V. Current TI Research Goals and Sub Goals

1. Reduce injuries and fatalities due to motor-vehicles

Introduction

Motor-vehicles are consistently the leading cause of traumatic occupational fatalities in the U.S., accounting for more than 29,000 deaths between 1992 and 2005—an average of 2,100 worker deaths each year—and more than 35 percent of all workplace fatalities.[1] About 65 percent of the victims were occupants (drivers and passengers) of vehicles on public roadways, 17 percent were occupants of vehicles off public roadways, and 18 percent were pedestrian workers. In addition to workers who are driving (or passengers in) motor-vehicles in traffic during work, pedestrian workers in construction work zones are at risk from both motor-vehicles and large construction vehicles.

Traditionally, many workers at risk of motor-vehicle-related injuries and fatalities have been considered homogeneous with the overall driving population in the U.S. in that they face the same risks, and are protected by the same laws, technologies, and other prevention approaches. When first considering TI research priorities nearly 40 years ago, NIOSH made the determination that research in the area of motor-vehicle risks and prevention was amply covered in the programs of other agencies and research institutions. Consequently, NIOSH excluded motor-vehicle-related safety research from its program.[2]

In the face of compelling data that demonstrated a lack of progress in reducing workplace crashes and fatalities, TI re-evaluated the situation in the mid- to late-1990s and elected to become involved in research and other activities aimed at reducing worker deaths and injuries from motor-vehicle incidents. TI also recognized that crash data systems that cover the general population did not adequately identify work relationship for crashes, and that no one was taking the lead in promoting needed enhancements to these data systems.

References:

1. BLS [2006]. *Census of Fatal Occupational Injuries*. Available on Web at: http://www.bls.gov/iif/oshcfoi1.htm. Website last accessed on October 17, 2006.

2. Arthur D. Little, Inc. [1972]. *Final Report relating to the Present Status and Requirements for Occupational Safety Research*, prepared for the National Institute for Occupational Safety and Health, Health Services and Mental Health Administration, Public Health Service under Contract No. HSM 099-71-30. Cambridge, MA: A.D. Little. 203 pp.

Sub goal 1.1: Reduce occupational injuries and fatalities due to highway motor-vehicle crashes

Issue:
Two specific populations-at-risk are targets for TI efforts: professional truck drivers and workers who drive or ride in motor-vehicles during work-related travel but are not professional drivers.

Despite specific safety regulations designed to protect them, the injury and fatality risks for the nation's estimated 2.6 million truck drivers are among the highest of all occupations. From 1992 to 2002, the Census of Fatal Occupational Injuries recorded 8,864 truck driver fatalities, an annual average of 806, more than any other occupation.[1] Two-thirds of these were due to transportation incidents. The 2004 fatality rate for U.S. heavy and tractor-trailer truck drivers was 48.2 per 100,000 workers, over 10 times the national average of 4.4 deaths per 100,000 for all workers. In 2004, the Survey of Occupational Injuries and Illnesses estimated 63,570 nonfatal injuries among heavy and tractor-trailer truck drivers—the second highest number among all occupations. The most common events causing these nonfatal injuries were overexertion (23 percent), contact with object/equipment (19 percent), and transportation events (17 percent).[2]

Risk factors for truck drivers include:

- Operational characteristics of the trucking industry (e.g., long work hours and irregular schedules) which predispose truck drivers to fatigue and may lead to crashes
- Sleep disorders, such as obstructive sleep apnea, which have also been associated with motor-vehicle crashes among truck drivers
- Hourly pay schemes that may provide an incentive to exceed speed limits or drive too fast for conditions
- Use of prescription medications
- Non-use of safety belts
- Medical conditions
- Actions of other motorists who do not understand the operating capabilities of large trucks.

Numerous stakeholders agree that there is a need for additional occupational safety and health research focusing on truck drivers. In 2003, NIOSH, Wayne State University, the Owner-Operator Independent Drivers Association, the International Brotherhood of Teamsters, and the Alfred P. Sloan Foundation sponsored the Truck Driver Occupational Safety and Health Conference. Several presenters at this conference made specific recommendations for research targeting issues of long work hours and fatigue.[3] Similarly, participants in the 2005 International Truck & Bus Safety & Security Symposium and the National Occupational Research Agenda (NORA) town hall meeting for the Transportation, Warehousing, and Utilities industry sector (December 5, 2005), called for improvements in injury and illness data collection so that effective interventions to promote driver health and reduce injuries can be developed.[4]

Although about 40 percent of those who died in occupational crashes in the U.S. were employed as "professional" vehicle operators, e.g., truck or bus drivers, the remaining 60 percent had primary job duties other than driving. In contrast with truck and bus drivers, who are covered by comprehensive Federal regulations, other workers who drive on the job have only rarely been

subjects of safety research and prevention efforts, and even today are not covered by any occupational safety and health regulations specific to driving. Responsibility for setting and enforcing vehicle safety policies falls to the employer, and small employers often lack the resources and know-how to implement effective programs.

Approach:
Since the inception of NIOSH in 1970, the Institute has been collecting, analyzing, and reporting upon surveillance data on occupational motor-vehicle injuries and fatalities. The development of the National Traumatic Occupational Fatalities (NTOF) Surveillance System in the 1980s provided the nation's first count of traumatic occupational fatalities, and confirmed that the leading cause was motor-vehicle incidents. That has not changed in the 26 years' worth of data collected both in NTOF and in the BLS Census for Fatal Occupational Injuries (CFOI).

The TI Program's overall approach has been to:

- Undertake a major research initiative in transportation safety, including research targeting truck drivers
- Identify opportunities to inform employers and other stakeholders of the risks associated with workplace driving for those who are not employed strictly as drivers
- Participate on the consensus standards committee that developed the first standard addressing safety for nonprofessional drivers
- Participate in global efforts to reduce motor-vehicle injuries and fatalities

Achieving a balance of activities that would address specific safety concerns for truck drivers along with those for other employee drivers has been a primary concern. Working with partners such as the American Society of Safety Engineers (ASSE) and the Network of Employers for Traffic Safety (NETS) has given TI Program staff the opportunity to learn about employer traffic safety concerns from a risk management perspective, to better understand the challenges of managing employee drivers, and to better serve the populations at risk and their representatives through research and outreach efforts.

Outputs and Transfer:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

In cooperation with numerous other stakeholders, TI Program staff contributed to the development of the American National Standards Institute (ANSI) standard Z15.1-2006, Safe Practices for Motor Vehicle Operations,[5] which received final approval from ANSI on February 15, 2006. The ANSI Z15.1 Standard is intended to further prevention of motor-vehicle crashes, which are the leading cause of workplace fatalities and a major contributor to workers' compensation and liability costs, lost productivity, and property loss. The standard, designed for use by any organization whose employees drive on the job, delineates minimum requirements for workplace traffic safety programs. The ASSE serves as secretariat of the Z15 Accredited Standards Committee, whose members represent more than 30 government agencies, insurance companies, employers, consulting groups, and trade associations. TI representatives have served on the ANSI Z-15 Committee from its inception in 2001. TI representatives contributed to all parts of the standard, and took the lead in drafting the portion of the standard that addresses crash data collection and incident analysis. In addition, the primary TI representative chaired the

subcommittee that resolved technical and editorial discrepancies across the sections of the standard and addressed the 100 pages of public comments received.
TI scientists are also represented on two Transportation Research Board (TRB) committees: Truck and Bus Safety (ANB70) and Vehicle User Characteristics (AND10). In this capacity, TI representatives contribute to committee-authored documents and strategic plans, review manuscripts to be presented at the TRB annual meeting, and participate in committee meetings and related conferences and workshops.

In response to a recommendation in the National Research Council monograph "Protecting Youth at Work,"[6] the U.S. Department of Labor (DOL) provided funds for TI Program staff to develop a report on the adequacy of Hazardous Orders (HOs) which define prohibited work activities for youth. The report made recommendations for existing HOs related to workplace driving by youth in agricultural and nonagricultural occupations.

Recent NIOSH-funded extramural grants have focused on preventing motor-vehicle-related injuries. One study found that extended-duration work shifts, which are currently sanctioned by the Accreditation Council for Graduate Medical Education, pose safety hazards for medical interns. These results have implications for medical residency programs, which routinely schedule physicians to work more than 24 consecutive hours.[7] Another study linked State workers' compensation to other data sources to better describe the burden and pattern of injuries among truck drivers. Findings from this study suggest that nationally available data on truck driver injuries underestimate seriously disabling injuries of the back, shoulder, and knees; and, that truck drivers are at greater risk of back and disc injuries than other occupational groups. These findings were reported at the 2006 National Occupational Research Agenda Symposium.[8, 9] A third study identified specific acoustic conditions that increase pedestrian workers' recognition of approaching motor-vehicles, and suggested that introducing temporary pavement treatments in work zones would produce tones that would increase worker safety. Study findings were published in the 2003 proceedings of the 9th International Conference on Auditory Display.[10]

TI staff prepared and disseminated a *Hazard Review* document that addressed issues such as identification of the worker groups at highest risk of crashes, the motor-vehicle safety regulatory climate, fleet safety recommendations for employers, distracted driving, use of cell phones while driving, and age-related driving issues.[11] Additionally, TI staff authored an MMWR article that was released in conjunction with World Health Day 2004.[12]

TI staff researched, wrote, and developed dissemination strategies for the transfer of other NIOSH publications addressing occupational motor-vehicle safety topics, including NIOSH Alerts on preventing worker deaths and injuries from traffic-related motor-vehicle crashes and refuse vehicles;[13,14] and reports identifying worker populations at risk of an occupational motor-vehicle-related injury or death, prevention strategies that employers can use to protect their workers, and specific risks faced by older drivers at work. More than 120,000 copies of these publications have been proactively distributed by the NIOSH Publications Office to targeted mailing lists and at conferences. Most have been reprinted several times.

NIOSH maintains comprehensive Web pages on motor-vehicle safety (www.cdc.gov/niosh/injury/traumamv.html) and on the NIOSH program for transportation, warehousing, and utilities (TWU) (www.cdc.gov/niosh/programs/twu).

Press releases were used to increase visibility of NIOSH or NIOSH-funded products related to vehicle safety. Much of the media response associated with the 2004 MMWR article (described below under Intermediate Outcomes) was fueled by the April 7, 2004 press release that accompanied it.[14] In the same way, the September 14, 2004 press release focused greater attention on NIOSH Director John Howard's appearance on a panel at the National Safety Congress that addressed the importance of safety belts in preventing worker injuries and fatalities.[15]

NIOSH co-sponsored the Truck Driver Occupational Safety and Health Conference held in Detroit, Michigan in April 2003. TI staff members gave presentations. The proceedings of the conference are nearing publication as a NIOSH document. NIOSH also co-sponsored the International Truck & Bus Safety and Security Symposium, held in Alexandria, Virginia on November 14-16, 2005.

Intermediate Outcomes:
Approval of the ANSI Z15.1 standard, Safe Practices for Motor Vehicle Operations, is a landmark achievement in worker protection.[5] This is the first occupational safety standard that offers comprehensive guidance to protect all workers who operate a motor-vehicle as part of their job. It fills a critical gap in guidance for organizations whose employee drivers are not covered by the Federal Motor Carrier Safety Regulations, which apply only to commercial drivers. ANSI Z15.1 will be particularly useful for small and medium-sized companies, which may not be aware of the need for a vehicle safety program or may lack the knowledge to implement a program.

The motor-vehicle *Hazard Review*[7] was featured in the February 2004 issue of the National Safety Council publication, *Safety + Health*.[16] It was also featured in the March 27, 2004 issue of the *Status Report*, published by the Insurance Institute for Highway Safety (IIHS).17 The June 2004 issue of *Safety + Health* featured an interview with the NIOSH Director, who responded to questions on occupational road safety. [18]

The MMWR article released around World Health Day 2004[12] generated media interest. The TI lead author was interviewed by the New York Times, CNN Radio, Reuters, and the Atlanta Journal-Constitution. The MMWR article was also featured in the June/July 2004 issue of Nation's Health, the newspaper-style publication of the American Public Health Association.[19] It was also featured in the Pittsburgh Post-Gazette and the Tulsa World.

Progress toward End Outcomes:
A final rule published by DOL in 2004 incorporated a NIOSH recommendation related to HO2 (Motor-Vehicle Occupations), and referred to NIOSH comments in the accompanying narrative.[20] DOL adopted the NIOSH recommendation that this HO be changed to comply with 1998 Congressional amendments to the Fair Labor Standards Act. The rule was changed to prohibit all workplace driving on public roadways by 16-year-old workers, and placed substantial restrictions on driving by 17-years-old workers. (See also Sub goal 8.1: Influence legislative changes to protect young workers.)

What's Next:
TI is collaborating with the Uniformed Services University of the Health Sciences to study the association between prescription medications and fatal motor-vehicle crashes among active duty military personnel. Other partners, including the National Highway Traffic Safety

Administration, are interested in results of the study. Another study is examining the influence of organizational and industry factors—such as scheduling practices, economic pressure, competition, and types of freight—on fatigue and safety in commercial truck drivers. TI is also a key participant in a national survey of long-haul truck drivers that will include modules on injury, health and lifestyle, fatigue, and sleep disorders. Another TI study involves collection of anthropometric and work-space data for a nationally representative sample of 500 U.S. truck drivers using traditional measurement methods and 3D scanning technology. Finally, TI is developing recommendations for improving the collection of crash data for State DOT employees, as well as vehicle safety recommendations for workers posted abroad.

In April 2006, a new TI-written RFA was issued for an extramural research grant program focusing on the safety and health of truck drivers.

External Factors:
Motor-vehicle incidents are the leading cause of workplace fatalities, but make up only about 3 percent of total U.S. traffic fatalities. Engaging the broader traffic safety community in prevention of occupational motor-vehicle crashes makes sense, given that many risk factors are shared. However, the toll of motor-vehicle crashes outside the workplace is so great that occupational safety issues are not a large part of the national traffic safety debate. Trucking, which becomes a public safety issue because of the large number of other motorists killed in crashes with trucks, is the exception.

NIOSH and the TI Program are relatively new players in the motor-vehicle safety arena. Until the late 1990s, TI allocated limited resources to data analysis and development of prevention strategies related to motor-vehicle crashes. In the late 1990s, TI staff began to develop a knowledge base in this area through data analysis, review of the literature, and contacts with stakeholders. In FY 2004 and again in FY 2007, TI competed successfully for internal funding for research related to motor-vehicle safety.

TI faces the continuing challenge of finding its niche within transportation safety research. The Transportation Research Board of the National Academies brings together thousands of researchers across all modes of transportation. There are numerous university-based transportation research centers that are well-respected and well-funded. For TI, the challenge is to develop research projects that address factors unique to occupational driving and to cultivate a strong stakeholder network that will ensure that research findings go directly to affected populations.

In the injury surveillance arena, TI clearly has a role to play in promoting better ascertainment of work relationship in existing crash data systems. The Fatality Analysis Reporting System does not identify as many work-related crashes as the Census of Fatal Occupational Injuries, and other general crash data systems do not capture work relationship at all. The lack of work relationship data in these systems impedes the identification of risk factors for occupational crashes.

OSHA has no regulations that cover workplace driving, and it has responded negatively to initiatives from research and interest groups in recent years urging it to develop regulations for safety belt use. OSHA’s inaction sends the message to employers that motor-vehicle safety falls outside their responsibility. As a result, employers appear to accept to some degree that crashes are an inevitable consequence of doing business.

Large organizations that have the resources to collect and analyze crash data understand the enormous financial and human toll of motor-vehicle crashes and may take steps to prevent crashes. In the absence of regulations, many employers with fewer resources elect not to take action.

For the trucking industry in particular, economic realities and the operating environment work against implementation and acceptance of occupational safety and health initiatives. For example, truck drivers are exempt from overtime provisions of the Fair Labor Standards Act. Strong industry pressure and a regulatory framework that allows long hours of work make it politically untenable to argue for either overtime pay or shorter hours. Mileage-based compensation schemes create an incentive to drive beyond speed limits and beyond the number of hours of driving permitted under the regulations. Finally, the nature of truck drivers' work environment makes communicating health and safety information very difficult.

References:

1. BLS [2006]. Census of Fatal Occupational Injuries. Table: Census of Fatal Occupational Injuries All Worker Profile, 1992-2002. Available on Web at: http://www.bls.gov/iif/oshwc/cfoi/cftb0186.pdf. Website last accessed on December 15, 2006.

