research program should make every effort to include all pertinent data of the types listed in the table.

Outputs may be tailored to the intended audience to communicate information most effectively and increase the likelihood of comprehension, knowledge, attitude formation, and behavioral intent. The extent of use of formative evaluation data (data gathered before communication for the purpose of improving the likelihood of the intended effects) and the extent of intended user feedback in the design of the output can be considered indicators of appropriate quality assessment.

TABLE 4 Examples of Research-Program Outputs to Be Considered

Peer-reviewed publications by NIOSH staff:

- Number of original research articles by NIOSH staff
- Number of review articles by NIOSH staff (including best-practices articles)
- Complete citation for each publication
- Complete copies of the “top five” articles
- Collaboration with other public- or private-sector researchers
- Publications in the field of interest with other support by investigators also funded by NIOSH (for example, ergonomic studies with other support by an investigator funded by NIOSH to do ergonomics work, in which case NIOSH should get some credit for seeding interest or drawing people into the field)

Peer-reviewed publications by external researchers funded by NIOSH:

- Number of NIOSH-funded original research articles by external researchers
- Number of NIOSH-funded review articles by external researchers (including best-practices articles)
- Complete citation for each written report
- Complete copies of the “top five” articles
- Collaboration with other government or academic researchers

NIOSH reports in the research program:

- Number of written reports
- Complete citation for each written report
- Complete copies of the “top five” reports

Sponsored conferences and workshops:

- Number of sponsored conferences
- Number of sponsored workshops
- Description of conferences and workshops (title, date, sponsors, target audience, number of participants, and resulting products)
- NIOSH’s assessment of value or impact

Databases:

- Number of major databases created by NIOSH staff
- Number of major databases created by external researchers funded by NIOSH grants
- Description of databases:
 - Title, objective (in one to four sentences), and start and stop dates
 - Partial vs complete sponsorship (if partial, who were cosponsors?)
 - Study or surveillance-system design, study population, and sample size
 - Primary “products” of the database (such as number of peer-reviewed articles and reports)
- Complete copies of the “top two” publications or findings, to date, from each database

Recommendations:

- Number of major recommendations
- Description of recommendations:
 - Complete citation (article, report, or conference where recommendation was made)
 - Summary in one to four sentences
 - Percentage of target audience that has adopted recommendation 1, 5, and 10 years later
 - Up to three examples of implementation in the field
- Identification of “top five” recommendations to date

Tools, methods, and technologies (TMT):

- Number of major TMT (includes training and education materials)
- Descriptions of TMT
 - Title and objective of TMT (in one to four sentences)
 - Complete citation (if applicable)
 - Percentage of target audience that has used TMT 1, 5, and 10 years later
 - Up to three examples of implementation in the field
- Identification of “top 5” TMT to date

TABLE 4 Examples of Research-Program Outputs to Be Considered (continued)

Patents:

Total number of patents

For each:

Title and objective (in one to four sentences)

Complete citation

Percentage of target audience that has used product 1, 5, and 10 years later

Up to three examples of implementation in the field

Identification of “top five” patents to date

Miscellaneous:

Any other important program outputs

Some activities such as collaborations can also legitimately be conceptualized as outputs, because the collaboration itself is a result of NIOSH efforts. Cooperation, coordination, more intensive collaboration, and eventual formal partnering can be considered important outputs leading to desirable intermediate outcomes. Technology and knowledge transfer is greatly facilitated through such relationships. The extent of collaboration with other organizations in the determination of research agendas, the conduct of research, the dissemination of research results, and interorganization involvement in the production of outputs can all be measures of output quality and quantity. The EC may consider coauthorship while trying to determine the importance of NIOSH research to the broader research community.

The NIOSH program should provide information on all relevant outputs of the program under review produced during the chosen period.

Questions to Guide the Evaluation Committee

1. What are the major outputs of the research program?
2. Are output levels consistent with resources allocated (were resources allocated and used efficiently to produce outputs)?
3. Does the research program produce outputs that address high-priority areas?
4. To what extent does the program generate important new knowledge or technology?
5. Are there widely cited peer-reviewed publications considered to report “breakthrough” results?
6. What, if any, internal or external capacity-building outputs are documented?
7. Are outputs relevant to both sexes, vulnerable populations, and do they address health disparities?
8. Are outputs relevant to health and safety problems of small businesses?
9. Are products user-friendly with respect to readability, simplicity, and design?
10. To what extent does the program help to build the internal or extramural institutional knowledge base?
11. Does the research produce effective cross-agency, cross-institute, or internal-external collaborations?
12. To what extent does the program build research and education capacity (internal or external)?

Assessment

The EC should provide a qualitative assessment discussing relevance and utility. The outputs of a highly ranked program will address needs in high-priority areas, contain new knowledge or technology that is effectively communicated, contribute to capacity-building inside and outside NIOSH, and be relevant to the pertinent populations. The discussion should cover those aspects in sufficient detail to support the qualitative assessment of the outputs.

III.B.7 Review of Intermediate Outcomes (Figure 2, Box E)

Intermediate outcomes are important indicators of stakeholder response to NIOSH outputs. They reflect the impact of program activities and may lead to the desired end outcome of improved workplace safety and health. Intermediate outcomes include the production by those outside of NIOSH of guidelines or regulations based wholly or partly on NIOSH research (products adopted as national or international public policy or as policy or guidelines by private organizations or industry); contributions to training and education programs sponsored by other organizations; use of publications or other materials by workers, industry, and occupational safety and health professionals in the field; and citations of NIOSH research by industrial and academic scientists.

