THE NATIONAL ACADEMIES' REVIEW

THE NIOSH CONSTRUCTION SAFETY AND HEALTH RESEARCH PROGRAM July 2007

Executive Summary

Program Mission
The NIOSH Construction Program provides national and world leadership to prevent work-related illness, injury, disability, and death by systematically gathering information, conducting targeted scientific research, and translating the knowledge gained into products, solutions and services tailored to meet construction needs. In collaboration with industry and labor partners and stakeholders, we are dedicated to improving safety and health conditions for all construction workers.

Introduction
Construction workers and employers build our roads, houses, and workplaces and repair and maintain our nation's physical infrastructure. The work is done under changing conditions involving inherently hazardous tasks and circumstances such as work at height or in excavations or around heavy machinery. Construction workers have high rates of work-related injuries and deaths in comparison with other industry sectors. For example, construction experiences the largest number of fatalities of any sector and while construction represents about 8% of the American workforce, construction workers experience about 22% of fatal injuries nationwide.

Working with industry and labor partners to address safety and health issues for construction workers has been the focus of the National Institute for Occupational Safety and Health (NIOSH) Construction Program for the last 17 years. This "Evidence Package" report presents an overview of the Program and its activities, outputs, and impacts over the last decade for evaluation by the Construction Research Program Evaluation Committee assembled by the National Academies. The report has four chapters as follows:

- Chapter 1 provides an overview of NIOSH and the rationale for this program review.

- Chapter 2 presents background information on the industry, along with the history, organization, and strategic planning process of the Construction Program.

- Chapter 3 describes the main goals of the program over the last decade, organized by subgoals that describe activities, accomplishments and future plans:

  Goal 1: Reduce the major risks associated with traumatic injuries and fatalities in construction

  Goal 2: Reduce exposures to health hazards associated with major risks of occupational illness in construction

  Goal 3: Reduce the major risks associated with musculoskeletal disorders in construction

  Goal 4: Increase understanding of construction sector attributes and contributing factors for improving occupational safety and health outcomes

- Chapter 4 presents NIOSH's vision for the future of the Construction program.

Background

Construction employs about 7.4 million employees along with an additional 2.5 million self-employed workers. The total annual value of construction is approximately $1.2 trillion. About 75% of the workforce is engaged in construction work with others performing administration, professional service, and sales work. About 80% of the 710,000 total construction businesses with paid employees have fewer than 10 employees, and these firms employ 24% of all construction employees. Large establishments with 500 or more employees represent less than 0.1% of all construction firms and employ about 7% of construction employees. Important safety and health problems include:

Fatal Injuries: Construction consistently loses more workers to traumatic injury death than any other major sector – there were 1,186 deaths in 2005. The fatality rate for construction is 11.0 deaths per 100,000 workers, which is fourth highest behind agriculture, mining, and transportation. Leading causes of construction fatalities include falls, electrocutions, struck-by events, and caught in or crushed by events.

Non-Fatal Injuries and illnesses: In 2005, BLS reported that the construction industry experienced a total of 414,900 nonfatal injuries and illnesses at a rate of 6.3 per 100 full-time workers in the industry. There were 157,100 cases involving days away from work for a rate of 2.4 per 100 full-time workers. Construction rates for both measures are the second highest rates among all sectors.

Musculoskeletal Disorders: Workers' compensation claims data show that musculoskeletal disorders (especially strains and sprains) are the most common and costly work-related conditions.

Health Hazards: Lack of reliable national data limit the ability to estimate the number of chronic illnesses cases associated with construction. Recognized health hazards and associated diseases among construction workers include silicosis, lead poisoning, hearing loss, carbon monoxide poisoning, manganese poisoning, asbestosis, allergic contact dermatitis, chronic obstructive pulmonary disease, occupational asthma, and hypersensitivity pneumonitis.