2. Bureau of Labor Statistics [2006e]. Survey of Occupational Injury and Illness. Table R12. Number of nonfatal occupational injuries and illnesses involving days away from work by occupation and selected events or exposures leading to injury or illness, 2004. Available on Web at: http://stats.bls.gov/iif/oshwc/osh/case/ostb1522.pdf. Last accessed on February 1, 2006.

3. Saltzman GM, Belzer MH [2003]. Truck driver occupational safety and health: A conference report and selective literature review. Unpublished proceedings of Truck Driver Occupational Safety and Health Conference, April 24-25 2003, Detroit Michigan. Available on Web at: http://www.ilir.umich.edu/TIBP/TruckDriverOSH/FinalReport.pdf

4. NIOSH [2005]. Comments of the National Institute for Occupational Safety and Health on the Federal Motor Carrier Safety Administration Notice of Proposed Rulemaking on the Hours of Service of Drivers, 49 CFR Parts 385, 390, and 395, Docket No. FMCSA 2004-19608. Cincinnati, OH: National Institute for Occupational Safety and Health. March 2005.

5. ANSI/ASSE [2006]. Safe practices for motor vehicle operations [American National Standard]. New York, NY: American National Standards Institute, ANSI/ASSE Z15.1-2006.

6. NRC (National Research Council/Institute of Medicine) [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States. Washington, DC: National Academy Press.

7. Barger LK, Cade BE, Ayas NT, Cronin JW, Rosner B, Speizer FE, Czeisler CD [2005]. Extended work shifts and the risk of motor vehicle crashes among interns. NEJM 352:125-134.

8. Oleinick A, Gandra CR, Simon C, Werner RA [2006]. Nature of injury data in the BLS annual survey seriously underestimate the medical burden of work injuries. NORA Symposium 2006: Research Makes a Difference, April 18-26, 2006, Washington, D.C.

9. Oleinick A, Werner RA, Blower DF, Gandra C, Simon CD [2006]. The utility of linked and transformed workers' compensation data to study work injuries by occupation among employees of Ohio for-hire carriers, 1997-1999. NORA Symposium 2006: Research Makes a Difference, April 18-26, 2006, Washington, D.C.

10. Neuhoff JG, Preston JG [2003]. A spatial auditory display for the prevention of pedestrian-motor vehicle collisions. Proceedings of the 9th International Conference on Auditory Display, Boston, MA.

11. Pratt SG [2003]. Work-related roadway crashes: challenges and opportunities for prevention (NIOSH Hazard Review). Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2003-119.

12. Pratt S [2004b]. Work-related roadway crashes - United States, 1992-2002. MMWR 53(12):260-264.

13. NIOSH [1998]. NIOSH Alert: Preventing worker injuries and deaths from traffic-related motor vehicle crashes. Cincinnati, Ohio: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 98-142.

14. NIOSH [1997]. NIOSH Alert: Preventing worker injuries and deaths from moving refuse collection vehicles. Cincinnati, Ohio: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 97-110.

15. NIOSH [2004c]. NIOSH Update: NIOSH recommends ways to prevent fatalities from work-related roadway crashes - April 7, 2004. Available on the Web at: http://www.cdc.gov/niosh/updates/upd-04-07-04.html. Last accessed on January 12, 2007.

16. NIOSH [2004d]. NIOSH Update: Requiring safety belt use is key employer policy for preventing job vehicle deaths, NIOSH says - September 14, 2004. Available on the Web at: http://www.cdc.gov/niosh/updates/upd-09-14-04.html. Last accessed on January 12, 2007.

17. Greene MV, Parker JG [2004]. Death in the fast lane. Safety + Health (February 2004): pp 42-45.

18. IIHS [2004]. Crashes are the leading cause of death on the job… Status Report 39(4):6-7 (March 27, 2004).

19. Greene MV [2004]. Howard: Workplace crashes are preventable. Safety + Health (June 2004): p. 38

20. APHA [2004]. Road safety, traffic systems global public health concerns. The Nation's Health (June/July 2004). Accessible on Web at: www.apha.org/enh/index.cfm?fa=IDetail&issue_ID=62004. Last accessed on December 19, 2006.

21. U.S. DOL [2004]. Child Labor Regulations, Orders and Interpretation; Child Labor Violations—Civil Money Penalties; Final Rule. 29 CFR Parts 570, 579, and 580. Federal Register 69(241):75382-75406.

Sub goal 1.2: Reduce occupational injuries and fatalities due to motor-vehicle incidents in highway and street construction work zones

Issue:
For the eight-year period between 1995 and 2002, 844 fatal occupational injuries* occurred at road construction sites. The majority of these fatalities, 693 cases (82 percent), were reported to be transportation incidents. Fatalities involving a worker being struck by a vehicle or mobile equipment accounted for 509 (73 percent) of the transportation incidents. Victims of these incidents were slightly more likely to be struck by dump trucks or construction machinery (32 percent) than by highway automobiles (28 percent).[1] The high percentage of transportation-related fatalities involving workers in work zones being struck by vehicles and equipment became a source of concern for governmental and private organizations.

Although these groups have taken steps to address the issue through regulation, awareness initiatives, and research, concern is that increases in road construction and structural changes in the industry may lead to increases in worker injuries and fatalities. This concern is underscored by two recent legislative actions, each of which includes safety-specific language: 1) the Safe, Accountable, Flexible, and Efficient Transportation Equity Act - A Legacy for Users, signed by President Bush in August 2005 and 2) the Federal Highway Administration Final Rule on Work Zone Safety and Mobility, with compliance required by October 2007.

Several factors are contributing to the issues faced by workers in highway and street work zones:

- Lack of knowledge on specific risk factors
- Lack of information on and evaluation of safety training programs designed for non-English speaking workers
- Insufficient adaptation of intervention technologies that are used in other industries
- Lack of scientific evaluation for existing and newly developed intervention approaches
- Inadequate guidelines, particularly for controlling vehicle and worker movements inside the work zone

Prompted by the data and stakeholder concern, TI is currently undertaking several efforts to address each of these factors to reduce motor-vehicle incidents in highway and street construction work zones.

Approach:
TI researchers analyzed existing data to determine the magnitude and circumstances of fatalities in the highway and street construction industry. The results prompted TI to initiate an effort to develop guidelines for addressing work zone safety, starting with a comprehensive review of the scientific literature, additional analysis of existing data from the BLS, and a review of relevant investigations conducted by the Fatality Assessment and Control Evaluation (FACE) Program. TI sponsored a 1998 workshop that focused on preventing injuries in work zones due to motor-vehicles and equipment. The workshop was attended by 54 individuals representing government, labor, industry, academia, and State Departments of Transportation. Information shared in the workshop sessions was the primary resource used to identify specific measures for preventing worker injuries from vehicles and equipment.

* Fatality count is inclusive of all industries, not just those in the highway and street construction industry.

In 1999, the TI Program added highway and street construction work zone fatalities as a specific target for investigations by the FACE Program. Through investigative guidelines developed by TI researchers, details related to the circumstances surrounding these fatalities are captured. Since the addition of this target, TI researchers have conducted 13 highway and street construction FACE investigations, 12 of which were of transportation-related incidents.

In 2000, TI researchers, in cooperation with the Washington State Department of Transportation, began testing interventions that provide construction equipment operators with the ability to monitor the blind areas around the equipment they are operating. This type of intervention is often referred to as a proximity warning system (PWS). The objective of this effort was to determine which systems were most effective and reliable in monitoring blind areas, not for determining injury prevention efficacy.

TI researchers also tested the effectiveness and reliability of another PWS called the Hazardous Area Signaling and Ranging Device (HASARD) for possible deployment in the highway and street construction industry. The HASARD system, originally developed by TI researchers for underground mining equipment, uses a technology that alerts both the equipment operator and the pedestrian worker when the worker enters a hazardous area (blind area) around the equipment.

TI launched an effort in 2002 to rigorously evaluate selected prevention measures designed to protect workers from being struck by construction vehicles and equipment. The selected measures are implemented on active road construction sites with control and treatment data collected. Interventions being evaluated include several PWS devices and an administrative approach called an internal traffic control plan (ITCP). ITCPs are designed to assist in controlling construction vehicle and worker movements inside the work zone. The PWS devices and the ITCP are promising interventions that have not yet been proven effective for preventing fatalities and injuries associated with construction vehicles and equipment.

Researchers in the NIOSH Education and Information Division (EID) are currently evaluating the effectiveness of safety training programs designed for Spanish-speaking road construction workers. In this effort, researchers are collecting data from supervisors who typically have only a rudimentary knowledge of Spanish, yet are responsible for directing workers and providing safety training.

Outputs and transfer:
(For those outputs not specifically cited, see Appendix 1: Supporting Evidence.)

TI researchers authored a NIOSH document, “Building Safer Highway Work Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment,”[2] that was based on stakeholder input received during the 1998 TI-sponsored workshop. The document provides specific measures that contractors, contracting agencies, policy makers, manufactures, law enforcements, and the research community can use to reduce work-related injuries in highway work zones. This document has been disseminated through targeted mailings, conference and exhibition handouts, and downloads from the NIOSH Website. From four separate printings, approximately 21,000 copies have been distributed.

The 13 highway work zone FACE investigation reports are accessible at: http://www.cdc.gov/niosh/injury/traumazoneface.html. Eight of these reports involve a highway

worker being struck by a motor-vehicle or equipment. Copies of the reports are also provided to the Occupational Safety and Health Administration (OSHA).

TI contractors authored five reports for use by TI researchers in developing the methodology to rigorously evaluate selected injury prevention measures for highway construction workers. The contractor reports provide information on blind area diagrams of specific equipment (areas around the equipment where the operator cannot see) and ITCP development for specific highway construction sites. Although originally developed solely for use by TI researchers, these documents are distributed externally upon request.

TI researchers have delivered 24 presentations at a wide variety of professional meetings to provide information about efforts to protect highway and street construction workers. Attendees were generally highway and street construction industry safety professionals and association members. Presentations usually focus on providing information about ongoing TI research relevant to the highway construction industry and soliciting participation in the TI research effort to evaluate injury prevention measures on active road construction sites.

Intermediate Outcomes:
The NIOSH document, "Building Safer Highway Work Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment,"[2] has been further distributed by OSHA offices in Washington D.C. and Puerto Rico, the Laborers' International Union of North America, the American Road and Transportation Builders Association (ARTBA), and the Washington State Department of Labor and Industries.

ARTBA and the National Safety Council (NSC) consulted with TI researchers in developing an OSHA 10-hour training course specifically for the road construction industry. Key measures from the NIOSH document were incorporated in the course training materials. This OSHA 10-hour course is provided to member construction companies for NSC and ARTBA, and is also a core component of the road construction safety training program for the Associated General Contractors of Vermont's Northeast Regional Safety Academy.

The Laborers' Health and Safety Fund of North America (LHSFNA) incorporated the Injury Prevention Measures and Glossary sections of the NIOSH document[2] in entirety in the Appendix and Glossary sections of their "Highway Workzone Safety Manual 2003."[3] Other organizations have used the document to:

- Provide risk management recommendations to clients (St. Paul and the CNA insurance companies)
- Support development of contract language to require contractors to use high-visibility clothing during disaster clean-up (Federal Emergency Management Agency)
- Guide strategic planning for transportation centers (Cleveland State University)
- Develop safety training videos (J. J. Keller and Associates)
- Incorporate injury prevention measures into a best practices guide (The Dallas Area Road Construction Work Zone Task Force)
- Develop safety training programs (Texas Engineering Extension Service, Laborers' Health and Safety Fund of North America, Washington State Department of Labor and Industries, and Wayne State University)

- Incorporate safety measures and FACE case examples into tool-box safety talks (highway and street construction companies)

In June 2000, the *Engineering News Record* published an article featuring the pending release of the NIOSH document.[4] The article noted that the document was much anticipated and included several of the injury prevention measures from the document.

The TI contractor reports on blind area diagrams and ITCP development were requested and used by the Washington State Department of Labor and Industries in developing recommendations for internal traffic control. PWS device manufacturers requested and used the blind area diagram contractor reports for product development and marketing. The blind area contractor reports have also been requested and used by individual construction companies for safety training. One of these companies used the reports for a company-wide safety stand down.*

In March 2004, The Bureau of National Affairs (BNA) published an article in its *Daily Report for Executives* that featured the ongoing TI research efforts to evaluate injury prevention measures on active road construction sites.[5] The article encouraged construction companies who were interested in participating to contact TI researchers. The article was written by a BNA reporter who attended a presentation by TI researchers at the 14th Annual Construction Safety Conference and Exposition.[6]

The National Asphalt Pavement Association (NAPA) commissioned an article for *Hot-Mix Asphalt Technology* to describe ongoing TI research efforts to evaluate injury prevention measures on active road construction sites. The article discussed the interventions being evaluated, data collection methods, and road construction site criteria.[7] The article also encouraged construction companies who were interested in participating to contact TI researchers.

What's Ahead:
The TI Program is continuing the effort to rigorously evaluate PWS and ITCP interventions on highway construction sites. Results of these studies will be published in peer-reviewed journals and disseminated to stakeholders in the highway and street construction industry in collaboration with partners including NAPA, ARTBA, NSC, and the Laborers' Health and Safety Fund of North America.

TI continues to include highway work zone fatalities as a target for FACE investigations to:
- Identify new risk factors and injury prevention strategies
- Identify, develop, adapt, and evaluate emerging technologies specifically related to PWS devices
- Influence the regulation activities of other governmental agencies such as OSHA by responding to proposed rulemaking and public comment notifications
- Respond to requests for information on highway and street construction worker safety
- Provide support to organizations advocating a safe work environment for these workers

* A "safety stand down" is a suspension of company or organizational operations for the purpose of reviewing safety policies and procedures, and/or training employees.

- Communicate with EID on efforts to better understand and evaluate safety training programs designed for Spanish-speaking road construction workers

External Factors:
Several factors challenge TI research in highway and street work zone safety, including the following:

- Regulation for safe work practices in work zones falls under the jurisdiction of both the Federal Highway Administration and OSHA
- The industry is fractured by relatively small family businesses located in disparate localities
- The work environment is mobile with constantly changing variables (e.g., weather, construction phase)
- The industry base is changing with corporate consolidation, foreign investments, adoption of night work, and an increase in the number of non-English-speaking workers
- Field-based research is resource intensive requiring significant travel, personnel, and equipment expense

TI researchers have been relatively successful in meeting these challenges by partnering through alliance memberships that involve government, industry, and labor representation.

References:

1. Pegula S [2004]. Fatal occupational injuries at road construction sites. Washington DC: U.S. Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review 127*(12): December 2004

2. Pratt SG, Fosbroke DE, Marsh SM [2001]. Building safer highway work zones: measures to prevent worker injuries from vehicles and equipment. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-128.

3. LHSFNA [2003]. Highway Workzone Safety Manual, 2003. Washington, DC: Laborers' Health and Safety Fund of North America, 129 pp.

4. Krizan WG [2000]. Construction declares war on highway work zone carnage. *Engineering News Record 244* (23): 36-41.

5. Scovron J [2004]. NIOSH seeks contractor participation in project to reduce roadway injuries. The Bureau of National Affairs, Daily Report for Executives, 56 DER A-7, 3-24-04.

6. Beaupre J, Hause M, Hammer R [2004]. Preventing workers from being struck by roadway construction equipment. Presented at the 14th Annual Construction Safety Conference and Exposition, Rosemont, IL, February 10.

7. Jay ML [2005]. Study seeks effective ways to reduce road work zone injuries. *Hot Mix Asphalt Technology 10* (3): 29-30.

2. Reduce injuries and fatalities due to falls from elevation

Introduction

One of the two leading causes of death and injury in the workplace (second only to motor-vehicle crashes), falls are responsible for disabling injuries to 313,000 American workers, and more than 700 occupational fatalities each year. Falls from elevations are a special concern. BLS (2004) data reveal that on average 651 American workers die and nearly 86,900 suffer an injury each year as a result of falls from elevation. The cost of a single fall-from-elevation injury usually starts at around $500,000 and easily reaches $1 million or more when third-party suits are involved in severe injury cases. The construction industry has the highest frequency of fall-from-elevation incidents, followed by the wholesale and retail trade, service, and transportation industries. Most often, construction workers fall from roofs, ladders, and scaffolds.

The first priority of the TI Falls from Elevations program is to seek engineering solutions to reduce fall hazards by conducting human factors and technology assessment studies.

