



**NATIONAL OCCUPATIONAL RESEARCH AGENDA (NORA)**

DRAFT PRELIMINARY PUBLIC COMMENT VERSION

**NATIONAL MANUFACTURING AGENDA**

August 18, 2009

**Developed by the NORA Manufacturing Sector Council**

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## **Introduction: Toward a National Agenda for Safety and Health in the Manufacturing Sector**

### **The Manufacturing Sector**

In 2007, over 16 million U.S. workers were employed in 21 manufacturing sub-sectors ranging from food, beverages, tobacco, and textiles to petroleum, chemical, metals, machinery, computers, transportation equipment, and furniture manufacturing. The largest sub-sectors were transportation equipment manufacturing, fabricated metal products manufacturing, and food manufacturing. Thirty per cent of the manufacturing sector workers were women and about thirty percent were minorities (15% Hispanic, 10% Black or African American, and 5% Asian).

Three hundred and ninety-three manufacturing sector workers died from work-related injuries in 2007. The leading causes of death were contact with objects and equipment (140), transportation incidents (102), and falls (48). The U.S. Bureau of Labor Statistics (BLS) reported 783,100 recordable injury or illness cases in manufacturing industries in 2007 with more than half of these requiring days away from work, job transfer or restriction. The leading causes of days away from work cases were contact with objects or equipment (70,210); overexertion and repetitive motion (52,120); and falls (26,160). There were fourteen industries that reported more than 100,000 nonfatal occupational injuries and illnesses to BLS in 2007; three of these were in the manufacturing sector: transportation equipment manufacturing (120,000), fabricated metal product manufacturing (112,800), and food manufacturing (102,000).

Although the data on occupational illnesses are limited, manufacturing had the highest numbers and rates of occupational illnesses in 2007. More than one quarter of these were hearing loss. The data on occupational illness morbidity and mortality are sparse, but we know that exposure to dusts, gases, mists, vapors, fumes, chemicals, fibers, shift work, and job strain can affect health outcomes ranging from cancer to chronic obstructive pulmonary disease to cardiovascular disease and many others. The extent of exposure and disease in manufacturing is a major gap in our knowledge due in large part to the often long latent period between exposure and the onset of disease. As a result, occupational diseases are often missed by traditional occupational health surveillance systems. This provides verification for the importance and relevancy of a national research agenda in partnership with the manufacturing stakeholders.

### **NIOSH Program Portfolio**

NIOSH conducts a range of efforts in the area of research, guidance, information, and service. To better coordinate these efforts, NIOSH is organizing our portfolio into various specific programmatic categories that can be readily communicated, strategically governed and evaluated. The NIOSH Program Portfolio focuses on relevance, quality and impact. This is achieved through strong involvement of partners and stakeholders throughout the entire research continuum (conceiving, planning, conducting, translating, disseminating and evaluating research). NIOSH programmatic and support structures provide a foundation for NIOSH staff to carry out its mission to provide national and world leadership to prevent work-related illnesses and injuries.

The NIOSH Program Portfolio has been organized into 8 NORA Sector Programs representing industrial sectors, and 24 cross-sector programs organized around adverse health outcomes, statutory programs and global efforts.

NIOSH has assigned Managers, Coordinators, and Assistant Coordinators to each of the Program Portfolio categories. NORA Sector Councils develop sector-based goals for the nation. A NIOSH Steering Committee has been formed for each NIOSH Sector and Cross-Sector Program to consider NORA priorities and other inputs and to establish output and outcome goals and a timeline for assessing performance.

### **The NORA Process**

The National Occupational Research Agenda (NORA) is a partnership program to stimulate innovative research and improved workplace practices. Unveiled in 1996, NORA has become a research framework for NIOSH and the nation. Diverse parties collaborate to identify the most critical issues in workplace safety and health. Partners work together to develop goals and objectives for addressing these needs. NORA is setting goals for the nation and utilizing partnerships extensively to carry out its work.

### **Stakeholder Input**

During 2005 and 2006, NIOSH and its partners held thirteen Town Hall Meetings in twelve different states and Puerto Rico seeking public input on the future of occupational safety and health research, as the first decade of NORA was ending. Over 1000 Stakeholders participated by attending the meetings and remotely via the NIOSH web site. Approximately 500 workers, employers, organized labor, professional associations, and academics provided feedback regarding important research needs. Several participants in the Town Hall meetings made comments specific to manufacturing sector issues. Some of the priority needs identified included intervention-effectiveness research including evaluation of training effectiveness; exposure monitoring research; a range of research and development efforts specific to nanomaterials including exposure assessment, appropriate use of personal protective technologies, and exposure limits; research on the prevention of musculoskeletal disorders including back injuries; research on the role of the organization of work on occupational safety and health outcomes; basic and applied research on noise and noise-induced hearing loss; chemical process safety; management systems; safety culture; outreach to and development of tools for small businesses; improved surveillance data; development of business cases and return on investment data; research on specific exposures including radon and non-ionizing radiation; and, research on various groups of potentially vulnerable workers including contract workers, young workers, older workers, and immigrant workers.