Program history

The Program began in 1990 when Congress provided funding ($1 million) and authorized NIOSH to *"develop a comprehensive prevention **program** directed at health problems affecting construction workers by expanding existing NIOSH activities in areas of surveillance, research and intervention."*

The Program has developed and evolved over time in three general phases:

***Phase 1:** 1990-95: Program Creation --Focus on needs assessment and developing surveillance capacity.* This period saw rapid growth as Congress provided direction and increased funding up to $12 million. National construction conferences were held to identify safety and health needs and priorities. Congressional language and funds called for expansion of extramural and intramural research capacity, including development of surveillance data for the industry and a cooperative agreement to establish a National "Center" for construction-oriented prevention strategies. Additional epidemiology studies and fatality investigations were also initiated. Other highlights include:

- 1991: NIOSH begins work on mortality studies for each construction trade.
- 1992: NIOSH establishes construction injury and fatality goals under *Healthy People 2000*, a U.S. Department of Health and Human Services effort to develop and promote national health objectives.
- 1993: The First National Conference on Construction Safety and Health establishes industry consensus on an Agenda for Change. Four regional conferences follow to promote and disseminate the agenda.
- 1994: *First Construction Compendium* describes 51 construction projects.

- 1995: The second Conference on Construction Safety and Health is held to solidify consensus on advancing the Agenda for Change. Surveillance uncovers the rapid rise of employees hired as independent contractors

- 1995: The Construction Center publishes a series of overview articles on the construction industry and its safety and health needs in the scientific literature, and completes the first reference guide for health and safety professionals.

- 1995: NIOSH convenes an outside review of the Program, which calls for a strengthening of the internal management of the Program.

Phase 2: *1996-2004: NORA -- Focus on risk-specific intervention research, including a special focus on musculoskeletal disorders and ergonomics.* During this period the first National Occupational Research Agenda (NORA) identified 21 national priority topics, creating a stronger matrix organization within NIOSH and stronger ties between industry stakeholders and NIOSH. In response to the1995 external review, NIOSH created a Construction Steering Committee to coordinate and give additional direction to the Program. The Committee performed a gaps analysis and these findings were integrated with the NORA and early Program agenda issues to produce a set of high priority construction topics. The first cooperative agreement for a "Construction Center" was competitively awarded to the Center to Protect Workers Rights (CPWR) a research center established by the Building and Construction Trades Department of the AFL-CIO that included a consortium of academic and industry research organizations. The Construction Center established a data center to gather together existing surveillance resources related to construction and initiated applied intervention research. Other highlights include:

- 1996: The Construction Center launches development of a standardized safety and health hazard awareness training program for construction workers. A national joint labor-management committee is established to coordinate development and program implementation. The program is widely adopted by employers, unions, and joint labor-management training funds**.** By 2007 some 50,000 workers receive the training annually, and 4,000 building trades instructors have been trained and certified to deliver the program.

- 1997: The second Construction Compendium describes 45 extramural and 74 intramural projects underway.

- 1997: The first edition of *The Construction Chart Book* is published. (A second edition is published by the Construction Center in 1998 and a 3rd edition in 2003. By 2004, 18,000 copies of this report have been distributed, and it is accessible on the CPWR website. The 4th edition is scheduled for publication in the Fall 2007).

- 1998: *Healthy People 2000* is updated for 2010 and includes a new 30% national reduction goal for construction industry injury and fatality rates. These become baselines for overall program evaluation.

- 2000: The *electronic library of construction occupational safety and health* (eLCOSH) (www.elcosh.org) is launched as a joint Construction Program and Center initiative. By 2007 it is getting more than 40,000 hits a week and a large demand for its Spanish language materials.

- 2002: The third Construction Compendium describes 49 intramural and 67 extramural projects. It also lists 16 *"High Priority" Construction topics* organized into three categories and encourages new intramural and extramural projects on these topics. The topics are used in the next five year Construction Center Request for Applications.

- 2003: Surveillance identifies a surge in Hispanic employment, with some 200,000 new workers entering the industry each year, which leads to a new emphasis on interventions directed at this population.