Intermediate outcomes allow inference that a program's outputs are associated with observed changes in the workplace. Thus, an intermediate outcome reflects an assessment of worth by NIOSH stakeholders (such as managers in industrial firms) about NIOSH research or its products (for example, NIOSH training workshops). Intermediate outcomes that are difficult to monitor but may be valid indicators of relevance or utility include self-report measures by users of NIOSH outputs. Such indicators include the extent to which key intermediaries find value in NIOSH products or databases for the repackaging of health and safety information, the extent to which NIOSH recommendations are in place and attended to in workplaces, and employee or employer knowledge of and adherence to NIOSH-recommended practices.

Questions to Guide the Evaluation Committee:

1. Do program outputs result in or contribute to stakeholder training or education activities used in the workplace or in school or apprentice programs? If so, how?
2. Do program activities and outputs result in regulations, public policy, or voluntary standards or guidelines that are transferred to or created by the workplace?
3. Has the program resulted in changes in employer or worker practices associated with the reduction of risk (for example in the adoption of new feasible control or personal protective technologies or administrative control concepts)?
4. Does the program contribute to changes in health-care practices to improve recognition and management of occupational health conditions?
5. Does the program result in research partnerships with stakeholders that lead to changes in the workplace?
6. To what extent do the program's stakeholders find value in NIOSH products (as shown by document requests, Web-site hits, conference attendance, and so on)?

7. Does the program or a subprogram provide unique staff or laboratory capability that is a necessary national resource? If so, is it adequate, or does it need to be enhanced or reduced?
8. Has the program resulted in interventions that protect both sexes, vulnerable workers, or address the needs of small businesses?
9. To what extent did the program contribute to increased capacity at worksites to identify or respond to safety and health threats?

Assessment

Only a qualitative assessment of product development, usefulness, and impact is required at this point in the EC report. Some thought should be given to the relative value of intermediate outcomes, and the FC recommends applying the well-accepted hierarchy-of-controls model. The discussion could include comments on how widely products have been used or programs implemented. The qualitative discussion should be specific as to the various products developed by the program and the extent of their use by specific entities (industry, labor, government, and so on) for specific purposes. Whether the products have resulted in changes in the workplace or in the reduction of risk should be discussed. The recognition accorded to the program or the facilities by its peers (such as recognition as a “center of excellence” by national and international communities) should be considered in the assessment. To be highly ranked, a program should have high performance in most of the relevant questions in this section. An aspect of the evaluation can be whether the same changes in stakeholder activities and behaviors would probably have occurred without NIOSH efforts.

III.B.8 Review of End Outcomes (Figure 2, Box F)

It is necessary for the EC to assess, to the greatest extent possible, NIOSH’s contribution to end outcomes—improvements in workplace health and safety (impact). For purposes of this evaluation, end outcomes are health-related changes that are a result of program activities, including decreases in injuries, illnesses, deaths and exposures or risk. Data on reductions in work-related injuries, illnesses, and hazardous exposures will be available for some programs, and in some cases they will be quantifiable. It is possible, however, to evaluate the impact of a NIOSH research program using either intermediate outcomes or end outcomes. If there is no direct evidence of improvements in health and safety, intermediate outcomes may be used as proxies for end outcomes in assessing impact as long as the EC qualifies its findings. The EC will describe the realized or potential benefits of the NIOSH program. Examples of realized intermediate outcomes are new regulations and widely accepted guidelines, work practices, and procedures, all of which may contribute measurably to enhancing health and safety in the workplace.

The FC recognizes that assessing the causal relationship between NIOSH research and specific occupational health and safety outcomes is a major challenge because NIOSH does not have direct responsibility or authority for implementing its research findings in the workplace. Furthermore, the benefits of NIOSH research program outputs can be realized, potential, or limited to the knowledge gained. Studies that conclude with negative results may nevertheless

have incorporated excellent science and contribute to the knowledge base. The generation of important knowledge is a recognized form of outcome in the absence of measurable impacts.

The impact of an outcome depends on the existence of a “receptor” for research results, such as a regulatory agency, a professional organization, an employer, and an employee organization. The EC should consider questions related to the various stages that lead to outputs, such as these:

1. Did NIOSH research identify a gap in protection or a means of reducing risk?
2. Did NIOSH convey that information to potential users in a usable form?
3. Were NIOSH research results (for example, recommendations, technologies) applied?
4. Did the applied results lead to desired outcomes?

Quantitative data are preferable to qualitative, but qualitative analysis may be necessary. Sources of quantitative data include

- Bureau of Labor Statistics (BLS) data on fatal occupational injuries (the Census of Fatal Occupational Injuries) and nonfatal occupational injuries and illnesses (the annual Survey of Occupational Injury and Illnesses).
- NIOSH intramural surveillance systems, such as the National Electronic Injury Surveillance System, the coal-worker x-ray surveillance program, and agricultural-worker surveys conducted by NIOSH in collaboration with USDA.
- State-based surveillance systems, such as the NIOSH-funded ABLES, and the SENSOR programs (for asthma, pesticides, silicosis, noise-induced hearing loss, dermatitis, and burns).
- Selected state worker-compensation programs.
- Exposure data collected in the OSHA Integrated Management Information System.