### **The NORA Manufacturing Sector Council**

Like the other NORA Sector Councils, the NORA Manufacturing Sector Council was charged with (1) developing and maintaining a sector-specific national occupational safety and health agenda and (2) to maximize the impact of occupational safety and health research through partnerships to promote widespread adoption of improved workplace safety and health practices based on research findings. Thus, the Council has

the dual role of establishing a national agenda, and also, fostering partnerships to improve the practice of occupational safety and health.

**Framework for Strategic Planning**

The process of conducting occupational safety and health research and prevention activities to ultimately improve the safety and health of workers can be arrayed as a logic model. A logic model includes the resources/inputs into a program, the program’s research activities, the outputs resulting from those activities, the actions that are taken by customers and stakeholders to disseminate and implement knowledge (research to practice), and finally the achievement of the end outcomes, the changes in work-related injuries, illnesses, hazardous exposures, and fatalities. Figure one below shows the core of a logic model for occupational safety and health research. In crafting a national occupational research agenda or strategic plan, it is useful to visualize how various levels of goals align with such a logic model. As shown in Figure 1, strategic goals align with end outcomes and are ideally directed at reducing occupational injuries, illnesses, hazardous exposures and fatalities. Intermediate goals align with the customer activities (stakeholders and partners) and outputs section of the logic model and focus on the efforts taken by various groups and entities to transform the knowledge and products generated by a program into practical application. Activity and Output goals align with those portions of the logic model that focus on the specific research and development activities to be undertaken as well as the products that result from those efforts. Specific examples of each step in the logic model include, but are not limited to:

**Inputs:** Budget, staff, facilities, stakeholder input, surveillance and other data;

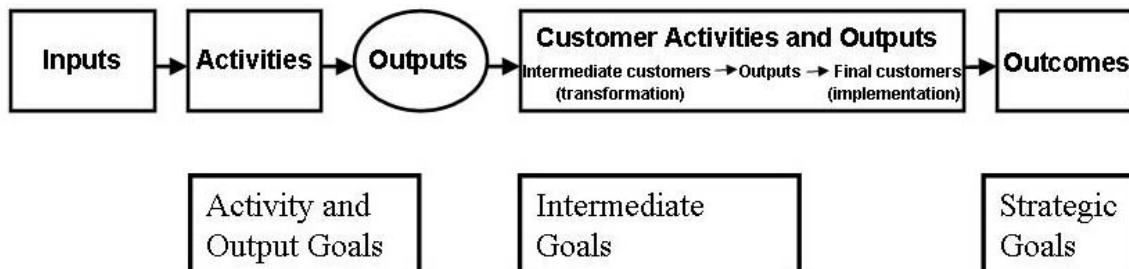
**Activities:** Surveillance, epidemiologic research, exposure assessment research, industrial hygiene sampling, methods development and control technology development

**Outputs:** Recommendations, publications, workshops/conferences, tools, methods;

**Customer Activities and Outputs/Intermediate Outcomes:** Training programs, engineering controls, consensus standards, regulations, trade and major media releases, and

**End Outcomes:** Reductions in work-related injuries, illnesses, hazardous exposures and fatalities.

*Figure 1. Logic Model of Occupational Safety and Health Research and Prevention and Related Framework for Strategic Planning*



**Stakeholders/Partners/Customers**

- Employees
- Employers
- Government and Non-Government Agencies
- Insurers
- Manufacturers
- Mass and Social Media
- Professional Associations
- Regulators
- Researchers
- Trade Associations
- Treatment Providers
- Worker Groups

**Developing a National Agenda**

Based on the available surveillance data, the expert input and judgment of Council members, and input from participants in NORA Town Hall meetings, the following strategic, intermediate and activity/output goals are proposed as a framework for improving occupational safety and health in the manufacturing sector. The goals are not presented in any particular or prioritized order. The numbering conventions are used only to facilitate the tracking of comments and implementation efforts.

We recognize that there are important occupational safety and health issues that are not reflected in the current draft and welcome input on whether and how to address them in future iterations of a National Manufacturing Agenda. Although motor vehicle transport incidents are the second leading cause of occupational injury and death in manufacturing, the Council has, to date, opted not to include a specific goal (or set of goals) addressing this issue, because, it is felt that the risk factors and related prevention strategies are not unique to manufacturing and may be better addressed through other mechanisms such as the strategic goals for the Transportation, Warehousing and Utilities Sector and the Wholesale, Retail and Trade Sector. Additionally, safety and health concerns related to dermal exposures in the workplace, exposures to potential reproductive and chronic disease hazards, and the impact of shift work, management culture and other organizational factors are within the domain of the Cross Sectors. As is the case in all NORA sectors, the NORA Manufacturing Sector Council has struggled with how to be

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strategic in identifying compelling issues to be addressed in the next five to ten years while also recognizing the broad array of hazards that workers may face in the sector.

### **Next Steps**

The NORA Manufacturing Sector Council is committed to refining the National Manufacturing Agenda based on input from employers, workers and their representatives, professional associations, academics, other government agencies, and any other stakeholders with an interest in improving safety and health in the manufacturing sector. As the National Agenda is finalized, the focus will turn to implementation. Partners are critical to conducting new research, assessing the state of the field, and for communicating findings to those in a position to make positive changes in the workplace. NIOSH is working to develop an inventory of databases containing information relevant to various types of occupational safety and health research to serve as a resource for all of the NORA sectors.