Protective equipment provides the last line of defense for workers to prevent falls from elevations in cases in which work redesigns or engineering controls are inadequate or impractical. Occupational Safety and Health Administration (OSHA) regulations require that fall-arrest harnesses, guardrails, or safety nets be used as protective measures for tasks that are performed above six feet of height. Fall-arrest harnesses especially are used at various construction phases. Adequate fall-arrest-harness-sizing and design would reduce the risk of worker injury and thus is the second priority of the TI Falls from Elevations program.

Falls from telecommunication towers during either the construction or maintenance phase is an emerging issue that has required special attention, and thus is the third priority of the TI Falls from Elevations program.

Sub goal 2.1: Reduce worker falls from roofs

Issue:
In 2004, falls from roofs killed 178 workers and constituted the leading cause for work-related fatalities in the construction industry.[1] Falls from roofs are also a major cause of serious nonfatal injuries in the construction industry. In 2004, 2,220 workers were seriously injured after falling from roofs.[2] Research to understand human fall mechanisms and to identify preventive measures is critical to the reduction of fall-from-roof incidents.

The TI Program seeks to establish engineering solutions to control factors that contribute to falls from roofs and thus minimize the possibility of workers making unsafe choices or taking actions that could go beyond their capabilities. These solutions include new work strategies, improved tools, enhanced engineering products, and modified protective equipment. A comprehensive literature review by the TI Program team identified critical influential factors and major knowledge gaps in preventing falls from roofs.[3] The review assisted the TI Program in setting research priorities for this Sub goal area.

Approach:
TI Program work in this Sub goal area over the past decade includes:

1. Developing an adjustable roof guardrail assembly that can accommodate various roof pitches to protect workers from falling to lower levels during their roofing work
2. Validating virtual reality technologies for fall-from-roof prevention research
3. Identifying the effects of visual cues on balance control during roofing work
4. Developing improved footwear designs for work on roofs
5. Establishing sensory-enhancing technology to improve workers' balance on roofs
6. Developing safer scissor lifts and work practices to minimize fall-from-roof exposures and to enhance scissor lift safety

Outputs and transfers:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

Guardrail assembly. Temporary guardrails offer a solution for protecting workers from falling to the lower level during their roofing work. Most of the current guardrail systems are designed for use on low pitch roofs. The TI Program has developed a prototype adjustable roof guardrail assembly that can accommodate a higher roof pitch range (27^o to 63^o) increasingly being seen in new residential-building construction.[4] A utility patent application regarding the invention was filed in October 2005.[5] The TI Program held a public meeting in 2004 to transfer the invention into practice.

Virtual reality technology. The TI Program developed a surround-screen virtual reality (SSVR) system, the first SSVR system in the world designed for occupational fall prevention research. Validation studies have confirmed that the SSVR system is a valid tool for fall-from-roof prevention research.[6,7] The system is currently used to evaluate human performance at elevation, identify risk factors leading to fall incidents, and assess new fall prevention strategies.

Thousands of scientists, safety professionals, and construction trade representatives from around the world have visited the SSVR facility and consulted with TI staff on the application of this emerging and advanced technology to occupational safety research.

Visual cues' effect on balance control. TI Program publications in *Injury Prevention* and *Human Factors* journals have shown that at elevated environments, vertical visual anchors within 15 feet of a person's eyes can significantly reduce postural destabilization.[8,9] The findings have practical implications for improving workers' safety during roofing work. Temporarily, roof guardrails can serve not only as physical barriers to protect workers from falling, but also as visual anchors to reduce workers' postural instability at elevation.

Footwear for work at roof. The TI Program used virtual reality technology to evaluate the effects of different styles of footwear on workers' instability at elevation and has reported results to the safety scientific community.[10,11] Workers' balance on elevated and narrow surfaces was significantly improved with footwear styles that had high uppers and provided good motion control. Proper shoe selection and improvements in the design of specialized work footwear would enhance workers' stability at height.

Sensory-enhancing technology to improve workers' balance. TI Program researchers, in collaboration with researchers from Boston University, built and tested a prototype randomly vibrating ("smart") shoe insert to improve workers' balance at elevation. The smart-shoe insert increases the pressure-sensitivity under the feet by inducing below-sensory-threshold mechanical vibrations.

Safer scissor lifts and work practices. The TI Program has developed a preliminary computerized model that would be used to analyze the impact of the mechanical load of the lifts and operator's stability (e.g., side force and sway), on the scissor lift platform at different heights during various static and dynamic work conditions.

Progress toward Intermediate Outcomes:
All efforts under this Sub goal area are at the stage of transferring knowledge and technologies developed through research to research organizations and private-sector companies for further development and commercialization. The processes of transfer and commercialization can proceed for years before products are realized, marketed, and implemented in workplaces to reduce risk, thereby reducing injuries and fatalities. Although there are no end outcomes to report, there are promising intermediate steps to report.

Guardrail assembly. Four companies responded to a program announcement in the Federal Business Opportunities publication. TI sent the prototype guardrail assembly to all four companies. After reviewing the prototype, two companies—Garlock Equipment Company and Hug One, LLC—expressed interest in producing and marketing the invention. These companies are currently conducting product development and cost analyses, and evaluating potential agreements with the TI Program to carry forward this manufacturing and marketing venture. TI is intent on finalizing agreements with these manufacturing partners to commercialize the design.

Virtual reality technologies. Staff members from the Finnish Institute of Health and the Japan Occupational Health University have expressed interest in adopting the TI SSVR concept as a technological foundation on which to develop their fall prevention research laboratories.

TI Program researchers have used the technology to identify human fall mechanisms and evaluate engineering concepts for fall-from-roof prevention.

Safer scissor lifts and work practices. A letter of agreement (LOA) was signed in 2004 (running through 2007) between the TI Program and SkyJack, Inc., a leading scissor lift manufacturer. The LOA represents an agreement to jointly develop alternative aerial lift designs and safer work practices to reduce aerial lifts-related injuries and fatalities. The partner has provided two scissor lifts and related engineering support to the TI Program. Using volunteer participants, the TI research team is performing static and dynamic experiments on changes to center-of-mass of the scissor lift under various work scenarios. SkyJack is testing the computer simulation software developed by TI that analyzes lift performance under various work conditions to determine its applicability to design of new lifts.

Intermediate Outcomes:
The published literature review from this study[3] has been cited and used as course, research, and strategic planning materials by more than 50 entities.

What's Ahead:
Guardrail assembly. The TI Program expects to finalize and sign agreements in 2007 with two manufacturing partners with the intent to commercial (manufacture and market) the guardrail assembly design.

Virtual reality technology. A Web page regarding the TI SSVR facility and research activities will be established in 2007 to allow the international safety community to use the program as a validated method and advanced technological foundation to develop fall prevention research laboratories.

Visual cues on balance control. A lay-oriented practical work solution guide will be developed in 2007 to help workers and contractors understand the role of visual anchors during roofing work. This guidance will show how to set adequate temporary roof guardrails in order to maximize their function in protecting workers from falling, as well as in reducing postural instability during roofing work.

Footwear for work on roofs. A practical, lay-oriented guide will be developed in 2007 to help workers and contractors select adequate footwear for roofing work. Interactions with a leading work-shoe manufacturer (Iron Age Corp.) and the American Society of Testing Materials (ASTM) International Committee F13 (Safety and Traction for Footwear) will continue, with the goal of pursuing the best ways to transfer TI research results to the footwear design process.

Sensory-enhancing technology to improve workers' balance. The effect of this sensory-enhancing device on workers' postural stability will be evaluated in 2007 with motion analysis methods and in simulated construction environments using the SSVR system. At the end of the study, the research findings will be directly transferred to the Afferent Corporation, developers of the sensory-enhancing device (which was originally designed for medical applications), to facilitate its further development for application in the occupational safety field.

Safer scissor lifts and work practices. The TI Program will continue to perform static and dynamic experiments on the changes to center-of-mass of the scissor lift. Specifically, the program will conduct dynamic curb tests, depression tests, and driving and stopping (jerking)

tests at a range of heights and with a range of loadings on the platform to validate computer simulation models. The study results will also provide critical information relating to scissor lifts to international standards committees for consideration in revising standards. These committees include the American National Standards Institute (ANSI) A92 Aerial Platforms Main Committee and various A92 sub-committees, the U.S. Technical Advisory Group to ISO Technical Committee 214 Elevating Work Platforms, and the Canadian Standards Association (CSA) B354 Elevating Work Platforms Technical Committee. Once successful tests are achieved, this joint TI-manufacturer research effort should ensure the commercialization and availability of new safety features on scissor lifts.

External Factors:
Multiple factors interactively affect the occurrence of falls from roofs. In the U.S., worker training on regulations (i.e., use of guardrails, safety nets, or fall-arrest systems) has for decades been the primary focus for preventing falls from roofs. However, many construction activities have been exempted from the regulatory requirements for practical reasons (i.e., technology, cost, and operation). In addition, research aimed at preventing falls has been hindered because of the difficulty in accessing work environments and worker activities at elevation (even with management and workforce cooperation), the dynamic nature in the construction industry, and even the potential injury risk to researchers. Also, testing new engineering solutions at elevated construction sites can expose workers to additional fall exposures and risks. Consequently, the fatalities and injuries associated with falls from roofs have remained high for decades.
The NIOSH TI Program for preventing falls from roofs was developed in the mid 1990s to address this major gap. It introduced bioscience research to better understand human fall mechanisms and develop innovative and cost-effective engineering solutions, such as new work strategies, improved tools, enhanced engineering products, and modified protective equipment. Recent advances in virtual reality, wireless sensing, and remote measurement technologies have enabled TI researchers to more effectively evaluate engineering interventions for fall protection.

The TI Program is transferring the new knowledge gained through research by developing low-cost engineering solutions to prevent falls from roofs. Industry cooperation in evaluating and implementing these solutions is an important component of the program. National success in reducing fall-from-roof fatalities and injuries in the next decade would be positively affected by:

1. Expansion of the national fall prevention program based on bioscience research and technology transfer with additional funding and human resources
2. Development of additional strong industry partners to commercialize new engineering solutions for fall prevention
3. Initiation of a national campaign to promote engineering innovations for fall prevention
4. Promulgation of a national safety standard that requires the implementation of effective new technologies to enhance worker safety during work on roofs

References:

1. BLS [2005]. 2004 Census of Fatal Occupational Injuries (revised data). Washington, DC: U.S. Department of Labor News, Bureau of Labor Statistics. Available on Web at: http://www.bls.gov/iif/oshcfoi1.htm#2004 Last accessed on December 1, 2006.

2. BLS [2006]. 2005 Case and Demographic Characteristics for Work-related Injuries and Illnesses Involving Days Away From Work -- R64. Detailed event or exposure by industry division. Washington, DC: U.S. Department of Labor News, Bureau of Labor Statistics. Available on Web at: http://www.bls.gov/iif/oshwc/osh/case/ostb1720.pdf. Last accessed on December 11, 2006.

3. Hsiao H, Simeonov P [2001]. Preventing Falls from Roofs: A Critical Review, *Ergonomics 44*(5), 537-561.

4. Bobick T [2006]. NIOSH-Designed Adjustable Roof Bracket and Safety Rail Assembly, Proceedings of the NORA Symposium 2006, *Research Makes a Difference,* Washington, DC, April 18-19, 2006.

5. Utility patent application was filed on October 24, 2005 for an adjustable roof guardrail assembly that can accommodate a roof pitch range of 27^{o} to 63^{o} (CDC Ref. No. I-016-04).

6. Hsiao H, Simeonov P, Dotson B, Ammons D, Kau T, Chiou S [2005]. Human responses to augmented virtual scaffolding models, *Ergonomics 48(10),* 1223-42.

7. Simeonov P, Hsiao H, Dotson B, Ammons D [2005]. Height effects in real and virtual environments, *Human Factors 47(2),* 430-438.

8. Simeonov P, Hsiao H, Dotson B, Ammons D [2003]. Control and Perception of Balance at Elevated and Sloped Surfaces, *Human Factors 45* (1): 136-147.

9. Simeonov P and Hsiao H [2001]. Height, Surface Firmness and Visual Reference Effects on Balance Control, *Injury Prevention 7(supplement I):*150-153.

10. Simeonov P, Hsiao H , Amendola A, Powers J, Ammons D, Kau T, Cantis D [2005]. Evaluation of footwear for improved balance at height using virtual reality technology. Presentation at the *XVIIth World Congress on Safety and Health at Work, Orlando, FL.*

11. Simeonov P, Hsiao H , Amendola A, Powers J, Ammons D, Kau T, Cantis D [2005]. Footwear effects on workers' instability in a virtual roof workplace. Abstract, in *Proceedings of the American Industrial Hygiene Conference and Expo 2005,* May 21-26, Anaheim, CA, 49-50.

Sub goal 2.2: Improve fall-arrest harnesses

Issue:
Fall-arrest harnesses provide the last line of defense to the 10.8 million construction workers in areas where fall hazards cannot be completely eliminated. Full-body harnesses replaced waist belts and chest-waist harnesses more than 10 years ago and are considered the standard body support component of a personal fall-arrest system in the United States and Canada.

Despite the important role played by harnesses as protective devices in construction and general industry, little has been published on proper fit and sizing and the physiological risk and traumatic exposure involved with falls from elevation that are arrested with harnesses. The anthropometric (human body measurement) data used in harness design are based on studies with military personnel in the 1970s and 1980s, and do not represent the current general U.S. worker population. Additionally, workforce demographics have changed, with more women and minorities employed in occupations that use harnesses. Resulting changes in the anthropometric characteristics of workers using harnesses mean that current sizing data is not only inadequate but also potentially dangerous.

Information is also lacking on how full-body fall harnesses fit workers when they are suspended after a fall. Research has shown that subjects experience respiratory distress within 5 to 30 minutes of suspension in a full-body harness. Updated information on human tolerance in suspended postures and on solutions to minimize suspension trauma is needed.

In short, the current limitations in harness design can result in non-use of harnesses, poor harness-user interfaces, improper size selection, or the failure to don harnesses properly, all of which can result in increased risk. The advanced technology and methods available through the TI Program makes it uniquely poised to redesign harnesses and sizing schemes to provide safer, more user-friendly, and ergonomically appropriate designs.

Approach:
The overall goals of this research effort are 1) the establishment of anthropometric guidelines for the design of improved full-body harnesses, and 2) the development of effective harness-sizing systems that will better accommodate the current population of U.S. workers.

The TI Program used an advanced scanning technology to perform whole-body 3D scans of workers in both standing and suspended conditions, the same conditions that workers would encounter during work and following a fall from height. The approach, which performed rapid 17-second whole-body scans, overcame a long-standing problem—human subjects in suspended conditions may go into respiratory distress in as little as five minutes, making tests with traditional, time-intensive anthropometric tools and methods unacceptable.

The TI Program then evaluated the range of body shapes accommodated by current sizing schemes and tested current "static fit" criteria for their usefulness in determining how well harnesses fit after a fall. Findings from these studies of workers in the construction trades showed that 24 to 40 percent of participants failed fit criteria for two types of harnesses, confirming the need for updated and accurate data on the interface between the human body and safety harnesses. Mathematical parameters were established to determine the points of contact between the human body in its various shapes and the safety harness, and to define optimal sizing

schemes. Thigh strap angle and harness back D-ring location were identified as additional critical static-fit-test criteria to predict post-fall harness fit, which is important for future harness design.

The power of these studies was increased through the addition of data from an international study and attendant database of human shape. This anthropometric database of 2,340 subjects, known as CAESAR (Civilian American and European Surface Anthropometry Resource), was developed by a similar 3D scanning procedure by a consortium of industrial and government agencies, to provide an extensive database of the human form. Along with two harness manufacturers, the TI Program team has applied the mathematical parameters that were developed through the TI pilot studies to the CAESAR database to establish the adjustment range of each harness component. This is an important step to enable transfer of the scientific research results into industrial design practice. The NIOSH TI Program is one of the few international programs with the ability to perform this 3D digitization research and human-harness-interface modeling for harness design applications.

Further, a human physiology study was completed to determine the effects of an intervention to reduce physiologic stress to those in suspended conditions. A TI invention (a harness accessory) which automatically supports a wearer in a sitting position with the knees elevated at a position at or above the hips after a fall was found to increase suspension times for subjects. Mean suspension time was measured at 58 minutes (range 39 to 60 min) for the tests with the harness accessory, but only 29 minutes (range 5 to 56 minutes) for tests without the accessory.