The FC is unaware of mechanisms for surveillance of many occupationally related chronic illnesses, such as cancers that arise from long exposure to chemicals and other stressors. The incidence and prevalence of many such outcomes are best evaluated by investigator-initiated research. Research that leads to new, effective surveillance concepts or programs warrants special recognition.

The EC should recognize the strengths and weaknesses of outcome data sources. Quantitative accident, injury, illness, and employment data and databases are subject to error and bias and should be used by the EC only for drawing inferences after critical evaluation and examination of available corroborating data. For example, it is widely recognized that occupational illnesses are poorly documented in the BLS Survey of Occupational Injuries and Illnesses, which captures only incident cases among active workers. It is difficult for health practitioners to diagnose work-relatedness of most illnesses that may not be exclusively related to work; furthermore, few practitioners are adequately trained to make such an assessment. Many of those illnesses have long latencies and do not appear until years after people have left the employment in question. Surveillance programs may systematically undercount some categories of workers, such as contingent workers.

In addition to measures of illness and injury, measures of exposure to chemical and physical agents and to safety and ergonomic hazards can be useful. Exposure or probability of exposure can serve as an appropriate proxy for disease or injury when a well-described

occupational exposure-health association exists. In such instances, a decrease in exposure can be accepted as evidence that the end outcome of reduced illness or injury is being achieved. That is necessary particularly when the latent period between exposure and disease outcome, as in the case of asbestos exposure and lung cancer, makes effective evaluation of the relevant end outcome infeasible.

As an example of how an exposure level can serve as a proxy, reduction in the number of sites that exceed an OSHA PEL or an American Conference of Governmental Industrial Hygienists threshold limit value is a quantitative measure of improvement of occupational health awareness and reduction of risk. In addition to exposure level, the number of people exposed and the distribution of exposure levels are important. Those data are available from multiple databases and studies of exposure. Apart from air monitoring, such measures of exposure as biohazard controls, reduction in requirements for use of personal protective equipment, and reduction in ergonomic risks are important.

Challenges posed by inadequate or inaccurate measurement systems should not drive programs out of difficult fields of study, and the EC will need to be aware of such a possibility. In particular, contingent and informal working arrangements that place workers at greatest risk are also those on which surveillance information is almost totally lacking, so novel methods for measuring impact may be required.

The commitment of industry, labor, and government to health and safety are critical external factors. Several measures of that commitment can be useful for the EC: monetary commitments, attitude, staffing, and surveys of relative importance. To the extent that resources allocated to safety and health are limiting factors, the EC should explicitly assess NIOSH performance in the context of constraints.

Questions to Guide the Evaluation Committee

1. What are the amounts and qualities of relevant end-outcomes data (such as injuries, illness, exposure, and productivity affected by health)?
2. What are the temporal trends in those data?
3. Is there objective evidence of improvement in occupational safety or health?
4. To what degree is the NIOSH program or subprogram responsible for improvement in occupational safety or health?
5. If there is no time trend in the data, how do findings compare with data from other comparable US groups or the corresponding populations in other countries?
6. What is the evidence that external factors have affected outcomes or outcome measures?
7. Has the program been responsible for outcomes outside the United States that have not been described in another category?

Assessment

The EC should provide a qualitative assessment of the program and subprogram impact, discussing the evidence of reductions in injuries and illnesses or their appropriate proxies.

III.B.9 Review of Potential Outcomes

There may be health and safety impacts not yet appreciated and other beneficial social, economic, and environmental outcomes as a result of NIOSH activities. NIOSH study results may be influential outside the United States, and there may be evidence of implementation of NIOSH recommendations and training programs abroad.

Questions to Guide the Evaluation Committee

1. Is the program likely to produce a favorable change that has not yet occurred or not been appreciated?
2. Has the program been responsible for social, economic, security, or environmental outcomes?
3. Has the program's work had an impact on occupational health and safety in other countries?

Assessment

The EC may discuss other outcomes, including beneficial changes that have not yet occurred; social, economic, security, or environmental outcomes; and the impact that NIOSH has had on international occupational safety and health.

III.B.10 Summary Evaluation Ratings and Rationale

The EC should use its expert judgment to rate the relevance and impact of the overall research program by first summarizing its assessments of the major subprograms and then appropriately weighting the subprograms to determine the overall program ratings.

Table 5 provides some background context to aid the EC in reaching overall ratings for relevance and impact. The EC could consider the items in Table 5 for each subprogram then for the overall program and assess the relevance of the research subprograms and program by reviewing earlier responses to the questions in Sections III.B.2 through III.B.5 (reviews of program challenges, strategic goals and objectives, inputs, and activities). Items 1-4 in Table 5 are pertinent to assessing relevance.

To assess overall impact, the EC first needs to consider the available evidence of changes in work-related risks and adverse effects and external factors related to the changes. The EC should review the responses to the questions in Sections III.B.6 through III.B.8 (reviews of outputs, intermediate outcomes, and end outcomes) and systematically assess the impact of the research program and its subprograms. Items 5-7 in Table 5 will be helpful. The EC should evaluate separately the impact of the research and the impact of transfer activities. Transfer activities occur in two contexts: NIOSH efforts to translate intellectual products into practice and stakeholder efforts to integrate NIOSH results into the workplace. High impact assessments require the EC's judgment that the research program has contributed to outcomes; for example, outcomes have occurred earlier than they would have or are better than they would have been in the absence of the research program, or outcomes would have occurred were it not for external factors beyond NIOSH's control or ability to plan around.