Phase 3: *2005 to the Present – Strategic goals, Research to Practice, and NORA -- Focus on Translation and diffusion research* New government planning approaches lead NIOSH to make a transition from "priorities" to "strategic goals" that include more detailed intermediate goals and performance measures. A new initiative called R2P for "Research to Practice" is launched to focus efforts on the importance of transferring research findings and technologies into the workplace. NIOSH reviews the status of NORA after the first decade and re-orients NORA around a sector-based approach for the second decade (2006-2016). Construction is selected as one of 8 sectors under NORA. Each sector is charged with developing its own sector-specific national agenda. NIOSH also decides to have its programs independently reviewed under the auspices of the National Academies. Other highlights include:

- 2005: The NIOSH Construction Program is the second NIOSH program to develop a set of draft strategic goals. The goals include 7 outcome goals and one goal related to surveillance.

- 2006: The NIOSH Construction Program is the first of eight sectors to convene a "NORA Construction Sector Council" to begin identifying top problems to develop a national agenda for the construction industry.

Organization and Management of the Program

The structure of the Program has evolved over time since and currently consists of the following general features:

- ***A Sector Council*** to recommend strategic plans and review the progress of the program. The Council will continue to have a membership divided between NIOSH staff from all the Divisions and stakeholders from the industry and interested research communities. We envision that the Council will meet 2-3 times per year, and that its involvement with the program will increase.

- ***A Program Manager and Coordinator*** to manage the program within NIOSH. The main roles of this function will be to (1) ensure that resources dedicated for the construction program are used to address established program goals; (2) that the strategic recommendations and findings adopted by the Sector Council are implemented; (3) that the matrix organization within NIOSH functions well so that cross-sector programs contribute to Construction Program goals as appropriate and needed; and (4) that the extramural communities continue to grow and contribute to the program and are as fully engaged in the program as possible.

- ***A Program Structure*** that is organized well and positioned to respond to new developments as they emerge, consisting of three "arms":
  - ***Intramural research on*** surveillance, methods development, exposure assessment and control technology research that takes advantage of expertise across NIOSH;
  - ***National Construction Center*** operated under competitively awarded 5-year cooperative agreements to build ties to the industry and focus primarily on characterizing the industry, developing best practices through research, and disseminating findings to the industry; and
  - ***Extramural Studies*** supported through grants to harness investigator-initiated ingenuity.

Logic Model

The Program uses a Logic Model to depict the research process beginning with inputs and ending with reductions in injuries, illnesses, and disorders in construction workers. The model helps guide and describe the program. A brief review of the Logic Model components with partial listings includes the following:

Inputs: these include strategic inputs such as goals, *Healthy People 2010*, and priorities derived from stakeholder input and surveillance findings. They also include production inputs such as budget and personnel.
Activities: these include a range of surveillance, research, and intervention activities performed by researchers and staff.
Outputs: these refer to a range of products resulting from research such as peer-reviewed journal articles, NIOSH publications, CD-roms, websites, patents, worker factsheets, videos etc.
Intermediate Customers: these are individuals or entities that use our Construction Program research. They range from other researchers to:

Congress and state legislatures; federal and state occupational safety and health agencies; safety and health experts and their professional societies; trade associations and labor unions, equipment suppliers, consensus standard organizations etc. Involvement with certain professional organizations has been especially important, including the ANSI A.10 Committee on Construction and Demolition, National Safety Council Construction Committee, American Society of Safety Engineers Construction Committee, American Industrial Hygiene Association Construction Committee, and union and employer organizations. Use of our research by these groups leads to the "*Intermediate Outcomes*" that eventually reduce worker injury and illness.

Final Customers: these are construction workers, supervisors, owners, contractors and subcontractors.

End Outputs: these are the ultimate impacts of reduced exposures, injuries, fatalities, and risks among construction workers.