Two major harness manufacturers (Mine Safety Appliances Co. and DBI-SALA Fall Protection Inc.) have actively participated in this research and are working with the TI research team to finalize the adjustment range of each harness component. These manufacturers have provided original static-test criteria, harness blueprints, and technical input for each study, and continued to provide feedback on proposed new sizing systems. They also are developing harness prototypes based on the proposed sizing systems and other TI Program study results reported above.

Outputs and Transfers:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

The research report on current harness-sizing issues and the effect of thigh strap angle and back D-ring location as additional harness static-fit-test criteria to enhance post-fall harness fit was published in the journal *Ergonomics* in 2003. The research received the prestigious International Ergonomics Association (IEA) Liberty Mutual Prize in Occupational Safety and Ergonomics in 2002. The information in the article is useful to construction employers and workers to ensure selection of the right size and proper donning of harnesses.

Findings from the human physiology study regarding the use of intervention technology to reduce suspension trauma potentials was presented at the American Industrial Hygiene Conference and Exposition in 2006. A provisional patent regarding the invention was filed in July 2006. The information will be shared with harness manufacturers along with the harness-sizing research results for the new generation harness design.

A provisional sizing scheme with an algorithm that describes the human torso shape-and-size distribution and a set of recommendations for producing vest-type harnesses has been accepted for publication by the *Human Factors* journal. A simplified version of the provisional sizing schedule was presented at the Ergonomics Society Conference and also published in Contemporary Ergonomics in 2005.

The draft report of a second provisional sizing scheme has also been shared with MSA and DBI-SALA.

Progress toward Intermediate Outcomes:
As mentioned, Mine Safety Appliances Co. (MSA) and DBI-SALA Fall Protection Inc. are currently developing prototype harnesses that incorporate the TI sizing scheme. Mine Safety Appliances Co. also has indicated interest in more extensive efforts to develop next-generation harness designs and prototypes using the criteria and schemes identified by the TI Program. MSA was strategically selected to participate in the TI pilot studies in year 2000, because company officials had previously expressed interest in revising fall protection designs using updated human form measurements. Both MSA and DBI-SALA also responded to a TI announcement in the Federal Business Opportunities in 2003 for partnership in harness-sizing studies and in transferring the knowledge to design and commercialization. Since the two manufacturers account for about 60 percent of the national market share of fall-arrest harnesses, the future adoption potential of the new harnesses and sizing systems in the construction trades is very high

What's Ahead:
NIOSH, two research contractors, and the two harness manufacturers are finalizing the adjustment range of each harness component. The final report was expected to be completed in December 2006. The two harness manufacturers and TI research team will complete prototypes of the new generation over-the-head harnesses in 2007. TI will use them to conduct studies to determine the validity and reliability of the second sizing system. Continued involvement with the manufacturing, standards, and user communities is anticipated. This will help ensure the diffusion of this technology throughout applicable industries. Additionally, dissemination of findings through peer-reviewed publications, conference presentations and proceedings, and focused fact sheets will remain a goal of research efforts. This project may also be extensible to other industries and internationally.

External Factors:
Support from stakeholders—including the Mine Safety Appliances Co., the American Society of Safety Engineers (ASSE), the International Safety Equipment Association (ISEA), the International Society of Fall Protection (ISFP) and California OSHA—has helped the TI Program obtain resources to advance scientific knowledge on formulating harness-sizing schemes and harness designs for various populations, including women and minorities, to assure the required level of protection, productivity, and comfort of harnesses to workers.

Active participation from the Mine Safety Appliances Co. (MSA) and DBI-SALA Fall Protection Inc. is facilitating the transfer of TI research to industry practice. Success in reducing fall-related injuries and fatalities on a national level, through the use of new generations of fall arrest harnesses, is expected. The following external factors would further enhance the outcome: 1) additional NIOSH funding and human resources to further the technology transfer for the subprogram, and 2) a national safety standard that requires the implementation of the updated anthropometric information in harness design to enhance worker safety during elevated work.

Sub goal 2.3: Reduce worker falls from telecommunication towers

Issue:
Between 1992 and 2005, 227 fatalities occurred that were associated with the construction or maintenance of telecommunication towers.[1] These included 178 deaths resulting from falls, 28 fatalities due to telecommunication tower collapses and 21 deaths from other causes which included, but were not limited to, electrocutions and struck-by incidents.[1] The leading causal factors involved in these fatalities were failure to use or the improper use of personal protective fall equipment, use of improper or inadequate hoisting equipment, lack of maintenance of hoisting equipment, lack of employer safety and health programs, and lack of structured training.[1]

Gross estimates of the risk for fatal injury for U.S. tower erectors suggest fatality rates from 10 to 100 times the average across all industries. While eight tower erectors lost their lives in 2005, 16 lost their lives in 2006. These numbers demonstrate that further work in evaluating this area of construction is necessary.

In 1996, in an effort to combat the high number of fatalities of their membership, and to gain consistent inspection procedures and regulation interpretations, NATE approached the U.S. Assistant Secretary of Labor. The Assistant Secretary instructed the National OSHA office to develop such procedures. As a result, the OSHA Telecommunication Tower Task Force was formed in April 1997. Members on the task force consisted of representatives from various government agencies, including two NIOSH representatives from the TI Program; and private industry groups, including NATE.

Approach:
TI reviewed Bureau of Labor Statistics and Occupational Safety and Health Administration (OSHA) data systems to identify and characterize fatal injuries incurred by workers constructing or maintaining telecommunication towers for the years 1992 through 2005.

TI researchers investigated 10 incidents involving 12 telecommunication tower-related fall fatalities from the years 1992 through 2001. Investigations of these fatal events revealed several important causal factors that are outlined in the **Issues** section above.

Outputs and Transfer:
TI participated in Telecommunication Task Force efforts and provided input to the preparation and dissemination of several important directives and publications. Specifically, TI has provided data analysis, investigative findings, and technical assistance to OSHA, NATE, and other organizations in the collaborative effort to address this emerging problem.

NIOSH researchers developed and disseminated the NIOSH Alert—"Preventing Injuries and Deaths from Falls During Construction and Maintenance of Telecommunication Towers," DHHS (NIOSH) Pub. No. 2001-1561—based upon data analysis and investigative findings. This Alert is now being reprinted in Spanish.

Additionally, [10] FACE reports were published from the TI telecommunication tower-related investigations and widely disseminated through NATE conferences and OSHA training classes.[2-11] These reports are available on the Web at: http://www.cdc.gov/niosh/face/default.html.

TI authored two articles entitled "NIOSH—A Resource for Occupational Health and Safety Support"[12] and "Falls- A Deadly Hazard for Tower Workers"[13] in the October 1998 and March 1999 issues of the NATE monthly publication *Tower Times.* NATE also provides a direct link to the NIOSH homepage and to relevant NIOSH publications in *Tower Times.* (http://www.natehome.com/TowerTimes/Index.cfm)

Intermediate Outcomes:
The Telecommunications Tower Task Force reviewed the leading identified causal factors and, to address these factors, developed and issued a compliance directive entitled "Interim Inspection Procedures During Communication Tower Construction Activities" (OSHA Compliance Directive CPL 02-01-029 - CPL 2-1.29).[14] This document contains the procedures to be used during the inspection of tower construction sites and the procedures to be followed during tower construction. Procedures for the hoisting of materials and employees, hoist selection and use, and fall protection for erectors were outlined. To address falls from these towers, which were the leading cause of fatalities, 100 percent fall protection is now required. This means that tower erectors have to use fall protection (being attached to the tower or a safe climbing device) from the time they leave the ground until they return to the ground. The 100 percent fall protection and personnel hoisting requirements contained in the initial and revised directive were supported by TI investigative findings and data input and, when used correctly, decrease worker exposure to fall hazards.

In March 2002, the compliance directive was revised to remove the restriction that employees' workstations had to be over 200 feet above ground before they could ride hoist lines to the workstations. An erector can now ride the hoist line to the workstation no matter what the height off the ground. The new directive was entitled "Interim Inspection Procedures during Communication Tower Construction Activities" (Compliance Directive CPL 02-01-036 - CPL 2-1.36).[15]

TI data analysis, information from fatality investigations, and recommendations were used in the development of the North Carolina Telecommunication Tower Standard,[16] the first in the nation. This standard outlines the proper safety and health procedures to be used during telecommunication tower construction and maintenance.

NATE has disseminated more than 8,000 copies of the NIOSH Alert to conference attendees at their annual conference and expositions.

Data, investigative findings from TI tower-related investigations, and TI technical input and assistance were used to develop:

- An OSHA safety checklist for telecommunication tower construction safety
- A three-day OSHA train-the-trainer program designed for OSHA compliance officers, contractors, tower erectors, tower owners, wireless service carriers, and tower component manufacturers
- The "Recommended Best Practices Site Safety Manual" produced by NATE at the request of the Advisory Committee on Construction Safety and Health
- A comprehensive NATE safety and health manual

TI researchers provided the Safety and Environmental Compliance Office of the Federal Aviation Administration (FAA) in Miami with information that led to the successful development of a scope of work involving the retrofitting of a damaged NDB antenna tower at Great Inagua, the Bahamas**.** This information included procedures to identify damaged tower components and procedures to replace these components without causing further damage to the tower or injury to workers. The FAA was also provided NATE and OSHA contacts who could supply additional information on accomplishing repair and replacement operations safely.

The president of wirelessestimator.com developed an article on the use of TI telecommunication tower-related reports as training aids for the wireless industry. Wirelessestimator.com is a free Internet service for the wireless industry. According to this site: "Tower construction industry leaders and safety professionals believe that FACE reports can be used effectively to create a greater awareness of how fatalities can easily arise and what preventative measures can be taken to keep them from occurring." The article that includes links to the reports can be found at: http://www.wirelessestimator.com/t_content.cfm?pagename=Fatalities. This Website also includes commentary on some of the FACE investigation reports from industry specialists.

TI researchers provided the Principal Specialist Inspector United Kingdom Health and Safety Executive Technology Division and the Specialist Team Leader United Kingdom Health and Safety Executive Technology Division with safety and health information developed jointly by TI, OSHA, and NATE pertaining to radio frequency (RF) radiation and working safely at heights. This information was provided through links to the TI and OSHA Websites.

What's Ahead:
In November 2006, OSHA and NATE formally entered into a nationwide partnership agreement. This agreement will require, at a minimum, that companies entering the partnership have a comprehensive safety and health program, have a competent person as defined by OSHA on each construction site, have all supervisory personnel complete an OSHA 30-hour tower safety course, and have all other workers on site complete an OSHA 10-hour safety course. Partner companies cannot have experienced a fatality within three years that resulted in a serious or willful violation. TI will continue to provide OSHA and NATE with updated statistics, investigative findings, suggested injury prevention measures, and technical assistance as needed.

External Factors:
While tower erector fatalities have not exhibited a steady downward trend, the lack of accurate data on the numbers of tower erectors currently building or performing maintenance services on telecommunication towers precludes the calculation of fatal fall rates. Rates (number of fatalities per number of workers per year) would provide better estimations of changes in risk over time.

References:

1. NIOSH [2001]. NIOSH Alert: Preventing injuries and deaths from falls during construction and maintenance of telecommunication towers. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-156.

2. NIOSH [1992]. FACE 92-05: Painter dies after 80-foot fall from electrical transmission tower in Indiana. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

3. NIOSH [1997]. FACE 97-10: Tower erector/inspector dies after falling 200 feet from a telecommunication tower to the ground-North Carolina. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

4. NIOSH [1998]. FACE 98-05: Tower worker dies after falling 130 feet from hoist cable to ground-Pennsylvania. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

5. NIOSH [1998]. FACE 98-07: Tower erector dies after falling 125 feet from cellular phone tower-South Carolina. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

6. NIOSH [1998]. FACE 98-20: Tower erector dies after falling 200 feet from telecommunication tower-North Carolina. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

7. NIOSH [1998]. FACE 98-21: Tower painter dies and a second painter injured after falling 900 feet while inside a man basket-South Carolina. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

8. NIOSH [1998]. 98MO161: Tower construction worker dies following 940-foot fall from television tower. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

9. NIOSH [1999]. FACE 99-01: Tower hand dies after 230-foot fall from communication tower-North Carolina. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

10. NIOSH [1999]. 99MO138: Tower construction worker dies following 40-foot fall from cellular tower. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

11. NIOSH [2000]. FACE2000-07: Three tower painters die after falling 1,200 feet when riding the hoist line-North Carolina. Morgantown, WV: U.S. Department of Health and

Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

12. Casini V, Lentz TJ [1998]. NIOSH—A Resource for Occupational Health and Safety Support Tower Times 4(10):35, 37 (October 1998).

13. Lentz TJ, Casini V [1999]. Falls- A Deadly Hazard for Tower Workers Tower Times 5(3):5-6 (March 1999).

14. OSHA [1999].Interim Inspection Procedures during Communication Tower Construction Activities (OSHA Compliance Directive CPL 02-01-029 - CPL 2.29). Available on Web at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=1532

15. OSHA [2002]. Interim Inspection Procedures During Communication Tower Construction Activities (OSHA Compliance Directive CPL 02-01-036 - CPL 2-1-36) Available on Web at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=2770&p_table=DIRECTIVES

16. NCDOL (State of North Carolina Department of Labor) [2005]. Title 13 of the North Carolina Administrative Code State Specific Rule 07F.0600 (13 NCAC 07F.0600) Communications Towers, effective February 1, 2005.

3. Reduce injuries and fatalities due to workplace violence

Issue:
Workplace violence (WPV) resulted in 564 homicides in 2005, 9.9 percent of the total number (5,702) of fatal occupational injuries.[1] Of these homicides, 182 occurred in retail establishments; 68 in food service and drinking places; 58 during State and local justice, public order, and safety activities; 41 in transportation; 11 in healthcare and social service settings; and three in education.[1] In 2005 there were also 14,560 occupational injuries involving lost work days in private industry due to assaults and violent acts by persons (9,850 were in educational and health services and 2,120 in transportation and utilities).[2] The societal cost of workplace homicide during 1992-2001 was estimated to be approximately $6.5 billion at a mean cost per homicide of $800,000.[3]

In FY 2002, Congress appropriated $2 million to the TI Program to "…develop an intramural and extramural prevention research program that will target all aspects of workplace violence and to coordinate its efforts with the Departments of Justice and Labor."[4] This allowed, for the first time, targeted extramural funding of research projects on workplace violence, including five grants that were funded in late FY 2002. The intramural research program has also been enhanced and includes a strong outreach component. Approximately 25 percent of the 2002 initiative funds have supported intramural WPV research, while the other 75 percent of the funds have gone for extramural WPV research activity.

Approach:
Historically, the Traumatic Injury (TI) workplace violence program has been focused on surveillance and reporting of WPV homicides and nonfatal injuries; causation, prevention, and prevention evaluation research in high-risk industries; and consensus building with national experts, stakeholders, and other Federal agencies for the development of strategic planning.

TI surveillance of work-related homicides and nonfatal WPV assaults has identified high-risk worker groups and monitored the effectiveness of prevention efforts. The TI National Traumatic Occupational Fatalities (NTOF) surveillance system enabled TI to report on the number and rates of WPV homicides (and other causes of death) in the 1980s and early 1990s when no other systems were available to provide an accurate count of workplace injury deaths.[5,6] More recently, TI has analyzed and disseminated occupational fatality data, including WPV statistics from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI) system.[1] In order to address the lack of statistics on the number and rate of nonfatal WPV injuries, TI developed and inserted modules of questions on WPV assaults, risk factors, and preventions into three national surveys during 2002-2006. These surveys are discussed in the Outputs and Transfer Section.

The TI intramural research approach is driven by surveillance data to focus on high-risk workers. During 1990 to 1998, the TI research focus was on identifying risk factors and identifying and evaluating prevention measures for workers with the highest risk of fatalities.

These included Type I violence* due to robbery of convenience stores and taxicab drivers. Since 2002, with the receipt of Congressional WPV initiative funds, the TI has expanded its research focus to include workers at high-risk of nonfatal WPV assaults in service industries (psychiatric hospitals workers and teachers) and on models for dissemination of known successful interventions into high-risk retail businesses (small grocery stores, gas stations, bakeries and donut shops, eating and drinking places, motel/hotels, and other high-risk retail businesses).

The TI extramural approach has focused research on all WPV types and has complemented the intramural effort. NIOSH funded 16 grants in WPV during 1996 to 2003. Response to the TI 2002 WPV RFA employing extramural WPV initiative funds was extraordinary and five research grants were funded in 2002, totaling $1.8 million. Of the 16 grants, five have focused on retail business workers, eight on healthcare and social service workers, one on police officers, one on long-haul truckers, and one on domestic violence in the workplace as research topics.