TABLE 5 Background Context for Program Relevance and Impact

Assess the following for each subprogram:

1. Relevance of current and recently completed research and transfer activities to objective improvements in workplace safety and health.
2. Contributions of NIOSH research and transfer activities to changes in work-related practices and reduction in workplace exposures, illnesses, or injuries.
3. Contributions of NIOSH research and transfer activities to improvements in work-related practices.
4. Contributions of NIOSH research to productivity, security, or environmental quality (beneficial side effects).
5. Evidence of reduction of risk in the workplace (intermediate outcome).
6. Evidence of reduction in workplace exposure, illness, or injuries (end outcome).
7. Evidence of external factors that prevented translation of NIOSH research results into intermediate or end outcomes.

The EC must assign one overall integer score for the *relevance* of the research program to the improvement of occupational safety and health and one overall integer score for the *impact* of the program on the improvement of occupational safety and health. The EC will use its expert judgment, summary assessment of research-program elements, and any appropriate information to arrive at those two scores. In light of substantial differences among the types of research programs that will be reviewed and the challenge to arrive at a summative evaluation of both relevance and impact, the FC chose not to construct an algorithm to produce the two final ratings.

Relevance and impact scores will be based on five-point categorical scales established by the FC (see Boxes 2 and 3) in which 1 is the lowest and 5 the highest rating. The FC has made an effort to establish mutually exclusive rating categories in the scales. When the basis of a rating fits more than one category, the highest applicable score should be assigned. It is up to the EC to determine how individual subprograms should influence final scores. Single integer values should be assigned. Final program ratings will consist of integer scores for relevance and impact and prose justification of the scores.

Box 2 includes the criteria for scoring the overall relevance of the NIOSH research program. As discussed in previous sections, numerous factors can be considered in assessing relevance. The scoring criteria focus on two: the EC assessment of whether the program appropriately sets priorities among research needs and the EC assessment of how engaged the program is in appropriate transfer activities. Table 6 provides some guidance regarding how the EC may weight research priorities and transfer levels when determining relevance scores.

BOX 2 Scoring Criteria for Relevance

- 5 = Research is in high-priority subject areas and NIOSH is significantly engaged in appropriate transfer activities for completed research projects/reported research results.
- 4 = Research is in priority subject areas and NIOSH is engaged in appropriate transfer activities for completed research projects/reported research results.
- 3 = Research is in high priority or priority subject areas, but NIOSH is not engaged in appropriate transfer activities; or research focuses on lesser priorities but NIOSH is engaged in appropriate transfer activities.
- 2 = Research program is focused on lesser priorities and NIOSH is not engaged in or planning some appropriate transfer activities.
- 1 = Research program is not focused on priorities and NIOSH is not engaged in transfer activities.

TABLE 6 Guidance for Weighting Research Priority and Engagement in Appropriate Transfer Activities in the Application of Relevance Score

Assessment of Research Priority	Engagement in Applicable Transfer Activities	Applicable Score
High priority	Significantly engaged	5
High priority	Engaged	4
High priority	Not engaged	3
Priority	Significantly engaged	4
Priority	Engaged	4
Priority	Not engaged	3
Lesser priority	Significantly engaged	3
Lesser priority	Engaged	3
Lesser priority	Not engaged	2
Not focused on priorities	Significantly	2
Not focused on priorities	Engaged	2
Not focused on priorities	Not engaged	1

The EC will consider both completed research and research that is in progress and related to likely future improvements in its assessment of relevance. The EC should keep in mind how well the program has considered the frequency and severity of the problems being addressed; whether appropriate attention has been directed to both sexes, vulnerable populations, or hard-to-reach workplaces; and whether the different needs of large and small businesses have been accounted for. It is up to the EC to determine how to consider external factors in assigning program scores.

Box 3 includes the criteria established for the rating of impact. In general, the EC will consider completed research outputs during the assessment of impact. In assigning a score for impact, it is important to recognize that a "major contribution" (required for a score of 5) does not imply that the NIOSH program was solely responsible for observed improvements in worker health and safety. Many factors may be required to effect improvements. The EC could say that NIOSH made "major contributions" if the improvements would not have occurred when they did without NIOSH efforts.

The EC has some concern that the imposed scoring criteria for impact might be considered a promotion of the conventional occupational-health research paradigm that focuses on health-effects and technology research without much emphasis on the socioeconomic, policy, surveillance, and diffusion research (as opposed to diffusion activities) needed to effect change. The EC should remember that not all intermediate outcomes occur in the workplace. Important outcomes that NIOSH can effect also occur much farther out on the causal chain. NIOSH, for example, has an important role to play in generating knowledge that may contribute to changing norms in the insurance industry, in health-care practice, in public-health practice, and in the community at large. The EC may find that some of those issues need to be addressed and considered as external factors that facilitate or limit application of more traditional research findings. Given the rapidly changing nature of work and the workforce and some of the intractable problems in manufacturing, mining, and some other fields, the EC is encouraged to think beyond the traditional paradigm.