### **Participate**

The NORA Manufacturing Council is interested in your suggestions for improving this strategic plan for the nation. Please submit comments to the NIOSH Docket referencing docket number NIOSH-184. Comments can be sent by email ([nioshdocket@cdc.gov](mailto:nioshdocket@cdc.gov)) or fax (513-533-8285) or by mailing them to:

NIOSH Docket Office  
NIOSH Mailstop C-34  
Robert A Taft Lab.  
4676 Columbia Parkway  
Cincinnati, OH 45226

General comments about the occupational safety and health issues in the manufacturing sector and inquiries about opportunities to participate in NORA partnerships can be sent to [NORAcordinator@cdc.gov](mailto:NORAcordinator@cdc.gov).

**Strategic Goal 1:** Reduce the number of injuries and fatalities due to contact with objects and equipment among workers in the manufacturing sector.

**Intermediate Goal 1.1:** Use intramural and extramural findings and other scientific research to compile a database and disseminate relevant information to workers and employers.

**Activity/Output Goal 1.1.1:** Compile and analyze existing data and available literature on the range of machine-related fatal and nonfatal injury incidents in manufacturing to assess the state of knowledge and identify important research gaps.

**Activity/Output Goal 1.1.2:** Gather detailed data on machines used in manufacturing with particular emphasis on potential hazards during set up and adjustment, maintenance and repair, as well as normal operation. The complexity of lockout/tag out procedures and the range of potential injury hazards such as caught in or compressed in running machinery and being struck by falling or flying objects related to the operation of the machinery should also be included.

**Activity/Output Goal 1.1.3:** Gather detailed data on injuries to workers in the manufacturing sector due to contact with objects and equipment with particular emphasis on machine-related hazards, worker demographics, experience and training, as well as specifics on the task at the time of injury.

**Intermediate Goal 1.2:** Develop and improve manufacturing equipment and training programs for workers and managers to reduce injuries and fatalities due to contact with objects and equipment among workers in the manufacturing sector.

**Activity/Output Goal 1.2.1:** Based on detailed data on machines and injuries in the manufacturing sector, develop and evaluate interventions based on improved machine designs to reduce injuries and fatalities due to contact with machines and equipment as well as from machine-related falling or flying objects.

**Activity/Output Goal 1.2.2:** Based on detailed data on machines and injuries in the manufacturing sector, develop design guidelines and risk assessment tools for the evaluation of equipment with emphasis on adaptability to small business.

**Activity/Output Goal 1.2.3:** Determine best practices for the communication of machine-related and other hazards/warnings with attention to the language, culture, and literacy of workers.

**Activity/Output Goal 1.2.4:** Review and evaluate standards for machine safety from other countries and the U.S. to determine the most effective approaches to ensuring operator safety.

**Intermediate Goal 1.3:** Adopt design recommendations for reducing worker injuries and fatalities that occur while operating equipment and/or machinery.

**Activity/Output Goal 1.3.1:** Partner with standards committees to help make existing user guidelines available free of charge.

**Activity/Output Goal 1.3.2:** Develop injury surveillance tools for use by employers, workers, and labor organizations and disseminate broadly.

**Activity/Output Goal 1.3.3:** Disseminate design guidelines and machinery risk assessment tools through partnerships with trade associations, employers, labor unions, and others.

**Activity/Output Goal 1.3.4:** Disseminate best practices guidelines and programs through partnerships with trade associations, employers, labor unions, and others.

**Activity/Output Goal 1.3.5:** Use surveillance, epidemiologic, and etiologic data to identify and track hazards in the workplace and adopt proven intervention strategies.

**Strategic Goal 2:** Reduce the number of injuries and fatalities resulting from falls among workers in the manufacturing sector.

**Intermediate Goal 2.1:** Disseminate materials and implement activities that move research into practice to prevent falls from elevations among workers in the manufacturing sector.

**Activity/Output Goal 2.1.1:** Improve surveillance and conduct epidemiologic studies in the area of occupational injuries and fatalities due to falls from elevations including the assessment of differences in falls associated with maintenance and repair modes as opposed to new construction.

**Activity/Output Goal 2.1.2:** Develop and evaluate interventions designed to reduce injuries and fatalities associated with the use of portable and fixed ladders.

Goal 2.1.2.1 Inventory existing research, regulations, guidance, and practitioner materials on ladder safety, and identify key gaps in current knowledge and practices on work injury prevention that needs to be addressed.

Goal 2.1.2.2 Use communication science and best practices to develop model materials on hazard awareness and safe practices, concerning falls from ladders including business case/worker case issues in multiple languages and media.

Goal 2.1.2.3 Form partnerships with equipment manufacturers, insurance companies, professional associations, and manufacturing stakeholders to disseminate materials on ladder safety.

**Activity/Output Goal 2.1.3:** Develop recommendations for the application and use of personal fall protection devices.

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Goal 2.1.3.1 Develop and evaluate engineering solutions and guidelines which address gaps in current knowledge and practices on attachment technology for fall protection devices.