TI has sought to coordinate the development of a national agenda for WPV research agenda through periodic national conferences, workshops, and stakeholder meetings. TI has also sought to coordinate research collaboration between Federal agencies in accordance to stakeholder recommendations.

Outputs and Transfer:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

During 1991 to 1994, 11 papers were published that presented national surveillance data on the number of and risk factors for WPV homicides.[7-17] TI research has been widely quoted in the literature and cited in OSHA guidelines. These papers have been cited in 154 publications.

More recently, one paper was published on the cost of WPV fatalities[3] and one paper was been submitted for publication in 2006 on homicide trends from 1993 to 2002.[18] The homicide trends paper indicates that although WPV homicides are decreasing, public safety, retail workers, and taxicab drivers are still at high-risk of WPV homicides. These data will further shape future TI intramural and extramural research strategic goals.

---

* Workplace violence has been categorized into four types for public health attention (Merchant and Lundell, 2001):

Type I is criminal intent in which perpetrator has no legitimate relationship to the business or its employees, and is usually committing a crime in conjunction with the violence. These crimes include robbery, shoplifting, and loitering. A large portion of Type I violence occurs in the late-night retail industry.

Type II is customer/client violence in which a perpetrator has a legitimate relationship with the business and becomes violent while being served by the business. This category includes customers, clients, patients, students, inmates, and other groups for which a business provides services. A large portion of Type II violence occurs in the healthcare industry, in settings such as nursing homes or psychiatric facilities where the victims are often patient care-givers. Police officers, prison staff, airline employees and teachers provide other examples of workers exposed to this violence.

Type III is worker-on-worker violence, in which the perpetrator is an employee or past employee of the business who attacks another employee.

Type IV is personal relationship violence in which the perpetrator does not have a relationship with the business but with the victim. A NIOSH study of the CFOI data on workplace homicides from 1993-2002, disclosed that Types I, II, III, and IV accounted for 82 percent, 3.8 percent, 8.2 percent, and 5.4 percent, respectively, of all (8,148) workplace homicides (Hendricks, Jenkins, and Anderson, in press 2006).

TI published a NIOSH Alert on occupational homicides in 1993[19] and a Current Intelligence Bulletin on WPV in1996.[20] Other publications provided additional reviews and recommendations.[21-26] These publications were groundbreaking reports—the first to highlight the problem in WPV on the national level.

TI disseminated its publications to other Federal agencies for use in development of WPV recommendations by these agencies. For example, TI made recommendations to OSHA, the Office of Personnel Management, and the FBI. See the Intermediate Outcomes section for more detail about outputs from these agencies.

Following the Alert and other NIOSH publications, TI responded to a large volume of media requests for WPV information. TI staff completed an on-air interview on "CBS Evening News" and contributed to CNN and national AP stories. ABC, NBC, CBS, and CNN radio provided coverage, along with the "Today Show" and "Good Morning America," and local media outlets. Over the past decade, other TI researchers have completed national television and radio interviews on the topic of WPV. TI has also responded to requests for print media interviews, often being called upon for expert input after specific incidents of workplace violence.

In addition to media interviews, In 2002 TI published a pamphlet on occupational hazards in hospitals [27] and in 2004 TI produced a DVD entitled "Violence on the Job"[28] to further disseminate its WPV recommendations.

During 1990 to 1998, TI conducted intramural research on robbery and robbery-related risk factors injury among late-night retail workers which confirmed the effectiveness of elements of Crime Prevention through Environmental Design (CPTED) programs to prevent robbery and associated injuries. This research confirmed recommendations in NIOSH Alerts and OSHA guidelines. Four papers [29-33] were published from four convenience stores studies and results were presented at three national conferences and meetings. The papers have been cited 25 times in other journal articles.

Because of the lack of detailed surveillance data on nonfatal workplace violence, NIOSH funded modules of questions to be inserted into three national surveys during 2002 to 2006. The purpose of these surveys was to evaluate workplace security operations, types and status of WPV programs and policies, employee training, and reporting procedures. These surveys include a special victims' survey of workplace risks conducted for TI in collaboration with the Bureau of the Census and the Bureau of Justice Statistics as part of its National Crime Victimization Survey (NCVS), a telephone interview survey of workers who were treated for work-related assault injuries in a sample of U.S. hospital emergency departments through the Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS), and a survey of employers with regard to workplace violence policies, training, and related issues conducted in collaboration with the Bureau of Labor Statistics (BLS) during 2005 and 2006. Two papers, currently in draft form, report on data from the 2002 to 2006 NCVS and NEISS surveys.

Between 1990 and 2005, TI researchers made at least 51 presentations on workplace violence at various occupational safety and health, public health, and criminology scientific conferences. Thirty-six of these were invited presentations. In addition, 17 invited presentations were given at labor or industry forums specific to workplace violence. NIOSH expertise is recognized and sought not only by research colleagues but also by industry and labor representatives. In 2001, during a Congressional Briefing sponsored by Senator Harkin and Representative Leach, Jim

Merchant (University of Iowa) argued for increased Congressional funding and identified NIOSH as taking a leading role in the national WPV effort.[34]

In a 1996 "Occupational Medicine: State of the Art Reviews" volume, there was one NIOSH-authored article.[13] Eight of the other 13 articles in this volume specifically referenced NIOSH research and recommendations while one reported the findings from a NIOSH-funded study. In the 2003 "Clinics in Occupational and Environmental Medicine" special volume on workplace violence, there was one NIOSH-authored article;[25] six of the other 12 articles specifically referenced NIOSH, and two articles reported findings from NIOSH-funded studies.

With regard to extramural research outputs, NIOSH awarded 16 grants in workplace violence during September 1999 to September 2002. Nine grants involved research on workplace violence risk factors and seven involved evaluations of interventions. Of the 16 grantees, six who provided summaries of their outputs had 43 publications and 62 presentations. Outputs from an example of some of these extramural grants are highlighted below:

During 1999 to 2002, NIOSH funded UCLA to develop and evaluate the Workplace Violence Prevention Program (WVPP) in 314 Los Angeles retail establishments. This project demonstrated a reduction in all violent crimes of more than 30 percent and in robbery more than 50 percent in high compliance establishments compared to non-intervention comparison groups. UCLA published three publications from this NIOSH extramurally funded research and a fourth has been submitted for publication. UCLA's WVPP was subsequently implemented by Santa Monica and Oxnard police departments which completed intervention projects in more than 60 retail establishments. There were nine publications from this study.

a. NIOSH funded an evaluation of the "OSHA Guidelines for the Prevention of Violence in Health Care and Social Service Settings." Researchers from the University of Maryland and the New York State Public Employees Federation partnered to implement and evaluate the OSHA healthcare guidelines in mental healthcare facilities. Particular emphasis was placed on the elements regarding management commitment and employee involvement in the development and implementation of specific violence prevention strategies in these facilities. There were four publications from this study.

b. NIOSH funded UCLA to evaluate the California OSHA "Guidelines for Security and Safety of Health Care and Community Service Workers" and California Assembly Bill 508: the California Hospital Safety Act. The evaluation included both process and outcome components in approximately 200 hospitals in California and New Jersey. The process evaluation identified changes in safety protocols and procedures, equipment, and training, as well as environmental and work practice modifications made in response to these State initiatives. The process evaluation also gauged each hospital's efforts to identify and respond to their individual risks through risk assessments and surveillance activities. The outcome evaluation examined changes in the incidence rate of assault events against employees before and after the initiatives. There were eight publications from this study.

In response to the Congressional funding initiative, TI created the Federal Interagency Task Force on Workplace Violence Research and Prevention with partners from the Departments of Labor and Justice and representatives from 20 Federal agencies. Details are provided in Appendix I: Supporting Evidence.

In 2003 TI hosted four stakeholder meetings in Washington, D.C. to gather input on how NIOSH could assist stakeholders in preventing WPV and to bring partners and stakeholders together to identify research gaps and direction for future research. Meetings were held on the topics of 1) healthcare, 2) domestic violence in the workplace, 3) retail, and 4) security/law enforcement. Attendees included municipal, State, and Federal government agencies, academia and professional associations, private industry and trade associations, security experts, and labor unions. A detailed description of the conferences, workshops, and meetings is included in the Appendix I: Supporting Evidence.

TI sponsored the national conference—Partnering in Workplace Violence Prevention: Translating Research to Practice— held in Baltimore, Maryland on November 17 to 19, 2004. A group of 182 representatives from a cross-sector of private industry, academics, trade associations, and Federal partners participated in this conference to make recommendations for a national WPV agenda. A conference summary document was published as a NIOSH numbered publication in September 2006.[35]

Intermediate Outcomes:
The contribution of TI surveillance and research likely contributed to an increase in research addressing WPV. The number WPV-related publications increased dramatically from 1970 to 2004 in the Medline database (see Figure 9 below).[36] Similar trends have been noted in the business, occupational safety and health, and legal literature. The dramatic upturn in interest in WPV, expressed in a high volume of published literature, occurred in the period from the late 1980s to the early 90s, coincident with TI surveillance findings and early reports in the literature indicating that homicide was a leading cause of traumatic occupational fatality.

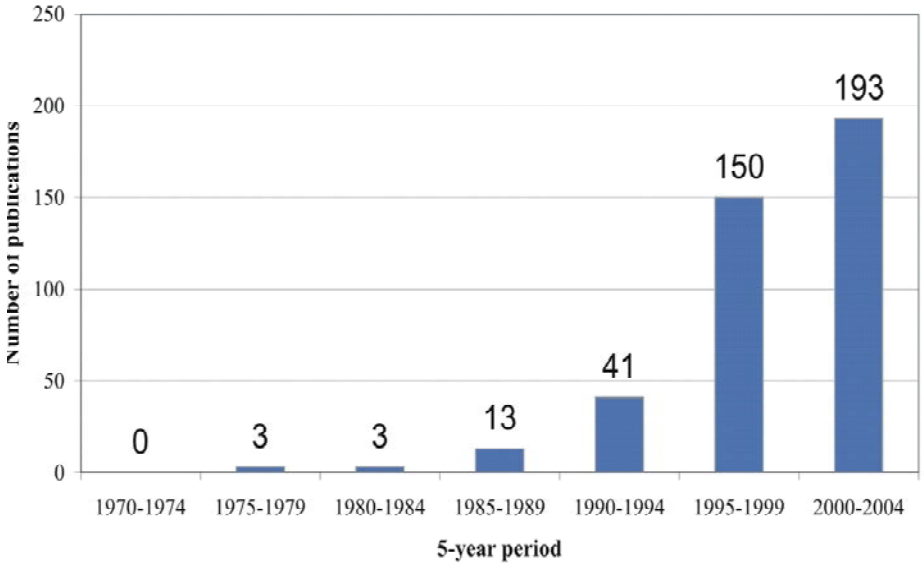

Figure 9: Medline entries for WPV for five-year periods from 1970 to 2004

In 1998, OSHA published its recommendations for WPV prevention programs in late-night retail establishments. 37 OSHA quoted TI surveillance and convenience store research. [5-7,29-33] The OSHA publication provided recommendations for management commitment and employee participation, worksite analysis of common retail robbery risk factors, security systems, prevention strategies (engineering controls/environmental designs, administrative and work practices, and post incident response), training of workers, and incident reporting and recordkeeping.

In 2000, OSHA published a fact sheet for recommendations for WPV in taxi and livery drivers. [38] OSHA quoted the NIOSH 1996 intelligence bulletin.[20] The fact sheet described the problem, risk factors, safety measures, employer responsibilities and rights.

In 2004, OSHA published guidelines for preventing WPV for healthcare and community service workers.[39] OSHA quoted NIOSH 1996 current intelligence bulletin and NIOSH recommendations for hospitals. [20, 27] The guideline provided recommendations for engineering controls and workplace adaptations, administrative and work practices, employer response, training, and recordkeeping and evaluation.

TI research and the OSHA recommendations[37-39] likely influenced many State and local workplace violence policies and regulations, although this has never been validated. TI assessed State-based approaches to WPV prevention and developed a compendium of State-based regulatory policies.[40] By October 2005, all but three States had developed workplace violence training materials, publications, or other guidance—10 had WPV policies, 15 had general WPV statutes, 11 had employers restraining order statutes, three had late-night retail statutes, and two had healthcare statutes.[40]

In 1998, The U.S. Office of Personnel Management (OPM) published a guide for agency planners in dealing with workplace violence. [41] NIOSH participated on the interagency workgroup which developed this guideline. The guide provided comprehensive approaches to analyzing and responding to threats or violent incidents in Federal workplaces.

The FBI published the proceedings of a 2002 symposium/workshop to address issues in response to workplace violence. [42] TI participated on the workgroup which developed these guidelines. The guidelines provided for threat assessment and management, crisis management and critical incident response, and legislative and research recommendations.

In 2005, the American Society for Industrial Security (ASIS) prepared guidelines for WPV prevention and response.[43] TI staff, at the request of the ASIS, participated on an expert panel to develop guidelines for WPV prevention and response in 2005. These guidelines were developed, submitted for public review and comment, and then published as consensus standards in late 2005.

During stakeholder meetings and conferences, partners and stakeholders provided recommendations on WPV research needs and roles for NIOSH, other Federal partners, State agencies, the private-sector, and other organizations.

Recommendations for future research from the 2004 conference[35] include:

1. Establish a national strategy/agenda
2. Conduct evaluation research
3. Develop consistent WPV definitions
4. Ensure consistent and universal reporting
5. Share data among partners
6. Conduct economics research

In addition to the NIOSH roles in conducting, collaborating in, and coordinating WPV research, these principal roles were suggested for NIOSH:

1. Developing and keeping a clearinghouse of information about WPV
2. Developing data gathering standards and a reporting system that capture all WPV events (verbal abuse and physical assaults)
3. Leading an effort to make WPV more visible

End Outcomes:
The number of workplace homicides decreased significantly from 1,074 in 1993 to 570 in 2004 (See Figure 10 below). The greatest decline in workplace homicides has been in the retail industry (from 525 in 1993 to 160 in 2004). Although progress has been made in reducing workplace violence, homicide is still a problem among police and security workers, late-night retail workers, and taxicab drivers. Additionally, workplace assaults leading to nonfatal injuries is a problem among police and security workers, late-night retail workers, taxicab drivers, bus drivers and other transportation workers, healthcare workers particularly in psychiatric facilities, and teachers.[2]

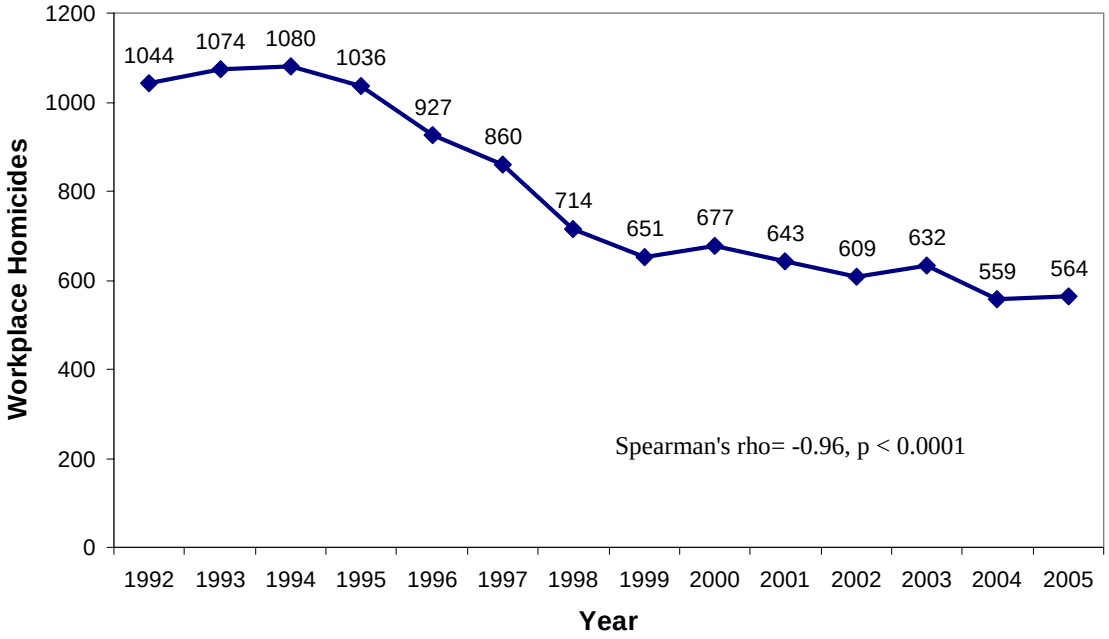

Figure 10. Number of Workplace Homicides in the U.S., 1992-2005
Source: BLS Census of Fatal Occupational Injuries (CFOI).[1]

TI surveillance data, research findings, coordination efforts, and extensive outputs and transfer activities have likely contributed to the decline in workplace homicides. However, many partners and stakeholders have also contributed. In addition to TI, a list of potential contributors to the reduced toll would have to include:

- Academic and industry security research in convenience stores, 1980 to 1998
- The National Association of Convenience Stores industry prevention guidelines
- The 1998 OSHA recommendations for robbery prevention in late-night retail establishments[37] and 2000 fact sheet on prevention measures for taxicab and livery drivers[38]
- State and local ordinances, polices, and training focusing on retail establishments and taxicab drivers
- Local community policing programs implementing CPTED elements in convenience stores, restaurants, banks, and shops
- Advocacy group pressure

What's Ahead:
The TI strategic plan aims to reduce WPV through evaluation and dissemination of effective interventions in high-risk industries and occupations. The TI Program plan will continue to focus on late-night retail clerks, healthcare and social service workers, teachers, and taxicab drivers, and other high-risk occupations. The TI WPV agenda will continue to build on previous research and achievements.