External factors: these are factors external to the program that influence the program at every stage but which are beyond our control. They add to the challenges of improving safety and health in construction. For example, construction worksites are by definition temporary, lasting the duration of the construction work. Employment is temporary and intermittent as well, and the worksite is usually fragmented with many different employers and trades working on a different site. Much of the work is done outside, and climatic factors play an important role. The work often involves improvisation and on-the-job problem solving. Exposures tend to be intermittent, and workers are often exposed as bystanders. Because construction is so different from other industries, it has its own OSHA standards and administrative structure.

Most construction employers are small, and lack professional safety and health expertise. They operate in a highly competitive environment driven by bidding for short-term contracts. There have been tremendous pressures to cut costs, which has resulted in many more workers being employed as independent contracts and a surge in immigrant workers, mostly from Central America. With temporary employment it is more difficult to assign responsibility for risks that result in chronic health conditions, including musculoskeletal and especially health risks. There are few incentives for employers to address such risks. These factors generally require different approaches to safety and health research than other industries. In an industry that never stands still, researchers have to learn to adapt to constantly changing situations. And because the industry is so much in flux, national data on employment, injuries and illnesses are less reliable that in other industries.

Main Program Goals

The goals listed in the evidence package represent a composite of the goals and priorities that were in place during the ten year time frame of the review. They draw from the earlier "High Priority Construction topics" combined with the more recent draft NIOSH Strategic Goals. The write-ups for each subgoal describe the activities, outputs, intermediate outcomes, relevant external factors along with

"What's ahead". Each subgoal also includes an appendix listing all outputs associated with the subgoal topic. The goals and their associated subgoals are listed below:

Goal 1: Reduce the major risks associated with traumatic injuries and fatalities in construction

1.1 Falls from elevation
1.2 Contact with electricity
1.3 Struck-by incidents involving vehicles, equipment, and tools
1.4 Confined spaces and excavations
1.5 Construction Vehicle Roll-Overs

Goal 2: Reduce exposures to health hazards associated with major risks of occupational illness in construction

2.1 Noise exposures and hearing loss
2.2 Lead exposures and various health effects
2.3 Silica exposures and silicosis
2.4 Asphalt fume exposures and various health effects
2.5 Dermal exposures and various skin disorders
2.6 Welding fume exposures and various health effects

Goal 3: Reduce the major risks associated with musculoskeletal disorders in construction

3.1 Disorders associated with awkward postures, lifting and carrying, and stressful hand-wrist conditions
3.2 Disorders associated with excessive exposure to vibration

Goal 4: Increase understanding of construction sector attributes and contributing factors for improving occupational safety and health outcomes

4.1 Use and improve surveillance resources to identify and track construction safety and health risks
4.2 Address special populations of employers and employees within construction
4.3 Optimize the role of safety and health in construction training efforts
4.4 Explore promising approaches for addressing construction hazards
4.5 Improve diffusion of safety and health research to construction practice

Program Budget

Over the last decade, the annual NIOSH Construction budget has averaged $17.8 million ranging from $20.4 million in 1997 to $13.8 million in 2007. Appropriated funding for the Program has remained flat since 1995. As a result of inflation, the funding available for the program has therefore eroded. The funding has been allocated approximately evenly between intramural and extramural components. The budget has been allocated as follows:

- Goal 1 (21%),
- Goal 2 (37%)
- Goal 3 (11%) and
- Goal 4 (18%)
- The remaining 13% related to support.

Evaluation
The evaluation of this program has been continuous and is preformed on several levels:

- ***Program Inputs***. Growth of program resources, including researchers, institutions and partners.
- ***Program Activities***. The Program will present a clear and balanced portfolio of activities that address the priorities established by the Sector Council.
- ***Outputs***. The Program will document the contribution it has made to new knowledge on all levels.
- ***Intermediate Outcomes***. The Program will develop a data base of intermediate outcomes, such as the adoption of findings or recommendations by relevant audiences or constituencies.
- ***End Outcomes***. The ultimate endpoints for the Program will be tied to the Objectives established in *Healthy People 2010,* and *Healthy People 2020* when they are developed. The NORA Construction Sector Council will likely propose additional endpoints related to Construction National Agenda goals.