BOX 3 Scoring Criteria for Impact

- 5 = Research program has made major contribution(s) to worker health and safety on the basis of end outcomes or well-accepted intermediate outcomes.
 - 4 = Research program has made some contributions to end outcomes or well-accepted intermediate outcomes.
 - 3 = Research program activities are ongoing and outputs are produced that are likely to result in improvements in worker health and safety (with explanation of why not rated higher). Well accepted outcomes have not been recorded.
 - 2 = Research program activities are ongoing and outputs are produced that may result in new knowledge or technology, but only limited application is expected. Well accepted outcomes have not been recorded.
 - 1 = Research activities and outputs do not result in or are NOT likely to have any application.
- NA = Impact cannot be assessed; program not mature enough.

III.C Assessment of NIOSH Process for Targeting Priority Research Needs and Committee Assessment of Emerging Issues

The second charge to the EC is the assessment of the research program's effectiveness in targeting new research and identifying emerging issues in occupational safety and health most relevant to future improvements in workplace protection. The EC is also asked to provide a qualitative narrative assessment of the program's efforts and to make suggestions about emerging issues that the program should be prepared to address. Among the most challenging aspects of research in illness and injury prevention are the identification of new or emerging needs or trends and the formulation of a research response that appropriately uses scarce resources in anticipation of them.

The EC should review the procedures that NIOSH and the research program have in place to identify needed research relevant to the NIOSH mission and should review the success that NIOSH has had in identifying and addressing research related to emerging issues. It should examine leading indicators from appropriate federal agencies, such as EPA, the Department of Labor, the National Institute of Standards and Technology, NIH, DOD, and the Department of Commerce. Those indicators should track new technologies, new products, new processes, and disease or injury trends.

One source of information deserving particular attention is NIOSH HHE reports. The HHE program offers a potential mechanism for identifying emerging research needs that could be incorporated as input into each of the programs evaluated. The EC should determine whether the program under review appropriately considers pertinent HHE investigation findings. Additional emerging issues may be revealed through consideration of NIOSH and the NIOSH-funded FACE reports, the AOEC reports, the US Chemical Safety Board investigations, and SENSOR and other state-based surveillance programs. Appropriate federal advisory committees and other stakeholder groups should also be consulted to provide qualitative information.

The EC should systematically assess how the research program and its subprograms target new research by evaluating each subprogram for the items listed in Table 7. The EC will have to determine how best to weight subprogram contributions in the program's targeting of new research.

TABLE 7 Targeting of New Research and Identification of Emerging Issues

Assess the following for each subprogram:

1. Past and present effectiveness in targeting most relevant research needs.
 2. Effectiveness in targeting research in fields most relevant to future improvements in occupational safety and health.
 3. Contribution of NIOSH research to enhancement of capacity in government or other research institutions.
-

Questions to Guide the Evaluation Committee

1. What information does NIOSH review to identify emerging research needs?
 - a. What is the process for review?
 - b. How often does the process take place?
 - c. How are NIOSH staff scientists and NIOSH leadership engaged?
 - d. What is the process for moving from ideas to formal planning and resource allocation?
2. How are stakeholders involved?
 - a. What advisory or stakeholder groups are asked to identify emerging research targets?
 - b. How often are such groups consulted, and how are suggestions followed up?
3. What new research targets have been identified for future development in the program under evaluation?
 - a. How were they identified?
 - b. Were lessons that could help to identify other emerging issues learned?
 - c. Does the EC agree with the issues identified and selected as important and with the NIOSH response, or were important issues overlooked?
 - d. Is there evidence of unwise expenditure of resources on unimportant issues?

The EC members should use their expert judgment both to evaluate the emerging research targets identified by NIOSH and to provide recommendations to NIOSH regarding additional research that NIOSH has not yet identified. Recommendations should include a brief statement of their rationale.

IV EVALUATION COMMITTEE REPORT TEMPLATE

Consistency and comparability among EC report formats is desirable, but the FC recognizes that each NIOSH research program is different and that each EC is independent. The outline provided in Box 4 flows from the FC's review of NIOSH's generalized logic model (Figure 1), the evaluation flowchart (Figure 2), and the assessment model described earlier in this document. The EC should feel free to use or adapt this outline as necessary when organizing its final report. The FC encourages each EC to look at prior EC reports for organizational ideas.

BOX 4 Suggested Outline for Evaluation Committee Reports

I Introduction

This section should be a brief descriptive summary of the history of the program (and subprograms) being evaluated with respect to pre-NORA, NORA 1, and current and future plans of the research program presented by NIOSH. It should present the context for the research on safety and health; goals, objectives, and resources; groupings of subprograms; and any other important pertinent information. (A list of the NIOSH materials reviewed should be provided in Appendix C.)

II Evaluation of Programs and Subprograms (Charge 1)

- A. Evaluation summary (should include a brief summary of the evaluation with respect to impact and relevance, scores for impact and relevance, and summary statements).
- B. Strategic goals and objectives: should describe assessment of the program and subprograms for relevance.
- C. Review of inputs: should describe adequacy of inputs to achieve goals.
- D. Review of activities: should describe assessment of the relevance of the activities.
- E. Review of research-program outputs: should describe assessment of relevance and potential usefulness of the research program.
- F. Review of intermediate outcomes and causal impact: should describe assessment of the intermediate outcomes and the attribution to NIOSH; should include the likely impacts and recent outcomes in the assessment.
- G. Review of end outcomes: should describe the end outcomes related to health and safety and provides an assessment of the type and degree of attribution to NIOSH.
- H. Review of other outcomes: should discuss health and safety impacts that have not yet occurred; beneficial social, economic, and environmental outcomes; and international dimensions and outcomes.
- I. Summary of ratings and rationale.