The TI Program will continue to collect, analyze, and disseminate national statistics on WPV homicides and nonfatal injuries. This will include analysis of BLS CFOI data, the National Electronic Injury Surveillance System (NEISS) emergency room data, BJS National Crime Victimization Survey data, and BLS Employer Survey data. TI will continue to monitor trends and impact of interventions. For example, TI will complete analyses and publications on the three national surveys to provide national statistics on nonfatal workplace violence. Additionally, these agencies will periodically be funded to continue to provide nonfatal WPV statistics.

NIOSH funded permanent changes to the NCVS to improve the quality and level of detail available to characterize workplace victimizations on an ongoing basis. For example, industry and occupation coding has been added to the NCVS for respondents who report experiencing workplace victimization. More detailed categories have also been added for variables describing the relationship of victims to offenders and the locations of work-related victimizations. These changes that were implemented in collaboration with the Bureau of Justice Statistics and the Bureau of the Census became effective in June 2001. These enhancements will allow continued monitoring of the nature and magnitude of workplace victimizations in addition to the in-depth, one-time surveys described above.

TI researchers have partnered with the former UCLA WVPP project research team to evaluate the administration of the WVPP using a community policing model. The goal of the TI approach is to facilitate development and to confirm the effectiveness of models which will increase enrollment and compliance of retail establishments to programs such as UCLA's WVPP. Community policing models which incorporate community organization involvement are to be evaluated. This project is now being developed for FY 2007 initiative funds.

Proposals for studies in general medical care and psychiatric care have been formulated. TI researchers have partnered with Veterans Home Administration (VHA) researchers to evaluate an intervention to reduce verbal threats and physical assaults to workers in VHA psychiatric hospitals. Pilot studies by the VHA have shown that WPV-focused twice-weekly community meetings between nurses and patients can reduce violent workplace events by as much as 50 percent. If future TI research in VHA hospitals supports the pilot findings, the intervention will be evaluated in private-sector psychiatric hospitals.

TI intramural researchers have also proposed to identify circumstances of WPV among teachers and other service workers, and to evaluate the effectiveness of current intervention programs.

TI will continue consistent with its Congressional mandate to work with other Federal agencies to conduct research to reduce workplace violence in the Federal sector. NIOSH will continue to sponsor workshops and conferences to promote and support WPV research and to help shape and achieve national strategic goals.

External Factors:
A variety of external factors have affected the evolution of the TI WPV program. For example, the distinction between public health and law enforcement objectives must be considered. Support from law enforcement agencies has provided some unique surveillance, risk factor, and intervention evaluation opportunities in convenience store robbery prevention research. On the other hand, lack of support from some law enforcement agencies has caused difficulties in the evaluation of State and local ordinances requiring taxicab or convenience store security measures.

Some businesses were unwilling to participate in WPV intervention evaluation studies for a variety of reasons, including distrust of researchers, inability to afford costly interventions, perceptions that their workers were not at sufficient risk to warrant the intervention, or concern with advocacy group and regulatory pressure for tighter security measures (such as multiple clerks on the third shift in convenience stores).

Resistance to the promulgation of Federal, State and local regulations for WPV prevention is a factor. For example, despite the evidence of effective intervention approaches, only three States have thus far adopted late-night retail (convenience store) ordinances.

Another factor impeding researchers is the difficulty they have in obtaining detailed nonfatal WPV injury surveillance data.

References:

1. Bureau of Labor Statistics [2006]. Census of Fatal Occupational Injuries, Current and Revised Data. Preliminary Data for 2005, available on BLS Website at: http://www.bls.gov/iif/oshcfoi1.htm#2005. Last accessed November 28, 2006.

2. Bureau of Labor Statistics [2005]. Nonfatal occupational injuries and illnesses requiring days away from work, 2005. NEWS, USHOL BLS 06-1982, Nov. 17, 2006.

3. Hartley D, Biddle EA, Jenkins EL [2005]. Societal cost of workplace homicides in the United States, 1992-2001. American Journal of Industrial Medicine 47: 518-527.

4. U.S. Congress [2002]. FY 2002 House/Senate/Conference/Appropriations Language [Senate S-107-84; Conference SR 107-350] for LHHS (Labor and Health and Human Services). January 11, 2002.

5. NIOSH [1989]. National Traumatic Occupational Fatalities: 1980-1985, DHHS (NIOSH) Publication No. 89-116. Cincinnati, OH: National Institute for Occupational Safety and Health, 28 pp. (September 1989).

6. NIOSH [1993]. Fatal Injuries to Workers in the United States, 1980-1989: A Decade of Surveillance, DHHS (NIOSH) Publication No. 93-108. Cincinnati, OH: National Institute for Occupational Safety and Health, 27 pp. (August 1993).

7. Bell CA [1991]. Female Homicides in United States Workplaces, 1980-1985. AJPH 81(6):729-732.

8. Castillo DN, EL Jenkins [1994]. Industries and Occupations at High Risk for Work-Related Homicide. Journal of Occupational Medicine 36(2):125-132.

9. Goodman RA, Jenkins EL, Mercy JA [1994]. Workplace-Related Homicide Among Health Care Workers in the United States, 1980 Through 1990. Journal of the American Medical Association 272:1686-1688.

10. Jenkins EL, Layne LA, Kisner SM [1992]. Homicide in the Workplace: The U.S. Experience, 1980-1988. AAOHN Journal 40(5): 215-218.

11. Jenkins EL [1994]. Occupational Injury Deaths Among Females: The U.S. Experience for the Decade 1980-1989. Annals of Epidemiology 4:146-151.

12. Jenkins EL [1996]. Homicide Against Women in the Workplace. Journal of the American Medical Women's Association 51(3):118-122.

13. Jenkins EL [1996]. Workplace Homicide: Industries and Occupations at High Risk. Occupational Medicine: State of the Art Reviews 11(2):219-225.

14. Jenkins EL [1998]. Prevention Strategies and Research Needs in Violence in the Workplace: Preventing, Assessing, and Managing Threats at Work. Edited by Carol W. Wilkinson. Rockville, MD: Government Institutes.

15. Jenkins EL [1998]. Violence in the Workplace: Scope of the Problem and Risk Factors in Violence in the Workplace: Preventing, Assessing, and Managing Threats at Work. Edited by Carol W. Wilkinson. Rockville, MD: Government Institutes.

16. Centers for Disease Control and Prevention (CDC) [1994]. Occupational Injury Deaths of Postal Workers—United States, 1980-1989. MMWR 43(32):593-595.

17. Bell CA, Jenkins EL [1992]. Homicide in U.S. Workplaces: A Strategy for Prevention and Research. DHHS (NIOSH) Publication No. 92-103. Cincinnati: National Institute for Occupational Safety and Health.

18. Hendricks S, Jenkins EL, Anderson KR. Trends in workplace homicides in the U.S. 1993-2002: a decade of decline. Am. J. Ind. Med., Submitted for publication, May, 2006.

19. NIOSH [1993]. Alert: Request for Assistance in Preventing Homicide in the Workplace. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 93-109.

20. Jenkins EL [1996]. Current Intelligence Bulletin 57, Violence in the Workplace: Risk Factors and Prevention Strategies. DHHS (NIOSH) Publication No. 96-100.

21. Fisher BS, Jenkins EL, Williams N [1998]. The Extent and Nature of Homicide and Nonfatal Workplace Violence in the United States: Implications for Prevention and Security in Crime at Work: Increasing the Risk for Offenders, Volume II. Edited by Martin Gill. Perpetuity Press, Leicester, UK.

22. Anderson KR, Tyler MP, Jenkins EL [2004]. Preventing workplace violence. Journal of Employee Assistance 34(4): 8-11.

23. Jenkins EL [2002]. Existing evidence of the prevalence of violence in health services within different geographical, social, and economic settings. In: Workplace violence in the health sector: State of the Art. Edited by Cary L. Cooper and Naomi G. Swanson. International Labor Organization.

24. NIOSH [2002]. Violence: Occupational Hazards in Hospitals. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2002-101.

25. Peek-Asa C, Jenkins EL [2003]. Workplace violence: how do we improve approaches to prevention? Clinics in Occupational and Environmental Medicine 3(4): 659-672.

26. Quick JC, Piotrkowski C, Jenkins EL, Brooks YB [2003]. Four Dimensions of Healthy Work: Stress, Work-Family Relations, Violence Prevention, and Relationships at Work. [Book Chapter] In: Psychology Builds A Healthy World: Opportunities for Research and Practice, 233-273.

27. NIOSH [2002]. Violence: Occupational Hazards in Hospitals, DHHS (NIOSH) Publication Number 2002-101. Cincinnati, OH: National Institute for Occupational Safety and Health, 10 pp.

28. NIOSH [2004]. Violence on the Job. DVD. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2004-100d.

29. Amandus HE, Zahm D, Friedmann R, et al. [1996]. Employee injuries and convenience store robberies in selected metropolitan areas. J Occup Environ Med 38(7):714-720. [Cited in 5 peer-reviewed articles].

30. Amandus HE, Hendricks SA, Zahm D, et. al. [1997]. Convenience store robberies in selected metropolitan areas – Risk factors for employee injury. J Occup Environ Med 39(5):442-447, May. [Cited in 9 peer-reviewed articles].

31. Amandus HE, Hunter RD, Hendricks JES [1995]. Reevaluation of the effectiveness of environmental designs to reduce robbery risk in Florida convenience stores. J Occup Environ Med 37(6): 711-717.

32. Hendricks SA, Landsittel DP, Amandus HE, Malcan J, Bell J [1999]. A matched case-control study of convenience store robbery risk factors. JOEM 41(11):995-1004. [Cited in 9 peer-reviewed articles]

33. Faulkner KA, Landsittel DP, Hendricks SA [2001]. Robbery characteristics and employee injuries in convenience stores. Am J Ind Med 40(6):703-709, Dec. [Cited in 2 peer-reviewed articles]

34. Bureau of National Affairs (BNA) [2001]. Occupational Safety and Health Reporter, March 8, 2001.

35. NIOSH [2006]. Workplace Violence Prevention Strategies and Research Needs: Report from the Conference Partnering in Workplace Violence Prevention: Translating Research to Practice, November 17–19, 2004, Baltimore, Maryland. NIOSH Publication No. 2006-144. Cincinnati, OH: National Institute for Occupational Safety and Health, 38 pp.

36. National Library of Medicine. PubMed bibliographic database search conducted on-line (search strategy: “workplace violence” OR “occupational violence” OR “workplace assault” OR “occupational assault” OR “workplace homicide” OR “occupational homicide”) [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=PubMed]. Date accessed: July 8, 2005.

37. OSHA [1998]. Recommendations for workplace violence prevention programs in late-night retail establishments. OSHA 3543, 1998.

38. OSHA [2000]. Risk factors and protective measure for taxi and livery drivers. USDOL OSHA, May 2000.

39. OSHA [2004]. Guidelines for preventing workplace violence for health care and social service workers. OSHA 3148-01R.

40. NIOSH [2005]. A state-based inventory of workplace violence policies, statutes, and training guidelines. Internal TI report (October 2005).

41. US Office of Personnel Management [1998]. Dealing with workplace violence: a guide for agency planners. OWR-09, February 1998.

42. FBI [2002]. Workplace violence: issues in response. Publication from June 10-14, 2002 Symposium, Leesburg, VA.

43. American Society of Industrial Security [2006]. Guidelines for WPV. (http://www.asisonline.org/guidelines/guidelineswpvfial.pdf).

4. Reduce injuries and fatalities due to machines

Introduction

Many workers operating or working around hazardous machinery or equipment are killed or injured. For the period 1980 to 1997, data from the National Traumatic Occupational Fatalities (NTOF) surveillance system documented that machinery was the third leading cause of death after motor-vehicles and homicides, accounting for approximately 13 percent of the total fatalities. Industry divisions with the highest number of fatal injuries due to machinery were: agriculture, mining, manufacturing, and construction.[1] More recent fatal and nonfatal occupational data confirm that machines are still a problem in the workplace. According to data from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) for 2005, on average, approximately 770 workers (14 percent) are fatally injured by some type of machine, plant and industrial powered vehicle, or tractor each year in the U.S. Tractors were the primary source of the largest number of such deaths (219), construction, logging, and mining machinery resulted in 199 deaths, forklifts in 94 deaths, and agriculture and garden machinery (excluding tractors) in 65 deaths.[2] Nonfatal injury and illness data from the 2005 BLS Survey of Occupational Injuries and Illnesses indicated that machines, plant and industrial powered vehicles, or tractors were the source of injury for 96,540 private-sector workers (eight percent) with lost-time injuries or illnesses.[3]

References:

1. CDC [2001]. Fatal Occupational Injuries – United States, 1980-1997. *MMWR 50*: 317--20.

2. Bureau of Labor Statistics. 2005 Census of Fatal Occupational Injuries (preliminary data). Washington, DC: US Department of Labor, Bureau of Labor Statistics; 2006. Available at http://www.bls.gov/iif/oshcfoi1.htm

3. Bureau of Labor Statistics. 2005 Survey of Occupational Injuries and Illnesses. Washington, DC: US Department of Labor, Bureau of Labor Statistics; 2006. Available at http://www.bls.gov/iif/oshcdnew.htm

Sub goal 4.1: Reduce injuries and deaths caused by tractor rollovers by increasing availability and use of effective roll-over-protective structures (ROPS)

Issue:

According to data from the BLS Census of Fatal Occupational Injuries, 1,894 agricultural workers died from tractor-related events between 1992 and 2000; 991of these deaths were due to tractor overturns.[1] The majority of these deaths involved farmers and farm workers over the age of 55 years. This same age group has also been found to have the highest fatality rates due to tractors. The use of roll-over-protective structures (ROPS) and seatbelts has been shown to be effective in preventing tractor overturn-related deaths and injuries.[2,3] TI Program data indicate that only 38 percent of tractors used on farms in the U.S. had a ROPS in 1993; this had increased to 50 percent in 2001.[1,4] The fatality rate for farm workers from tractor overturns has decreased only slightly since 1992.

Tractor data from the TI Program's Traumatic Injury Surveillance of Farmers (TISF) indicate that many tractors still in service were manufactured prior to the release of ROPS as an option on farm tractors in the mid- to late-1960s.[4,5] In addition, these non-ROPS tractors are primarily small to medium size "utility" tractors (tractors between 20 and 90 horsepower) used primarily on farms such as livestock operations (including dairies), field crop operations, and fruit and vegetable operations. Agricultural safety professionals have identified several barriers preventing farm operators from placing ROPS on tractors, including the cost and inconvenience of placing ROPS on older farm tractors. Additionally, for some agricultural operations, ROPS may interfere with tractor use in low-clearance areas.

The three types of farming where clearance is a major issue are livestock operations, dairy operations, and fruit/nut tree operations (because of the need to drive tractors into animal facilities or through rows of trees in an orchard). Based on 1993 tractor survey data, these farms accounted for about 2.7 million tractors, of which 67 percent did not have ROPS.[9] While it is not possible to say that all of these tractors do not have ROPS because of clearance issues, it does show that these farms had lower than average ROPS usage. TI is unaware of any data on whether farmers deferred buying new tractors because ROPS were standard on new tractors. While there are fold-down ROPS available for low clearance use on new tractors, they require the operator to manually put the folded ROPS into the upright position upon exiting a low clearance area.