Program Impact
Given the nature of a research program, it is a major challenge to directly impact prevention or to demonstrate a cause-effect relationship between our work and outcome metrics. We achieve our impact by working indirectly through and with our customers and partners. We believe that the Construction Program has made important contributions to construction industry performance since program inception in 1990.

Prior to 1990 there were few safety and health researchers specializing in construction safety and health. There is now a national cadre of researchers with interest in construction safety and health, and new programs focused on construction safety and health research are emerging at many institutions. The U.S. is now a world leader in construction research, particularly in the field of intervention application. Research outputs from the program provided an evidence-based foundation to supplement professional opinion for guidance, regulation and stakeholders practices. During the first five years of the Program, with emphasis on industry characterization and surveillance, much of the outputs came from research using existing databases. This research was disseminated to the industry primarily through national and regional conferences. Two of the

main outputs were a series of mortality studies on the various trades performed by NIOSH, and the development of task-based exposure measures.

From 1995 the emphasis has been on intervention research and this has resulted in not only a large body of published scientific research but also various types of solutions that employers and workers could adopt. These were first introduced as simple publications, but more recently, the move is towards interactive online solutions data bases. We estimate that the during the years 1996-2006, that the Construction Program has produced over 600 peer-reviewed journal articles on construction safety and health topics, and provided over 500 presentations. About a half million NIOSH publications have been distributed and over 1 million Construction Center Pocket Cards on construction hazards. The eLCOSH website currently gets an estimated 2 million hits a year. The fourth edition of the Construction Chart Book, used widely by construction stakeholders and researchers, is due out later this year. Examples of how construction stakeholders have used our research outputs to make an impact include the following:

-Program researchers, working through a partnership involving labor, management, equipment supplier, and government client groups, helped develop and independently evaluate asphalt paving vehicle controls for reducing operator exposures. The group agreed to a nationwide plan to install the resulting controls on all new highway class pavers. This type of paver accounts for about 90% of the hot mix asphalt placed annually.

-Program supported academic researchers in the state of Washington developed a website and specific worker and supervisor training materials for 11 different trades to disseminate noise and hearing protection findings from their research. The Washington Department of Labor and Industries distributes the materials to businesses within the state and a company that makes hearing protection used the construction-specific hearing protection recommendations from the study to develop a new hearing protector with a moderate noise reduction rating appropriate for certain construction uses.

-“Design for Safety” materials developed by a Construction Program researcher were customized and used by Washington Group International (WGI), a large international construction firm to deliver full-day training programs using corporate resources to more than 500 (as of spring 2007) of its engineers. WGI plans to continue this program until all 1,800 of its engineers globally have received basic design for safety training

-The success of the *Smart Mark* program initially developed through Construction Program efforts has been demonstrated through its adoption by construction project owners (Tennessee Valley Authority employing over 15,000 construction workers on a given day) and states (Connecticut, Massachusetts) and the number of construction workers (approximately

50,000/per year with over 500,000 workers trained since program inception) who are trained and certified according to the Smart Mark program. Intermediate customers associated with *Smart Mark* are construction owners and users, employers, unions, and joint labor/management training centers, among whom are 4,000-5,000 training instructors certified to teach the *Smart Mark* training program.

The Construction Program incorporated construction national injury and fatality outcome goals from program inception via development of *Healthy People 2000* benchmarks. These initial goals called for a 30% reduction in nonfatal and fatal injury rates over the decade. These goals were met and exceeded during the earlier years of the Construction Program.

The corresponding *Healthy People 2010* objectives developed for the second decade of the program again call for 30% reductions using 1998 baselines of 8.7 nonfatal injuries per 100 fulltime workers and 14.5 fatal injuries per 100,000 workers. With five years still to go (the most recent available data are from 2005), the available metrics show that the industry has continued to improve its performance and is close to meeting these goals.