III NIOSH Targeting of New Research and Identification of Emerging Issues (Charge 2)

The EC should assess the progress that the NIOSH program has made in targeting new research in occupational safety and health. The EC should assess whether the NIOSH program has identified important emerging issues that appear especially important in terms of relevance to the mission of NIOSH. The EC should respond to NIOSH's perspective and add its own recommendations.

IV Recommendations for Program Improvement

On the basis of the review and evaluation of the program, the EC may provide recommendations for improving the relevance of the NIOSH research program to health and safety conditions in the workplace and the impact of the research program on health and safety in the workplace.

Appendix A Framework Document

Appendix B Methods and Information-Gathering

Appendix C List of NIOSH and Related Materials Collected in the Process of the Evaluation

V BIOGRAPHICAL SKETCHES OF CURRENT COMMITTEE MEMBERS

DAVID H. WEGMAN, *Chair*, is dean of the School of Health and Environment at the University of Massachusetts, Lowell. He also serves as adjunct professor at the Harvard School of Public Health. Dr. Wegman's research involves epidemiologic studies of occupational respiratory disease, musculoskeletal disorders, and cancer. Recent work has focused on the examination of health and safety risks among construction workers involved in the building of the Third Harbor Tunnel and the underground Central Artery in Boston, and the study of the relationship of work risks and age both among child laborers and older adults. He has also

written on public health and policy issues concerning hazard and health surveillance, methods of exposure assessment for epidemiologic studies, the development of alternatives to regulation and the use of participatory methods to study occupational health risks. Dr. Wegman served as chair of the NRC-IOM Committee on Health and Safety Needs of Older Workers and the Committee on the Health and Safety Consequences of Child Labor. He has also been a member of the NRC-IOM Panel on Musculoskeletal Disorders and Work, the IOM Committees to Review the Health Consequences of Service During the Persian Gulf War and to Review Gender Differences in Susceptibility to Environmental Factors. He received his M.D. from Harvard Medical School.

WILLIAM B. BUNN, III is vice president of health, safety, security, and productivity at International Truck and Engine Corporation (formerly Navistar International) in Warrenville, Illinois. Previously, he was medical director and director of healthcare, workers' compensation, disability, and safety for Navistar International, and prior to that was Director of International Medical Services for Mobil Corporation. Dr. Bunn has an appointment as professor of clinical preventive medicine at Northwestern University School of Medicine. He received the Occupational and Environmental Education Foundation Award in 2003, the William S. Knudsen Award in 2002, and the Institute for Health and Productivity Management Corporate Health and Productivity Award in 2001. He chaired the National Research Council Committee on Department of Energy Radiation Epidemiological Research Programs, and has served on numerous advisory committees including the Science Advisory Board of EPA, Board of Scientific Counselors of the National Institute for Occupational Safety and Health and Committee on Clinical Services. He is also a fellow board member and former officer of the American College of Occupational and Environmental Medicine. He received a J.D. and M.D. from Duke University, and an M.P.H. from the University of North Carolina.

CARLOS A. CAMARGO is an associate professor of medicine and epidemiology at Harvard Medical School, an emergency physician at Massachusetts General Hospital (MGH) and a research epidemiologist at the Channing Laboratory, Brigham and Women's Hospital in Boston, Massachusetts. His research focuses on asthma and other [respiratory/allergy](#) problems in several large national cohorts (e.g., the Nurses' Health Studies). He also chairs the Steering Committee of the Emergency Medicine Network (EMNet, www.emnet-usa.org), a research collaboration involving 181 emergency departments. This network has completed numerous multicenter studies and randomized trials focusing on [respiratory/allergy](#) emergencies and public health issues. Dr. Camargo is past president of the American College of Epidemiology and recently served on the 2005 U.S. Dietary Guidelines Advisory Committee. He currently serves on the National Institute of Health's National Asthma Education and Prevention Program's Third Expert Panel (the group writing the 2007 national asthma guidelines). He has over 250 peer-reviewed publications. Dr. Camargo received his M.D. from the University of California, San Francisco; his M.P.H. from the University of California, Berkeley; and his Dr.P.H. from the Harvard School of Public Health.

SUSAN E. COZZENS is a professor of public policy at the Georgia Institute of Technology, director of its Technology Policy and Assessment Center, and associate dean for research at its Ivan Allen College. She earned her Ph.D. in sociology from Columbia University. She is currently working on research in the fields of science, technology, and inequalities; she continues to work internationally on developing methods for research assessment, as well as science and

technology indicators. Prior to joining the faculty at the Georgia Institute of Technology, she was the director of the Office of Policy Support at the National Science Foundation. Dr. Cozzens has served as a consultant to numerous organizations, including the Office of Science and Technology Policy, National Science Foundation, Office of Technology Assessment, General Accounting Office, National Cancer Institute, National Institute on Aging, and National Institutes of Health. She has served on several NRC and IOM committees, including Evaluation of the Sea Grant Program Review Process, Assessment of Centers of Excellence Programs at NIH, Research Standards and Practices to Prevent the Destructive Application of Biotechnology, and the Committee to Review the NIOSH Hearing Loss Research Program. Dr. Cozzens is the past editor of *Science, Technology, & Human Values* and the *Journal of the Society for Social Studies of Science*. She currently is the co-editor of *Research Evaluation*.