Goal 2.1.3.2 Disseminate these solutions and guidelines throughout manufacturing and other sectors.

**Activity/Output Goal 2.1.4:** Compile available research and best industry practices on managing work teams which frequently work unobserved.

**Activity/Output Goal 2.1.5:** Strengthen the current knowledge base and risk assessment techniques on exposure factors which contribute to falls.

**Intermediate Goal 2.2:** Disseminate materials and implement activities that move research into practice to prevent falls on the same level among workers in the manufacturing sector.

**Activity/Output Goal 2.2.1:** Conduct surveillance and research to determine key factors, such as friction coefficients, levelness of floors, and transition from one flooring surface to another which contribute to falls on the same level.

Goal 2.2.1.1 Develop and evaluate engineering interventions and guidelines to address current gaps in accident prevention/protection strategies for falls on the same level.

Goal 2.2.1.2 Disseminate these solutions and guidelines throughout the industry.

**Activity/Output Goal 2.2.2:** Conduct research to assess the impact of environmental factors such as lighting and housekeeping on falls.

Goal 2.2.2.1 Develop and evaluate engineering interventions and guidelines to address the impact of environment factors on falls.

Goal 2.2.2.2 Disseminate these solutions and guidelines throughout the industry

**Intermediate Goal 2.3:** Use intramural and extramural findings generated as outcomes from this strategic goal as well as other scientific research to compile and disseminate a searchable database with the relevant information on the occurrence, causes and interventions for the prevention of falls.

**Activity/Output Goal 2.3.1:** Conduct research on fall prevention.

**Strategic Goal 3:** Reduce the number and severity of musculoskeletal disorders (MSDs) among manufacturing sector workers.

**Intermediate Goal 3.1:** Apply NIOSH intramural and extramural research and other scientific research findings and activities to reduce the number and severity of musculoskeletal disorders among manufacturing sector workers.

**Activity/Output Goal 3.1.1:** Identify important research gaps by compiling and evaluating existing data and available literature on overexertion and repetitive motion injuries in manufacturing to assess the state of knowledge including the extent of missing and mis-classified data in existing systems.

**Activity/Output Goal 3.1.2:** Develop innovative strategies to collect data to address identified research gaps, such as the severity of MSDs using economic measures, lost work days, and signs and symptoms (e.g., number of body sites affected, severity of pain/discomfort, or weakness) or additional sources of data that have not previously been used to describe work-related MSDs.

**Activity/Output Goal 3.1.3:** Prioritize specific musculoskeletal disorders and sub-sectors within manufacturing for targeted prevention efforts based on the review of data and literature.

**Activity/Output Goal 3.1.4:** Evaluate existing ergonomic standards and best practices to identify areas where additional evidence-based research is needed to improve recommendations for prevention.

**Activity/Output Goal 3.1.5:** Conduct etiologic research to determine the contribution of biomechanical, work organization, psychosocial, and personal risk factors in the development of low back and upper limb-related MSDs.

**Intermediate Goal 3.2:** Provide intervention tools and engineering controls to reduce the number and severity of musculoskeletal disorders among sector workers.

**Activity/Output Goal 3.2.1:** Assess available “best practices” and other existing interventions to more clearly identify how they have been implemented in manufacturing workplaces and their efficacy.

**Activity/Output Goal 3.2.2:** Develop cost-effective engineering controls to reduce exposures to job-related factors associated with the development of low back and upper-limb related MSDs.

**Activity/Output Goal 3.2.3:** Evaluate interventions designed to reduce low back and upper limb MSDs in manufacturing settings. Interventions should include work organization factors, individual job tasks, and personal risk factors. Include both large plants and small businesses in both process and outcome evaluations.

**Activity/Output Goal 3.2.4:** Evaluate occupational safety and health workplace programs for return to work after MSDs with particular emphasis on company culture and ability of programs to minimize worker pain, discomfort, and re-injury.

**Activity/Output Goal 3.2.5:** Develop new tools for assessing ergonomic hazards during specific manufacturing tasks.

**Activity/Output Goal 3.2.6:** Develop methods for validating new and existing ergonomic assessment tools specific to manufacturing tasks.

**Activity/Output Goal 3.2.7:** Conduct laboratory research to characterize the exposure/response relationships between specific biomechanical factors (e.g., repetitive motion, stress, strain, torsion, compression, and posture) with tissue injury, biomarkers of injury, altered physiological responses, adaptation, and disease.

**Intermediate Goal 3.3:** Implement activities that move research into practice to prevent musculoskeletal disorders among manufacturing sector workers.

**Activity/Output Goal 3.3.1:** Develop business cases for adopting interventions to reduce MSDs by partnering with employers, workers, and worker representatives in targeted sub-sectors within manufacturing.

**Activity/Output Goal 3.3.2:** Develop communication materials specific to the risk factors and potential prevention strategies for MSDs in manufacturing and disseminate through multiple channels including employers, labor organizations, and small business groups.