Another issue that impacts ROPS design is the lack of updated anthropometry (human body measurement) data for agricultural populations that operate tractors. Inappropriate fit of people to workplace vehicles and equipment can directly or indirectly result in injury to workers. Individuals in the United States are becoming taller and heavier with time. Much of the available anthropometric data used in assessing the fit or design of machines in the workplace, including tractors, are outdated, two-dimensional, and do not typically include data on working women and minorities.

Approach:
Based on the tractor demographic data and the barriers to ROPS use identified by others, TI has undertaken an intramural program to increase the use of ROPS on farms in the United States. The program involves surveillance of ROPS use, evaluation of the cost-benefit of ROPS, and engineering research to develop ROPS designs that address common barriers.

In 1994, the TISF system was established as a means of collecting occupational injury data for farmers and farm workers across the United States. In addition to injury information, the TISF collected data on tractors used on U.S. farms and whether these tractors had a roll-over-protective structure (ROPS). TISF collected data on the tractor manufacturer, model, age, ROPS status, and the hours of use of each tractor on a farm. Farms averaged more than two tractors each with an average age of more than 20 years. More than 60 percent of U.S. farm tractors were without a ROPS. In addition to providing baseline tractor information for TI and others in the agricultural safety and health community, these TISF tractor data enabled TI researchers to estimate the most common tractor models used on farms that were without ROPS. The TI Program used these data to identify common older tractor models for assessing their structural integrity—particularly their ability to support ROPS structures during overturns—and for designing new ROPS for retrofitting them.

Although TISF was discontinued in 1997, surveillance of occupational injuries to farmers and farm workers was re-established through the Occupational Injury Surveillance of Production Agriculture (OISPA) project. As with the TISF before it, OISPA collected demographic and ROPS use information on farm tractors used on farms in the U.S. These data indicated that the use of ROPS had increased in the United States between 1993 and 2001, with nearly 50 percent of all tractors in use on farms having either a ROPS roll bar or a ROPS cab in 2001. Roll bar style ROPS showed the largest increase in use (75 percent). Historically, tractors have had a long useful lifetime and the average age increased somewhat over the eight years between surveys.

Figure 11: AutoROPS prototype test, 1999

The distribution of the most common tractors without ROPS changed little between the surveys, with the oldest tractors, the Farmall models, being slowly taken out of service.

Based on the tractor information collected through the TISF, a cost-effectiveness assessment of retrofitting tractors with ROPS was conducted.[4] The study concentrated exclusively on fatalities due to tractor overturns. The key findings from the study were that the immediate ROPS retrofitting of the most common farm tractor model in 1993 would save nearly 1,500 lives over 20 years at an estimated savings of $825,000 per life. The paper also found that a 1985 ASAE voluntary standard to place ROPS on all farm tractors manufactured after 1985 was having an impact on the use of ROPS. But the paper concluded that it would take 20 to 25 years for the standard to increase the use of ROPS on farms sufficient to cause a major reduction in tractor overturn deaths. A more complex economic analysis incorporated the cost of nonfatal injuries with the cost of fatal injuries associated with tractor overturns.[7,8] This analysis found that retrofitting tractors with ROPS would save approximately $490,000 per averted injury, and that the United States could save approximately $1.5 billion by retrofitting tractors with ROPS.

The TI engineering approach is focused on development of an auto-deploying ROPS (AutoROPS) for use in low clearance areas, and cost-effective ROPS designs (CROPS) for retrofit. While conducting this work, TI researchers began to have concerns about the anthropometric data used to define the ROPS protective zone for national consensus ROPS standards. This resulted in a separate research project to collect anthropometric data on a large sample of farm workers.

In 1993, the TI Program began development of AutoROPS, and in 1995 it began development of an AutoROPS overturn sensor. A ROPS was needed that could be lowered and latched for day-to-day use, but that could deploy during an overturn. Plus, an overturn sensor was required to monitor tractor operating conditions and provide a signal that would deploy the AutoROPS when needed. By 1999, TI had developed workable devices. The AutoROPS was tested at West

Virginia University and the sensor was tested in an intramural TI Program laboratory. However, to verify that the components would work together, TI conducted field tests. In the spring of 2000, the first AutoROPS overturn test was conducted at the NIOSH Pittsburgh Research Laboratory (PRL). It showed that the AutoROPS worked. Subsequent testing refined the AutoROPS structure and sensor designs.

In June, 2003, TI placed an announcement in the Federal Business Opportunities publication, soliciting equipment manufacturers for a partnership. TI subsequently entered into a partnership with SCAG Power Equipment. SCAG wanted TI to develop an AutoROPS for a line of zero turn lawn mowers.

TI secured a grant through the California State University—San Bernardino, Office of Technology Transfer and Commercialization (OTTC) to continue work with SCAG. (The OTTC mission is to promote the transition of new technologies to the marketplace.[10]) A new AutoROPS was developed with SCAG for its Turf Tiger zero-turn commercial mower. TI petitioned the American Society of Agricultural and Biological Engineers (ASABE) to begin work on a performance standard for the AutoROPS–ASABE-X599, Standardized Deployment Performance of an Automatic Telescoping ROPS for Agricultural Equipment. This standard was developed collaboratively by tractor manufacturers, ROPS manufacturers, academics, and government researchers. Once a standard is issued, manufacturers such as SCAG can begin producing the AutoROPS.

In 2000, a new NORA project continued the AutoROPS work. It included research for Cost-effective ROPS (CROPS) and composite ROPS. The CROPS research investigated the use of readily available commercial parts to construct a ROPS for different model tractors. Based on the estimates of common tractors in use without ROPS, the TI team chose 10 tractor models for CROPS designs. Initially, the researchers investigated different CROPS designs for a Ford 4600 model tractor (because TI already owned one). In 2002, the team successfully designed, built, and tested a CROPS design that passed the SAE-J2194 industry ROPS standard.

Having demonstrated that the CROPS could be a valid option for rollover protection, the team began work on five more CROPS designs. Through Federal Business Opportunities, TI solicited help from a ROPS manufacturer. A partnership with FEMCO resulted. FEMCO was responsible for manufacturing two of the five CROPS designs. Due to FEMCO's production schedule, they have not yet produced any CROPS. The TI Program team completed the designs for all five tractor models. However, there were more models identified that required a CROPS design.

To address the gap in updated, reliable anthropometry data, the TI Program began collecting 3D body measurements of specific worker populations—including farmers and farm workers—using whole-body scanning technology. The use of 3D body form models allows designers and manufacturers to deliver more accurate, better fitting products through a substantial reduction in measurement error and a reduced reliance on body form assumptions.

A total of 100 agricultural workers were scanned using the 3D system.[11] The results showed that the vertical clearance for the current Society of Automotive Engineers ROPS standard is approximately 12 percent too short. In 2004, TI presented these data to the Society of Automotive Engineers J2194 Standard Committee for its consideration in updating the tractor cab dimension standard. To date there has been no revision to the SAE-J2194 Standard. If the standard is updated, it should have an impact on the design of the next-generation tractor cabs,

affording better protection to the estimated six million tractor and farm machine operators in the U.S. Other uses of these data are also being explored.

Outputs and Transfer:
Tractor data from the TISF have been referenced in a minimum of 25 peer-reviewed journal articles based on a reference search for the manuscript "Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993" by Myers and Snyder [1995].

Economic analyses of ROPS retrofitting by NIOSH have been referenced in a minimum of 32 peer-reviewed journal articles based a search of the series of manuscripts published by Myers and Snyder, and Myers and Pana-Cryan.

TI has authored 15 peer-reviewed articles and 19 conference presentations on various topics including surveillance data on tractor-related injuries and fatalities, the anthropometry of the farm worker population, economic analyses related to tractor overturn deaths and ROPS, and engineering analyses of the performance and effectiveness of ROPS, AutoROPS, and CROPS. (See the Supporting Appendix section for a list of these outputs.)

Progress toward Intermediate Outcomes:
In 1985, ASAE adopted the voluntary standard S318.10, which recommended that all new farm tractors sold in the U.S. be fitted with a ROPS. TI estimates that more than 95 percent of all tractors used on farms manufactured after the adoption of this voluntary standard have a ROPS. The use of these newer ROPS–equipped tractors accounts for most of the 12 percent increase in ROPS use on farms.

A new standard for AutoROPS, ASABE-X599, Standardized Deployment Performance of an Automatic Telescoping ROPS for Agricultural Equipment, is in draft form and has undergone its first review by ASABE. This standard, once issued, will give the ROPS manufacturers required performance criteria to build and test the consumer availability of the AutoROPS.

Intermediate Outcomes:
Tractor data collected through the TISF survey were used by Colorado State University to help target engineering research evaluating the ability of pre-ROPS tractors to withstand the forces of a tractor overturn if a ROPS were designed and mounted on them. TISF tractor prevalence data were used to identify common tractors by manufacturer and model for ROPS retrofit evaluations (e.g., Ford 8-N). The TISF data were the only information source for prioritizing these research evaluations.

External Factors:
External factors affecting TI efforts include workers' lack of perceived need for ROPS or sense of urgency to obtain ROPS, and the attitudes and behaviors of manufacturers who are generally reluctant to assist in proving concepts or adopting new safety technology relevant to their products due to concerns about liability. Manufacturers, particularly those with a large share of the market, proceed slowly to finalize and prove new safety technology. Manufacturers are reluctant to implement new technology without a specific consensus standard addressing building and testing criteria. Voluntary standards from organizations like ASABE or SAE are critical to getting manufacturers to adopt new technology. Regulatory mandates for the use of ROPS have not occurred in the U.S., despite mandates in other nations, such as Sweden.

Small companies are often more willing than large “name brand” companies to partner with researchers and take risks in order to gain stature in the market. Therefore, a TI strategy was to work with small manufacturers. Another strategy was to engage with manufacturing partners (and relevant trade associations) early in the development process to seek their input and ensure their buy-in of the end product. Additionally, in the final stages of prototyping and testing, partnership agreements that share and formalize roles and responsibilities of both the government and the manufacturers help to avoid manufacturer efforts to forestall progress towards a proven safety technology. The importance of facilitating the development of product standards simultaneously with new technology was also an important lesson.

Also, the patent process is very time consuming and can significantly delay product adoption. TI is continuing to learn about the costs versus the benefits of patenting technology.

What’s Ahead:
The TI Program continues to track the use of ROPS on farms through the OISPA project. Efforts to develop the X599 AutoROPS Performance Standard within ASABE are continuing,with the goal to have the standard published within the next two years. The CROPS project continues until the end of 2007. By then, TI expects to have reached an important intermediate outcome: a ROPS manufacturer offering CROPS as an alternative for consumers. The University of Kentucky is using OISPA tractor prevalence data from 2001 and 2004 for an economic analysis project of ROPS use on farms. The project includes analysis of tractor and ROPS use by hours worked, farming operation, and the need/feasibility of retrofitting ROPS to existing tractors. TI plans to complete five additional CROPS designs and is seeking a new partnership with a ROPS manufacturer for production and sale of CROPS.

References:

1. Myers JR. [2003]. Tractor occupational safety and health update. In: Record of Tractor-Related Injury and Death Meeting. Pittsburgh, PA, February 13-14, 2003, pp. 5-23. Morgantown, WV: NIOSH.

2. Thelin A. [1990]. Epilogue: Agricultural occupational and environmental health policy strategies for the future. *American Journal of Industrial Medicine 18:53*

3. Cole HP, Myers ML, Westneat S. [2004]. Cost-Effectiveness of Promoting Roll-Over Protective Structures (ROPS) and Seat Belts on Family Farm Tractors. Technical report to CDC/NIOSH. Lexington, Ky.: Southeast Center for Agricultural Health and Safety, University of Kentucky.

4. Myers JR, Snyder KA. [1995]. Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993. *Journal of Agricultural Safety and Health 1(3):185-197.*

5. Arndt JF. [1971]. Rollover protective structures for farm and construction tractors-a 50 year review. In: Society of Automotive Engineers Earthmoving Industry Conference, April 5-7, 1971, Peoria, IL.

6. Thelin A. [1990]. Epilogue: Agricultural occupational and environmental health policy strategies for the future. *American Journal of Industrial Medicine 18:53*

7. Pana-Cryan, Myers ML. [2000]. Prevention effectiveness of Roll-Over Protective Structures-Part III: economic analysis. *Journal of Agricultural Safety and Health 6*(1):57-70.

8. Pana-Cryan R, Myers ML. [2002]. Cost effectiveness of Roll-Over Protective Structures. *American Journal of Industrial Medicine 42*(S2):68-71.

9. Myers JR, Snyder KA. [1995]. Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993. *Journal of Agricultural Safety and Health 1*(3):185-197.

10. OTTC. [2006]. Office of Technology Transfer and Commercialization. http://ottc.csusb.edu/what_we_do.htm (last accessed on July 28, 2006).

11. Hsiao H, Whitestone J, Bradtmiller B, Zwiener J, Whistler R, Kau T, Gross M, Lafferty C. [2005]. Anthropometry criteria for the design of tractor cabs and protection frames. *Ergonomics 48*(4):323-353.

Sub goal 4.2: Reduce worker injuries and deaths caused by paper balers

Issue:
On average, approximately 800 workers in the U.S. are killed and 18,000 workers suffer amputations each year while using machinery. Between 1986 and 2002, 43 workers were killed operating recycling industry balers in the United States. Of these fatalities, 29 involved horizontal balers that were baling paper and cardboard.[1]

Machine-related deaths or injuries often occur when workers are servicing or maintaining machines. If machines are not properly de-energized and safeguarded during these tasks, hazardous energy can be released unexpectedly, causing injury to employees. Unexpected energy releases often occur when power is not turned off before workers begin servicing a machine, when power is unexpectedly turned on during the servicing process, or when stored energy is released (which can occur even when power is turned off). One-third of all hazardous-energy-release casualties occur while workers are cleaning or unjamming machines.[2] Balers, including paper and cardboard balers, often become jammed during regular operation, requiring the jammed material to be removed before operations can continue. Employees can mistakenly perceive the jammed machine to be safe since operation has stopped.

Current OSHA regulations are not specific for balers, but general regulations can be applied to situations encountered when using a baler. One important standard addresses the control of hazardous energy, also known as “lockout” or “lockout/tagout” (29 CFR 1910.147). The OSHA lockout standard requires that procedures be developed to place appropriate devices on the energy isolating mechanisms that either prevent (lock), or warn workers (tag) of the potential for unexpected energizing or release of energy.

Approach:
Although lockout/tagout procedures may reduce the risk of hazardous energy being released, they can be easily bypassed, ignored, or forgotten. A control system that automatically detects hazardous operating conditions and automatically responds to safeguard workers has been developed by TI researchers. This system, called JamAlert, detects a jam in a recycling baler by monitoring the strain that the shear bar experiences and the pressure at which the ram operates. If both of these values exceed a limit that is associated with jamming, the power to the baler is eliminated. A “captured key” method is used to ensure that the power cannot be returned to the machine until the employee is a safe distance away from the operating zone. This allows the jam to be cleared without the threat of an unexpected energy release.[3]

To develop this automatic protective device, TI researchers conducted laboratory tests to characterize the parameters of machinery jams and developed machine load (compression) signatures that occur during the compacting operation. A prototype device was designed and built that would respond to such parameters and shut off the power for safe clearing of the jam. The prototype was tested on a TI-owned and -operated baler under a variety of operational conditions, including those expected to produce a jam.

As part of the design effort, TI researchers worked closely with members of the ANSI Z245.5 Baler Safety Committee to ensure the prototype met or exceeded standards recommended by the committee. Also, equipment users, equipment builders, and safety device manufacturers have been consulted during the course of this research.

Outputs and Transfer:
The principal product of this research was the prototype protective device for baling equipment (JamAlert). An industry partner was recruited to carry forward field testing and commercialization. HJA International responded to this call and entered into a Cooperative Research and Development Agreement (CRADA) with TI. HJA has many years of experience in developing and marketing products for the recycling baler market.

TI researchers presented a paper at the 2005 American Society of Mechanical Engineers (ASME) International Mechanical Engineering Congress and Exposition concerning the laboratory testing that led to the JamAlert design recommendations.[3] An employee invention report and a U.S. patent application have been filed for the JamAlert.