LETITIA K. DAVIS is director of the Occupational Health Surveillance Program in the Massachusetts Department of Public Health, where she has worked for the last 20 years to develop state-based surveillance systems for work-related illnesses and injuries. The Occupational Health Surveillance Program uses surveillance findings to inform state and local prevention activities, and over the years has undertaken a variety of educational intervention activities as well. Dr. Davis has served as principal investigator for a community-based intervention project to enhance the health and safety of young workers. More recently she has served as principal investigator for a study examining the feasibility of working with community health centers to collect data on occupational health experience of immigrant workers. Dr. Davis is also lead occupational health consultant to the Council of State and Territorial Epidemiologists. Dr. Davis serves as adjunct faculty of the Department of Work Environment at the University of Massachusetts at Lowell and as a visiting lecturer on occupational health at the Harvard School of Public Health. She is also a past member of the Board of Scientific Counselors of the National Institute for Occupational Safety and Health and of the National Advisory Committee on Occupational Safety and Health. Dr. Davis received her doctorate in occupational health from the Harvard School of Public Health. She has previously served on the Institute of Medicine's Committee on Health and Safety Implications of Child Labor.

JAMES W. DEARING is senior scientist at the Institute for Health Research with Kaiser Permanente Colorado where he co-directs the Center for Health Dissemination and Implementation Research (with Russell Glasgow). Until 2006, he was professor and director of graduate studies for the School of Communication Studies at Ohio University and has been a faculty member at Michigan State University, a visiting faculty member at the University of Michigan, and a visiting scholar at the University of California, Berkeley. Dearing studied under and collaborated with Everett M. Rogers for 20 years. Dearing's primary area of expertise is the application of diffusion of innovation concepts to challenges of moving evidence-based practices, programs, and policies into practice. He has led research projects about community-based health system reform, mass media agenda setting, community health promotion planning, interorganizational networks, and organizational change. He holds a Ph.D. in communication theory and research from the Annenberg School for Communication at the University of Southern California. Dr. Dearing serves on the National Research Council (NRC) committee that developed the framework for the evaluation of the National Institute for Occupational Safety and Health's (NIOSH's) research programs, and has most recently conducted studies sponsored by the National Science Foundation, the John D. and Catherine T. MacArthur Foundation, the

Robert Wood Johnson Foundation, and the National Heart, Lung and Blood Institute. His most recent book is *Communication of Innovations* (co-edited with Arvind Singhal).

FRED A. METTLER, JR. is currently professor emeritus in the Department of Radiology at the University of New Mexico School of Medicine. He was chair of the department for 18 years from 1984 to 2003. He is currently Chief of Radiology and Nuclear Medicine at the New Mexico Federal Regional Medical Center. He graduated with a B.A. in mathematics from Columbia University and in 1970 he received an M.D. from Thomas Jefferson University. He received a Master's in public health from Harvard University in 1975. He is an academician of the Russian Academy of Medical Sciences and a fellow of both the American College of Radiology and the American College of Nuclear Physicians. Dr. Mettler has authored over 310 scientific publications, including 18 books on medical management of radiation accidents, medical effects of ionizing radiation, and radiology and nuclear medicine. He holds four patents. He was a scientific vice-president of the National Council on Radiation Protection and Measurements, and remains a member. He has chaired two committees for the Institute of Medicine and National Research Council. He is currently the U.S. Representative to the United Nations for Radiation Effects and is an emeritus Commissioner of the International Commission on Radiation Protection. He was the health effects team leader of the International Chernobyl Project.

FRANKLIN E. MIRER is Professor of Environmental and Occupational Health at Hunter College of the City University of New York. Previously, he served for decades as director of the Health and Safety Department for the United Automobile, Aerospace and Agricultural Implement Workers of America (UAW). He holds a Ph.D. in physical organic chemistry from Harvard University and is a toxicologist and certified industrial hygienist. His primary scientific interest is exposure and risk assessment in the occupational environment, and the interaction of science and policy in setting and enforcing health regulations. Dr. Mirer has served on National Academies committees on Institutional Means for Risk Assessment, Risk Assessment Methodology, and the Review of the Health Effects Institute. He has testified before House and Senate committees on occupational safety and health matters. He was inducted into the National Safety Council's Health and Safety Hall of Fame and is a fellow of the Collegium Ramazzini and the American Industrial Hygiene Association. He holds appointments as an adjunct professor at the Michigan School of Public Health, adjunct associate professor at the Mt. Sinai School of Medicine, and visiting lecturer at the Harvard School of Public Health.

JACQUELINE NOWELL is the director of the Occupational Safety and Health Office at the United Food and Commercial Workers International Union. Ms. Nowell and her staff develop and monitor ergonomic programs in the red meat, poultry, and retail industries. They develop educational materials and conduct training programs for local union stewards and leadership on a variety of safety and health issues in the union's represented industries. She is a member of the American Public Health Association and American Industrial Hygiene Association as well as serving on National Institute for Occupational Safety and Health/National Occupational Research Agenda Traumatic Injuries and Special Populations at Risk Teams. She is currently a board member on the District of Columbia Occupational Safety and Health Board that establishes policies related to occupational safety and health issues in the District of Columbia. Ms. Nowell received her Master's in public health from the University of California, Los Angeles and is a certified industrial hygienist. She has worked for the New York Committee for

Occupational Safety and Health and was an assistant professor at Hunter College's School of Health Sciences and Environmental and Occupational Health Science Program.