**Strategic Goal 4:** Reduce the incidence of occupationally-induced hearing loss in the manufacturing sector.

**Intermediate Goal 4.1:** Implement surveillance activities to identify and reduce sources of noise exposures, conduct longitudinal analyses of hearing outcomes, implement hearing protection usage guidance, and utilize proven effective engineering noise control solutions.

**Activity/Output Goal 4.1.1:** Identify and inventory sources of exposure resulting in risk of hearing loss to manufacturing sector workers, including ototoxicants.

**Activity/Output Goal 4.1.2:** Assess the scope of occupational hearing loss in manufacturing through analysis of existing hearing databases.

**Activity/Output Goal 4.1.3:** Develop selection and usage surveillance data on hearing protection devices in manufacturing.

**Activity/Output Goal 4.1.4:** Identify and publicize proven effective noise control measures in manufacturing.

**Intermediate Goal 4.2:** Implement research and development activities for identifying effective noise controls, educational outreach, economic cost benefit examples, and quiet-by-design activities for controlling exposure through reducing the noise at the source.

**Activity/Output Goal 4.2.1:** Develop new cost effective engineering controls to reduce source noise in workplaces, including quiet by design projects (e.g., metal fabrication, stamping press operations, vibrating conveyor systems, etc.).

**Activity/Output Goal 4.2.2:** Develop worker and employer education materials specific to the use of engineering controls to reduce noise exposure in workplaces.

**Activity/Output Goal 4.2.3:** Partner with manufacturers and develop business cases to implement use of engineering controls that reduce source noise.

**Activity/Output Goal 4.2.4:** Develop, post, and publicize generic sound emission purchasing specification to assist in quiet-by-design initiatives.

**Intermediate Goal 4.3:** Implement research and development activities for personal hearing protection devices, effective means of fit-testing protectors, guidance, and educational materials for use of hearing protection in the workplace.

**Activity/Output Goal 4.3.1:** Develop, assess, and promote effective fit-testing systems for personal hearing protection devices in manufacturing settings.

**Activity/Output Goal 4.3.2:** Conduct research on the performance and utilization of hearing protection devices in manufacturing, including barriers to effective use.

**Activity/Output Goal 4.3.3:** Develop worker and employer education materials regarding the selection and use of hearing protection devices in manufacturing workplaces.

**Intermediate Goal 4.4:** Implement research activities to identify hearing loss risk factors for impulsive noise in manufacturing.

**Activity/Output Goal 4.4.1:** Conduct epidemiological research to identify hearing loss risk factors specific to impulsive noise in manufacturing.

**Intermediate Goal 4.5:** Implement research activities to identify hearing loss risk factors for ototoxicants in manufacturing.

**Activity/Output Goal 4.5.1:** Conduct epidemiological research on ototoxicants in manufacturing.

**Activity/Output Goal 4.5.2:** Conduct research on identified and suspected ototoxicants found in manufacturing settings.

**Intermediate Goal 4.6:** Implement research activities to develop metrics of intervention effectiveness for hearing loss to validate consensus standards, and to publicize or assess the effectiveness of hearing conservation programs.

**Activity/Output Goal 4.6.1:** Evaluate existing standards (e.g., EU, ISO, ANSI) to determine if research is needed to validate or improve the standards.

**Activity/Output Goal 4.6.2:** Conduct research to evaluate the effectiveness of interventions (e.g., engineering controls, Personal Protective Equipment (PPDs) and educational materials) in reducing occupational-induced hearing loss.

**Activity/Output Goal 4.6.3:** Develop and publicize assessment tools and methodologies to measure hearing conservation program effectiveness.

**Strategic Goal 5:** Reduce the number of respiratory conditions and diseases due to exposures in the manufacturing sector.

**Intermediate goal 5.1:** Use surveillance, epidemiologic, and etiologic data to identify and track hazards for airways diseases in the workplace.

**Activity/Output Goal 5.1.1:** Conduct surveillance and epidemiologic studies to assess the extent, severity, and burden of work-related airways diseases among workers in the manufacturing sector (including the full range of food production industries potentially at risk for flavorings-related lung disease). Potential sources of data include traditional occupational health surveillance data as well as other sources such as personal health insurance databases.

**Activity/Output Goal 5.1.2:** Conduct etiologic research including laboratory and toxicological research on suspected hazards for work-related airways diseases.

**Activity/Output Goal 5.1.3:** Conduct toxicology research, including inhalation studies, to better characterize the toxic potential and mechanisms of toxicity of known and suspected hazards for work-related airways diseases (e.g., diacetyl and other potentially harmful artificial flavorings).

**Intermediate goal 5.2:** Disseminate information about known and suspected hazards for work-related airways diseases to workers and employers.

**Activity/Output Goal 5.2.1:** Develop and apply methods to identify where exposures that may result in work-related airways diseases occur in primary manufacturing settings as well as to downstream users.

**Activity/Output Goal 5.2.2:** Develop and improve sampling and analytical methods for assessing exposure to hazards for work-related airways diseases (e.g., diacetyl and other artificial flavorings).

**Intermediate goal 5.3:** Adopt effective intervention strategies to prevent workers from developing work-related airways diseases.

**Activity/Output Goal 5.3.1:** Develop new interventions, evaluate existing and new interventions, and disseminate information on effective interventions for reducing exposures that may result in work-related interstitial lung diseases.