-Non-fatal injuries: the injury rate by 2005 was 6.3 injuries per 100 fulltime workers, approaching the target rate of 6.1 injuries per 100 fulltime workers.

-Fatal injuries: the fatal injury rate by 2005 was 11.1 per 100,000 workers, approaching the target rate of 10.2 fatal injuries per 100,000 workers.

Thus, as of 2005 and with five years to go, somewhere between 75- 93% of the construction objectives for *Healthy People* 2010 have been achieved. While there is little question that these are positive signs of progress, and that the Construction Program has contributed to this improved safety and health performance, we do believe that a portion of the decline in the injury rate is likely due to under-reporting of injuries. This issue is discussed in more detail in the evidence package.

Judging progress on occupational illness and musculoskeletal disorders is more difficult to measure given limitations in national surveillance systems. Occupational illnesses, especially chronic illnesses, are known to be greatly underreported. The Construction Program has worked to characterize the highest exposures for important construction health hazards such as silica, lead, and noise, and to develop interventions for high exposure tasks and operations to ready these hazards for guidance and regulation to drive wider risk management.

We can point to specific examples where we believe we have contributed to reduced exposures. For example, we anticipate that our engineering control work on the asphalt partnership will contribute to reduced exposures for an estimated 300,000 asphalt paving workers once the newer equipment with

controls is completely phased in. Additionally, Program supported demonstration projects have shown that incorporating model lead specifications addressing comprehensive lead exposure precautions in construction contracts is an effective way to reliably reduce the incidence of elevated blood lead for workers de-leading and rehabilitating bridges. This has been shown in Connecticut, Michigan, and New Jersey.

Vision for the future

The Construction Program plans to build upon the solid foundation provided by the program's organization and focus. It has proven it can deliver results in spite of the many characteristics of this industry that make safety and health improvement difficult. NIOSH believes that the three-pronged approach to the organization of the Program, with NIOSH Intramural, the National Construction Center, currently awarded to CPWR, and extramural, investigator initiated research grants, is well suited for the construction sector. We propose to continue the program with this structure. There will be an open re-competition for the Construction Center in 2008, and peer review will determine its award.

We foresee many industry characteristics continuing, but anticipate changes ahead related to intensifying workforce changes regarding the influx of immigrant workers, continuing changes in work organization, and introduction of new technologies and materials such as nano-scale materials. We also anticipate that energy efficiency will be a major driver in the years ahead.

The creation of a NORA Construction Sector Council is an important development that will play an increasing role in the decade ahead. The Council is charged with identifying a "National Agenda" for construction and it has identified ten "top problems" which are currently being developed into strategic goals. Our plan is to use these NORA agenda goals combined with the findings and recommendations from this National Academies review to guide our next cooperative agreement and to further strengthen the future program and its research directions.

Research to Practice will also play an important role and we are looking to focus on several special emphasis areas such as:

- *Vulnerable populations:* We plan to intensify our efforts to reach immigrant workers, especially Hispanic workers, and the development of training and communication tools for them.
- *Small to medium sized employers*: We plan to intensify our efforts at reaching small employers by adapting best practices from high performance employers and developing new industry partnerships and applying the use of social marketing theory and methods to reach small employers.

- *Design for safety:* We will work to incorporate safety and health into the design phase and hope to accelerate this work by engaging new partners such as the architecture community and the green construction movement.

There are other developments in the industry that need to be tracked and examined. The growth of the informal part of the industry, characterized by independent contractors, needs to be understood and addressed on many levels, including national data collection, application of safety and health regulations and policy, and impact on the industry as a whole and its safety and health performance. We also need to improve the ways in which we make the business case for best safety and health practices.

Some of the future activities that are being contemplated, such as the use of social marketing, would most likely require significantly more funding than the current level.

Summary

We believe the program is well-focused, with a history of significant accomplishments and a well designed program structure to build on in the future. The program is positioned well to anticipate the needs of the future, to implement precautionary actions where needed, to continuously measure impact and to steadily improve its performance.