RAJA V. RAMANI is emeritus George H., Jr. and Anne B. Deike Chair of Mining Engineering and professor emeritus of mining and geo-environmental engineering at The Pennsylvania State University. Dr. Ramani holds M.S. and Ph.D. degrees in mining engineering from Penn State, where he has been on the faculty since 1970. His research activities include mine health, safety, productivity, environment, and management; flow mechanisms of air, gas, and dust in mining environs; and innovative mining methods. Dr. Ramani has been a consultant to the United Nations, World Bank, and National Safety Council and has received numerous awards from academia and technical and professional societies. He was the 1995 president of the Society for Mining, Metallurgy, and Exploration. He served on the U.S. Department of Health and Human Services' Mine Health Research Advisory Committee (1991-1998). He was the chair of the National Academy of Sciences (NAS) Committee on Post Disaster Survival and Rescue (1979-1981) and a member of Health Research Panel of the NAS Committee on the Research Programs of the U.S. Bureau of Mines (1994). He was a member of the Department of Interior's Advisory Board to the Director of U.S. Bureau of Mines (1995) and a member of the Secretary of Labor's Advisory Committee on the Elimination of Coal Worker's Pneumoconiosis (1995-96). More recently, he was a member of the NAS Committee on Technologies for the Mining Industries (2000-2001) and the NAS Committee on Coal Waste Impoundments (2001-2002). In 2002, he chaired the the Pennsylvania Governor's Commission on Abandoned Mine Voids and Mine Safety that was set up immediately following the Quecreek Mine inundation incident and rescue. Dr. Ramani is a member of the National Academy of Engineering.

JORMA RANTANEN is the director emeritus of the Finnish Institute of Occupational Health. Dr. Rantanen has served as president of the International Commission on Occupational Health. He has led efforts to anticipate emerging workplace hazards, built an international network of occupational safety and health professionals, and improved working conditions in developing nations. He has been a pioneer in the development and recognition of comprehensive occupational health, including development of healthy and safe work environments, promotion and maintenance of work ability, and introduction of healthy work practices and lifestyles. He was awarded the National Institute for Occupational Safety and Health Lifetime Achievement Award in Occupational Safety and Health. He is the author of more than 430 research reports and book chapters covering medical biochemistry, radiation biology, toxicology, and risk assessment. Dr. Rantanen holds a Ph.D. in radiation biology and medical biochemistry from the University of Turku.

ROSEMARY K. SOKAS is professor and director of environmental and occupational health sciences at the University of Illinois at Chicago School of Public Health. She previously served in the Office of the Director of the National Institute for Occupational Safety and Health as lead medical officer and associate director for science. There she led a team of senior scientists that coordinated institute policy and science, promoted the National Occupational Research Agenda, and developed institute-wide initiatives, including ones to focus on health care workers and under-served minority workers. Prior to that, Dr. Sokas directed the Office of Occupational Medicine for the Occupational Safety and Health Administration. She has previously served as professor of medicine and of health sciences at the George Washington University School of

Medicine and School of Public Health, and as assistant professor of medicine at The University of Pennsylvania. Her research areas focus on intervention effectiveness projects for high-risk and low-wage workers, including home care workers, construction workers, and immigrant workers. She is the principal investigator for the CDC-funded Illinois Public Health Research Fellowship Program, which supports a cohort of pre and post-doctoral trainees as they develop transdisciplinary research skills targeting health promotion and protection through the elimination of health disparities. Dr. Sokas earned her M.D. from Boston University and her M.O.H. and M.Sc. from the Harvard School of Public Health.

RICHARD L. TUCKER is vice-president of Tucker and Tucker Consultants, Inc., a private consulting organization related to management of large projects. Dr. Tucker's career has included three overlapping, but complementary, aspects. He has been a professor and researcher at two universities, and, in retirement, holds the Joe C. Walter, Jr. Chair Emeritus at the University of Texas at Austin. He has been an academic administrator and director of a major research center involving several hundred construction industry executives. He has also had considerable direct industry involvement as an employee, an executive, and a consultant with several of the world's largest companies and projects. He has been personally involved in developing improved construction productivity methods, industry benchmarking, and metrics. Dr. Tucker has published over 100 reports and journal articles. He is a member of the National Academy of Engineering and the National Academy of Construction. Dr. Tucker has a Ph.D. in civil engineering from the University of Texas.

JAMES J. ZUICHES is professor and extension specialist in the Department of Community and Rural Sociology at Washington State University (WSU). Dr. Zuiches has also served as the dean of the WSU College of Agricultural, Human and Natural Resource Sciences, director of the Agricultural Research Center, director of Cooperative Extension, and vice-chair and member of the Washington State Board of Natural Resources. His research specializations include demography, community and rural sociology, and research administration. He has also written on research priorities, indirect costs, distance education, and the returns on investment in research. Dr. Zuiches has received the Sustained Superior Performance Award from the National Science Foundation and is a fellow of the American Association for the Advancement of Science. He served on the National Research Council Committee on the Future of Colleges of Agriculture in the Land-Grant University System, and on the NRC Board on Agriculture and Natural Resources from 1996 until 2001. He has a Ph.D. in sociology from the University of Wisconsin in Madison.