**Activity/Output Goal 5.3.2:** Conduct research to identify and refine strategies that improve industry-wide adoption of interventions to prevent work-related airways diseases.

**Activity/Output Goal 5.3.3:** Develop and apply methods to identify where exposures that may result in work-related airways diseases occur in primary manufacturing settings as well as to downstream users.

**Activity/Output Goal 5.3.4:** Develop and disseminate best practice recommendations for reducing worker exposure to hazards for work-related airways diseases (e.g., diacetyl).

**Intermediate Goal 5.4:** Use surveillance, epidemiologic, and etiologic data to identify and track hazards for work-related interstitial lung diseases in the workplace.

**Activity/Output Goal 5.4.1:** Conduct surveillance, epidemiologic studies, and field studies to assess the extent, severity, and burden of work-related interstitial lung diseases among workers in the manufacturing sector. Potential sources of data include traditional occupational health surveillance data as well as other sources, such as personal health insurance databases.

**Activity/Output Goal 5.4.2:** Conduct etiologic research, including laboratory and toxicologic studies, on suspected hazards for work-related interstitial lung diseases.

**Activity/Output Goal 5.4.3:** Conduct epidemiologic and laboratory studies to elucidate mechanisms of work-related interstitial lung diseases (e.g., beryllium-induced disease), including studies that clarify the roles of genetic susceptibility and gene-environment interactions.

**Intermediate Goal 5.5:** Disseminate information about known and suspected hazards for work-related interstitial lung diseases to workers and employers.

**Activity/Output Goal 5.5.1:** Develop and apply methods to identify where exposures that may result in work-related interstitial lung diseases occur in primary manufacturing settings as well as in downstream users.

**Activity/Output Goal 5.5.2:** Develop, refine, and validate improved methods for assessing exposure to hazards for work-related interstitial lung diseases (e.g., beryllium).

**Intermediate Goal 5.6:** Adopt effective intervention strategies to prevent workers from developing work-related interstitial lung diseases.

**Activity/Output Goal 5.6.1:** Develop new interventions, evaluate existing and new interventions, and disseminate information on effective interventions for reducing exposures that may result in work-related interstitial lung diseases.

**Activity/Output Goal 5.6.2:** Conduct research to identify existing strategies or conduct research to develop effective dissemination strategies that improve industry-wide adoption of effective interventions for preventing work-related interstitial lung diseases.

**Strategic Goal 6:** Reduce the incidence and prevalence of cancer due to exposures in the manufacturing sector.

**Intermediate Goal 6.1:** Identify and track populations at the greatest risk of being exposed to known and suspected workplace carcinogens. Develop educational materials for the workforce.

**Activity/Output Goal 6.1.1:** Improve cancer surveillance methods to better understand and track cancer as a disease with emphasis on identification of subsectors at risk for occupational exposures. Identify protective factors related to prevalence of cancer outcomes among manufacturing workers. Evaluate trends in hazardous exposures and the demographic distribution of cancer in the manufacturing sector.

**Activity/Output Goal 6.1.2:** Conduct and promote exposure assessment and hazard evaluations of known and suspected carcinogens in manufacturing settings.

**Activity/Output Goal 6.1.3:** Develop a methodology to investigate cancer clusters. Develop educational materials documenting cases, explaining exposures, latency and the nature of each form of cancer for workers.

**Intermediate Goal 6.2:** Adopt proven strategies and interventions for reducing hazardous exposures and disseminate educational materials regarding potential carcinogenic risk factors.

**Activity/Output Goal 6.2.1:** Develop and evaluate interventions designed to reduce the incidence of cancer in the manufacturing sector.

**Activity/Output Goal 6.2.2:** Develop strategies to reduce exposure to identified and suspected carcinogenic agents.

**Activity/Output Goal 6.2.3:** Develop and disseminate educational materials regarding risk factors and prevention strategies related to cancer in manufacturing settings.

**Intermediate Goal 6.3:** Use etiologic and mechanistic based research to improve standards that protect workers from exposures to known or potential carcinogens.

**Activity/Output Goal 6.3.1:** Conduct and promote etiologic research on cancer in the manufacturing sector.

**Activity/Output Goal 6.3.2:** Identify mechanisms to improve risk assessment for occupational cancer in the manufacturing sector.

**Activity/Output Goal 6.3.3:** Conduct research to identify the impact of genetic and other individual-based factors and identify biomarkers of susceptibility in cancer.

**Intermediate Goal 6.4:** Participate in collaborations and partnerships to promote the inclusion of new and suspected carcinogens into already existing databases to identify gaps and important emerging issues for sub-sectors.

**Activity/Output Goal 6.4.1:** Pursue partnerships with national and international agencies and other organizations to explore sources of data for new and suspected carcinogens.

**Activity/Output Goal 6.4.2:** Improve partnerships with state and local health departments and agencies to improve and promote data sharing for statistical analysis or inclusion in etiologic or surveillance research.

**Strategic Goal 7:** Reduce the incidence of injuries, illnesses, and fatalities among understudied and vulnerable populations in the manufacturing sector such as contract workers, younger and older workers, immigrants, and pregnant and nursing workers.

**Intermediate Goal 7.1:** Use research findings on data collection barriers involving understudied and vulnerable populations to refine data elements and methods and for collecting injury and illness data on these populations.

**Activity/Output Goal 7.1.1:** Develop surveillance measures to better understand occupational exposures and risk and protective factors for injuries, illnesses, and hazardous exposures among vulnerable and understudied populations.

**Activity/Output Goal 7.1.2:** Identify understudied populations not included in existing research and make recommendations for including them in future work.

**Activity/Output Goal 7.1.3:** Identify and understand barriers to collecting data on injuries and illnesses in vulnerable and understudied populations.

**Intermediate Goal 7.2:** Develop guidelines, recommendations, and standards to protect younger and older workers' safety and health, taking age related susceptibility factors into account.

**Activity/Output Goal 7.2.1:** Identify sub-sectors within manufacturing that employ younger and older workers and their related occupational injury and illness risks.

**Activity/Output Goal 7.2.2:** Identify and understand the physiologic and developmental impact of exposure and mechanisms of susceptibility among young workers.

**Activity/Output Goal 7.2.3:** Identify and understand the impact of exposure and mechanisms of susceptibility among older workers.

**Activity/Output Goal 7.2.4:** Understand mechanisms of interaction between hazardous workplace exposures and medication use among older workers.

**Intermediate Goal 7.3:** Develop interventions that reduce organizational instability among contract workers.

**Activity/Output Goal 7.3.1:** Identify sub-sectors within manufacturing that employ contract workers and their related occupational injury and illness risks.

**Activity/Output Goal 7.3.2:** Identify and understand the impact of organizational instability on the safety and health, including psychosocial outcomes, of contract workers.

**Activity/Output Goal 7.3.3:** Investigate approaches to work with employers to extend safety and health protections to contract workers comparable to those offered to regular employees.

**Intermediate Goal 7.4:** Develop culturally-appropriate interventions to protect the safety and health of immigrant workers.

**Activity/Output Goal 7.4.1:** Identify sub-sectors within manufacturing that employ immigrant workers and the related occupational injury and illness risks.

**Activity/Output Goal 7.4.2:** Identify and develop best practices to prevent injuries, illnesses, and hazardous exposures in manufacturing sub-sectors that employ significant numbers of immigrant workers.

**Activity/Output Goal 7.4.3:** Translate existing knowledge regarding occupational safety and health issues in manufacturing to be language and culturally appropriate to the relevant workforce(s) by sub-sector.

**Activity/Output Goal 7.4.4:** Develop approaches through partnerships with large and small businesses and community advocates to protect immigrant workers in manufacturing.

**Intermediate Goal 7.5:** Reduce pre-conception, gestational, and nursing exposures to reproductive toxicants.

**Activity/Output Goal 7.5.1:** Identify sub-sectors within manufacturing that employ women of child bearing age (e.g., pregnant and nursing workers) and their related occupational injury and illness risks.

**Activity/Output Goal 7.5.2:** Identify and develop best practices, including alternative duty considerations, to prevent injuries, illnesses, and hazardous exposures to women of child bearing age (e.g., pregnant and nursing workers).

**Activity/Output Goal 7.5.3:** Identify and understand the physical, chemical, ergonomic, and work organization (e.g., shift work) exposures that increase the risk of illness and injury among women of child bearing age (e.g., pregnant and nursing workers).

**Activity/Output Goal 7.5.4:** Identify and understand mechanisms of susceptibility, such as transplacental transfer or breast milk transference of chemicals, on the risk of illness for pregnant workers and their offspring.

**Activity/Output Goal 7.5.5:** Identify sub-sectors within manufacturing where there are potential pre-conception exposures to reproductive toxicants.

**Strategic Goal 8:** Reduce the incidence of injuries, illnesses, and fatalities within small businesses (fewer than 100 employees) and specific sub-sectors within the manufacturing sector.

**Intermediate Goal 8.1:** Identify and prioritize occupational safety and health issues within small businesses and specific sub-sectors within the manufacturing sector.

**Activity/Output Goal 8.1.1:** Collect, compile, and analyze data and available literature to identify sub-sectors with high risk of injuries/illnesses and fatalities.

**Activity/Output Goal 8.1.2:** Identify barriers to interventions in high-risk sub-sectors.

**Activity/Output Goal 8.1.3:** Understand job-related factors that contribute to injury risk in high-risk sub-sectors.

**Intermediate Goal 8.2:** Collaborate in the development of tools and interventions to aid small businesses in identifying and controlling hazards.

**Activity/Output Goal 8.2.1:** Develop new tools, resources, and documents to help small manufacturing businesses recognize and control hazards.

**Activity/Output Goal 8.2.2:** Identify, disseminate, and promote the use of guidance documents and other resources with emphasis on company culture to assist small manufacturing businesses in assessing and prioritizing interventions in a cost-effective manner.

**Activity/Output Goal 8.2.3:** Work with standard setting organizations to develop standards scaled appropriately for small businesses that include health and safety considerations for procedures, methods, and equipment.

**Intermediate Goal 8.3:** Develop materials to disseminate interventions and research results on controls to small businesses.

**Activity/Output Goal 8.3.1:** Develop or improve intervention programs and practices to reach small businesses.

**Activity/Output Goal 8.3.2:** Evaluate programs to better understand best work practices in small businesses including company culture, job demand, control, management training, resources, etc.

**Activity/Output Goal 8.3.3:** Identify barriers and ways to overcome barriers to implementation of best practices in small businesses.

**Intermediate Goal 8.4:** Identify the needs, conduct outreach, and assist small businesses and sub-sectors.

**Activity/Output Goal 8.4.1:** Develop and evaluate outreach programs to small businesses.

**Activity/Output Goal 8.4.2:** Identify non-governmental organizations, trade groups or other organizations such as insurance carriers, State agencies, and Chambers of Commerce, that can serve as communications pathways to small businesses. (Coordinate with the NIOSH Small Business Assistance and Outreach Program).

**Activity/Output Goal 8.4.3:** Pursue and foster strategic partnerships to identify sub-sectors of small businesses with high injury and illness rates.

**Activity/Output Goal 8.4.4:** Conduct outreach through the assigned risk pool businesses as administered by the states.

**Activity/Output Goal 8.4.5:** Pursue and foster partnerships with other agencies, such as the Manufacturing Extension Partnership program of the National Institute of Standards and Technology (NIST), leading to improvements in occupational safety and health in small businesses.

**Strategic Goal 9:** Enhance the state of knowledge related to emerging risks to occupational safety and health in manufacturing.

**Intermediate Goal 9.1:** Utilize the NIOSH HHE program, REACH, EPA's HPV program, other sources of data, and innovative methods to collect and analyze data to identify, investigate, and track emerging risks – agents, processes, new technologies-associated health risks, potential hazards in the manufacturing sector, and new diseases in

the manufacturing sector. Develop methods to communicate best practices and lessons learned.

**Activity/Output Goal 9.1.1:** Utilize the NIOSH Health Hazard Evaluation (HHE) program and other innovative methods to identify new agents, processes, or technologies that may pose hazards to occupational safety or health in the manufacturing sector.

**Activity/Output Goal 9.1.2:** Explore new sources of data and innovative methods for analyzing existing data to identify emerging occupational safety and health risks in manufacturing by specific sub-sector and occupation.

**Activity/Output Goal 9.1.3:** Monitor new agents, processes, and technologies introduced in the manufacturing sector to identify potential hazards and to prioritize issues to be further investigated.

**Activity/Output Goal 9.1.4:** Investigate the risks associated with human interaction with complex machinery systems with robotic controls.

**Activity/Output Goal 9.1.5:** Develop an innovative communication method (e.g., a moderated blog, a web-based diary, etc.) to capture dialogue around emerging science and policy issues regarding safety and health topics in the manufacturing sector.

**Activity/Output Goal 9.1.6:** Identify manufacturing settings of sufficient size and exposure to permit etiologic studies of agents, processes, or technologies that may be linked to adverse health outcomes.

**Intermediate Goal 9.2:** Conduct surveillance and develop exposure assessment methods, engineering controls, containment systems, and other interventions for occupational risks, protective factors, and outcomes as a result of exposure to nanoparticles and nanomaterials.

**Activity/Output Goal 9.2.1:** Determine if nanoparticles and nanomaterials pose risks for work-related injuries and illnesses, including research on exposure (including exposure assessment research and development), dose, and toxicity in manufacturing workplaces.

**Activity/Output Goal 9.2.2:** Develop and evaluate interventions for reducing occupational exposures to nanoparticles.

**Strategic Goal 10:** Reduce the number of catastrophic incidents (e.g., explosions, chemical accidents, or building structural failures) in the manufacturing sector.

**Intermediate Goal 10.1:** Disseminate and implement the surveillance findings to eliminate and prevent catastrophic incidents.

**Activity/Output Goal 10.1.1:** Define catastrophic incident, conduct surveillance, and collect data on catastrophic incidents in the manufacturing sector, including specifics on regulatory coverage.

**Intermediate Goal 10.2:** Implement available practices, policies, and interventions to prevent explosions and structural failures.

**Activity/Output Goal 10.2.1:** Develop (if necessary), validate, and promote tools to predict risk of catastrophic failure.

**Activity/Output Goal 10.2.2:** Evaluate the effectiveness of insurance audits/evaluations for catastrophic failures.

**Activity/Output Goal 10.2.3:** Conduct global benchmarking comparing the effectiveness of various country- or region-specific regulations and corporate standards.

**Activity/Output Goal 10.2.4:** Develop management culture assessment and risks of change management for catastrophic failures.

**Activity/Output Goal 10.2.5:** Validate, improve, and promote the use of root-cause analysis methods and techniques.

**Activity/Output Goal 10.2.6:** Develop and disseminate training and educational materials based on lessons learned from past experiences of catastrophic failures, common root causes, operations, hazards, and meta-analyses.

**Activity/Output Goal 10.2.7:** Promote global collaboration with appropriate private and public sector entities such as the U.S. Chemical Safety and Hazard Investigation Board to prevent the occurrence of catastrophic incidents.