The latest TI findings and program information on baler hazards was provided to the standards committee for the ANSI Z245.5 Standard on "Baling Equipment Safety" by the TI expert who served as a voting committee member.[3,4] Other members of the committee included safety experts from baler manufacturers, municipal waste authorities, and waste handling companies.

TI prepared and published a NIOSH Alert entitled "Preventing Deaths and Injuries While Compacting or Baling Refuse Material" (*NIOSH* Publication No. 2003-124).[5]

Intermediate Outcomes:
Findings from this research have been used by the ANSI Z245.5 standards committee in a revision of the Baling Equipment Safety standard. As an example, both the 1997 and 2002 revisions of the standard include a requirement for a key-lock on-off switch or similarly functioning security switch. This requirement resulted from a risk assessment conducted by TI researchers in 1995.[6] Users of the revised standard will be municipal and commercial recycling centers.

Baler manufacturers are already providing purchasers of new balers with safety equipment and safety instructions that meet the revised standard's requirements. Although ANSI standards are voluntary, OSHA routinely cites companies under the General Duty Clause, citing an ANSI standard as an indication that a hazard and the means for its control are generally known. As a result, all baler manufacturers should be meeting the ANSI Z245.5-2002 standard.

An earlier phase of this research involved a risk assessment study performed by TI that led to a decision by Congress (an amendment to the Fair Labor Standards Act) to permit workers under the age of 18-years-old to load, but not operate paper balers, particularly in grocery stores where cardboard boxes are baled for recycling.[6] The younger workers are permitted to perform baler loading specifically if the baler has safeguards that meet the ANSI Z245.5 standard.

What's Ahead:
The TI project team will continue supporting the work to be accomplished via the CRADA with HJA, International. TI researchers plan to coordinate design optimization and field testing of the JamAlert with HJA. Modifications may be needed to JamAlert to enhance its operation under routine use.

External Factors:
The primary external factor that has affected this project is convincing a company to invest its time and capital to manufacture the JamAlert device. Companies are not quick to invest money into something they did not design. With safety devices, another external factor is the issue of liability. Companies have to make sure that implementation of the device will not open them up to liability claims/lawsuits. When a company does show interest, it tends to move very slowly.

References:

1. Taylor B [2002]. Paper Recycling Supplement – Clean and Healthy, *Recycling Today*, October 2002. http://www.recyclingtoday.com/article

2. Grund E [1995]. Lockout/Tagout: The Process of Controlling Hazardous Energy, NSC Press, Itasca, IL.

3. Mick T, Means K, Etherton J, Powers J, McKenzie Jr EA [2005]. Design Recommendations for Controlling Jam-Clearing Hazard on Recycling Balers, 2005 ASME International Mechanical Engineering Congress and Exposition, Orlando, FL, November 5-11, 2005, (IMECE2005-79699).

4. Etherton J, McKenzie Jr EA [2001]. The Machine Operator's Jammed-Feedstock-Clearing Task: A Safety Design Challenge, in *Safety Engineering and Risk Analysis*, B. Ale ed., Mechanical Engineering Conference and Exposition, November 2001 in New York. New York: ASME.

5. NIOSH [2003]. Preventing Deaths and Injuries While Compacting or Baling Refuse Material, Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2003-124.

6. NIOSH [1995]. Review of Safeguarding Technology Used on Paper Balers, prepared in response to a request from the USDOL Wage and Hour Division.

Sub goal 4.3: Reduce injuries and deaths caused by machines through the conduct of fatality investigations and dissemination of prevention strategies

Issue:
A major difficulty in planning and prioritizing a research program to address machine safety is the large variety of machines, both fixed and mobile, used in a wide array of industrial settings. Occupational injury and fatality surveillance data do not usually have the degree of specificity required to accurately identify individual machines or types of machines involved in worker injuries and deaths, and enable an accurate comparison of risks among individual or types of machines. Even when surveillance enables researchers to identify machine-related injuries and deaths, rarely is enough information about the circumstances of the injury available to identify causal factors and potential prevention options.

One approach the TI Program uses to address the problem of machine-related fatalities is through the conduct of investigations through the Fatality Assessment and Control Evaluation (FACE) Program. Beginning in the mid 1990s, machine-related fatalities were selected as an investigation target area, although some machine-related fatalities had been investigated by TI staff prior to this time. Targeting machine-related occupational deaths for investigation has enabled TI staff to recognize and address machine hazards and to provide detailed case information and prevention recommendations to at-risk populations, regulators, machine manufacturers, and others whose actions and decisions impact workplace risk.

Approach:
The goal of the FACE Program is to prevent work-related fatalities and injuries by identifying work situations at high-risk of fatal injury and developing and disseminating prevention strategies to those who can intervene in the workplace.[1] FACE is voluntarily notified of selected occupational fatalities (currently machine-related, workers under 18 years of age, highway construction work zones, and Hispanic workers) by the Departments of Labor in the States of Maryland, North Carolina, South Carolina, Tennessee, and Virginia, Federal OSHA Area Offices in Ohio and Pennsylvania, and the Allegheny County Coroner's Office in Pittsburgh, Pennsylvania. All are in geographic proximity to the TI facilities in West Virginia to reduce travel expenses. FACE is also notified of work-related deaths of youth under 18 years of age across the nation by the Wage and Hour Division, U.S. Department of Labor. Additionally, through cooperative agreements, TI funds nine States to conduct fatality investigations in their respective States using the FACE methodology. The State-based FACE Program includes California, Iowa, Kentucky, Massachusetts, Michigan, New Jersey, New York, Oregon, and Washington.

Through on-site fatality investigations, TI staff members collect agent, host, and environment information from the pre-event, event, and post-event phases of the fatal incident via a case-series design to facilitate descriptive analysis of the incidents. These investigations are not conducted to find fault or place blame on employers or individual workers, but to better understand the chain of events and contributing factors that led to the fatal event and to develop recommendations for preventing similar deaths. The results of TI investigations are disseminated through narrative reports for each fatality, and all investigative reports are available through the NIOSH Website (http://www.cdc.gov/niosh/face/default.html).

Findings from FACE investigations are frequently combined with TI surveillance data to describe specific injury problems and develop prevention recommendations that are further disseminated through NIOSH-numbered publications such as Alerts, Workplace Solutions, and Hazard IDs. The results from the FACE Program have the unique capability to reach workers at risk through targeted dissemination of products to specific audiences that provide timely intervention strategies for reducing specific types of injury hazards.

Outputs and Transfer:
Since 1994, the outputs from these machine-related investigations have included 45 investigative summary reports and 10 NIOSH-numbered documents which address a variety of specific machine-related hazards, including:

- Crane tip-overs and contact with overhead power lines
- Compacting and baling refuse material
- Forklifts
- Skid-steer loaders
- Scalping from working with hay balers
- Rollover and struck-by hazards on ride-on rollers/compactors
- Hydraulic excavators and backhoe loaders
- Entanglement in wood chippers
- Explosion hazards from drilling into sealed frames on agricultural equipment

As part of the dissemination process, TI frequently targets specific audiences to receive information products based on the topic area. Prior to using this more targeted dissemination strategy (which TI began implementing in the 1980s) NIOSH-numbered documents were typically distributed to a general NIOSH mailing list of approximately 2,000 addressees. This approach was inadequate for transferring TI prevention strategies to the industries and workers who were at greatest risk from the identified hazards. During this time period, TI also began preparing documents with more focus on workers to facilitate implementation of the recommendations. This included a change in the physical appearance of the documents, such as a more eye-pleasing cover and improved document formatting for easier readability. Reader response cards included with each document provide feedback to the TI Program on how the information is used for injury prevention efforts in the workplace.

Below are examples of TI outputs from FACE investigations of machine-specific hazards.

During 2006, the Alert, “Preventing Worker Injuries and Deaths from Mobile Crane Tip-Over, Boom Collapse, and Uncontrolled Loads,” was disseminated to a targeted mailing list of more than 8,600 specific businesses. These included:

- Heavy construction equipment rental (1,745 addresses)
- Steel erection (881 addresses)
- Telecommunications contractors (429 addresses)
- Masonry contractors (2,001 addresses)
- Demolition contractors (1,382 addresses)
- Machinery-movers and erectors (465 addresses)
- Utility contractors (1,119 addresses)

- Construction heavy projects (233 addresses)
- Other construction companies (387 addresses)

In 2004, based on the Alert, "Preventing Electrocutions of Crane Operators and Crew Members Working Near Overhead Power Lines," TI mailed a packet of materials which included four crane-related FACE investigative reports and the recommendations summary page from the Alert to approximately 4,600 crane rental and crane service establishments across the nation. The information described crane-related injury risks and steps employers can take to prevent worker death and injury. Recipients were encouraged to use these materials for training purposes, toolbox talks, and as support for safety program development.

The TI Alert, "Preventing Deaths and Injuries While Compacting or Baling Refuse Material," was distributed to paper baler manufacturers and trade associations. The Alert provides statistics on baler-related deaths, relevant machine and workplace standards, illustrative case examples, and concrete steps that employers and workers can take to work safely with these machines. A follow-up effort from FACE investigations of the serious hazards of working with paper balers led to an engineering research project by the TI Program which ultimately resulted in development of the JamAlert device described in Sub goal 4.2.

To address shared concerns about the incidence of young workers being fatally injured while operating forklifts, TI and the Department of Labor's Wage and Hour Division (WHD) collaborated in December 2002 to send an information packet including three FACE reports and the summary sheet of recommendations from the TI Alert, "Preventing Injuries and Deaths of Workers Who Operate or Work Near Forklifts," to more than 10,000 retail warehouses and storage facilities. This mailing also included a sticker that could be affixed to forklifts warning that no operators under 18 years of age were permitted.

During 2000 and 2001, TI received five reports of worker deaths associated with excavators or backhoe loaders. These incidents involved two fatal injury scenarios: being struck by the moving machine or by swinging booms and buckets, or being struck by quick-disconnect excavator buckets that unexpectedly detached from the excavator. In response to these incidents, TI developed a Workplace Solutions document entitled "Preventing Injuries and Deaths When Working with Hydraulic Excavators and Backhoe Loaders." This publication is a non-technical and concise version of TI research targeted to the end user, e.g., safety and health practitioner, employer, supervisor, operator, foreman, worker or worker representative. The hazards and recommendations identified in this document also apply to other manufacturers and types of construction equipment. With the assistance of the Association of Equipment Manufacturers and its membership, TI disseminated more than 11,000 copies of this Workplace Solutions both nationally and internationally.

The Agricultural Health Nurse Program of New York State, funded by NIOSH, identified an incident that resulted in the scalping of a woman in New York when her hair became entangled in the rotating driveline of a hay baling machine. Subsequent investigation by TI staff identified four additional cases that had occurred, all females. The same model of hay baler was involved in all of these incidents. TI investigations indicated that when the women leaned under the driveline to adjust the tension on the hay bales, their hair became entangled in the driveline. The drivelines were covered by a U-shaped tunnel guard that left the bottom of the rotating driveline exposed. In response to these incidents, TI developed an Alert entitled "Preventing Scalping and Other

Severe Injuries from Farm Machinery." This publication was targeted to the end user, including farm operators, farm workers, county agricultural extension agents, equipment dealers and equipment manufacturers. Although only one model of machinery was involved in these incidents, the hazards and recommendations identified applied to many manufacturers and other types of agricultural equipment.

Through the NIOSH-funded Community Partners for Healthy Farming program in New York State, TI received two separate reports of farm workers who were injured while attempting to drill holes into sealed agricultural plow frames in order to mount a hitch or a "slow-moving vehicle" sign. These workers received serious skin burns and other injuries when the drill bits penetrated the frames releasing and igniting flammable gases. Subsequent TI investigations indicated that hydrogen and methane gas may be produced within sealed frames that are filled during manufacture with scrap metal for use as ballast. It was determined that the uncleaned, assorted, machine shop metal scrap ballast was reacting electrochemically with water and emulsion-type cutting oils to liberate flammable gases. As a result of these investigations, TI staff developed a Hazard ID Bulletin, "Ignition Hazard from Drilling into Sealed Frames of Agricultural Equipment," which summarized the hazards and steps to reduce injury. TI staff also developed and distributed a Technology News Bulletin entitled "The Explosion Hazard from Hydrogen Gas Generation Inside Sealed Frames."

Intermediate Outcomes:
To further broaden the reach and impact of TI prevention strategies, TI frequently collaborates with other public and private-sector partners. Additionally, the results and recommendations are frequently distributed by other organizations and groups which help to maximize the dissemination of this important prevention information. A number of examples follow.

Following the TI and Wage and Hour Division (WHD) distribution of prevention information related to forklifts in retail warehouses and storage facilities, TI, WHD, and OSHA collaborated in additional outreach efforts in January 2004 to distribute 5,000 copies of this same packet, along with an OSHA bulletin, to a broader mailing that included OSHA alliance partners such as members of the Industrial Truck Association (ITA). These packets contained a letter signed by John L. Henshaw, then Assistant Secretary of Labor, Tammy D. McCutchen, then Administrator of the Wage and Hour Division of the Employment Standards Division, and John Howard, M.D., Director of NIOSH. In addition, this package included both an English and Spanish version of the forklift sticker warning that no operators under 18 years of age were permitted.

As a result of the mailing of the packet pertaining to the Alert, "Preventing Electrocutions of Crane Operators and Crew Members Working Near Overhead Power Lines," a crane rental company requested additional copies of the package to include with each crane they rented. A construction contractor who received these materials requested multiple copies and praised the packet as the most useful safety tool he ever received from the government. In communication with TI, he wrote: "I had heard about the accidents, but didn't know the causes. I will circulate the publication among my employees who work with cranes. It will give us an opportunity to discuss crane safety using real life examples. I am sure my employees will find it as fascinating as I did."

After TI disseminated the Workplace Solutions, "Preventing Injuries and Deaths When Working with Hydraulic Excavators and Backhoe Loaders," the document received positive responses from the International Union of Operating Engineers and the Association of Equipment

Manufacturers. The Association of Equipment Manufacturers provided TI with an international mailing list with more than 200 entries for further dissemination. Additionally, several OSHA regional offices that were focusing on hazards associated with excavators and backhoes requested copies for further distribution.

With the assistance of the Association of Equipment Manufacturers and the National Asphalt Pavement Association, TI disseminated more than 20,000 copies of the Workplace Solutions, "Preventing Injuries When Working with Ride-On Roller/Compactors," both nationally and internationally.

Shortly after the Alert, "Preventing Scalping and Other Severe Injuries from Farm Machinery," was released, dissemination of the document to equipment dealers and county agricultural extension agents led to increased requests for a retrofit developed by the manufacturer that was already available. The retrofit enclosed the rotating drivelines and significantly reduced the hazard. Requests for the retrofit guard increased to the point that the manufacturer's inventory was exhausted and additional production was needed to fill orders.

Once the Hazard ID Bulletin, "Ignition Hazard from Drilling into Sealed Frames of Agricultural Equipment," was disseminated, the manufacturer ceased using the scrap for filling its equipment frames and began using clean stainless steel punch-out scrap. Additionally, while TI staff members were investigating this hazard, *Successful Farming* magazine ran a cover story detailing a project by the Future Farmers of America (FFA) in Kansas to replace slow-moving vehicle signs on all agricultural machinery in the State. The cover picture was of two youth drilling into a sealed frame. Following TI contact, the FFA issued a nationwide bulletin to all FFA chapters describing the hazard of drilling into sealed frames, and *Successful Farming* ran an article on the TI Hazard ID summarizing the hazard and steps to reduce injury. Penn State University also reprinted portions of the Hazard ID in its *Agricultural Safety and Health News*.[2] After the dissemination of the Hazard ID and the Technology News Bulletin highlighting the ignition hazard, TI received two calls that identified this hazard as being present in different types of machines and industries. While a mechanic was welding on a dragline at a surface mining operation in Australia, an ignition occurred whose source was identified as hydrogen. In another instance, while a weight pod on a mobile crane was being welded, a hydrogen ignition occurred. TI results had alerted others to similar hazards that were occurring on other types of equipment.

End Outcomes:
Work-related fatalities caused by machines, plant and industrial powered vehicles, or tractors have shown a steady decline since 1992. Based on available data from the BLS Census of Fatal Occupational Injuries, the number of deaths declined 16 percent and fatality rates per 100,000 workers declined 30 percent from 1992 through 2005.[3] While it is difficult to quantify the contributions of the TI Program to these reductions, the role of the program in providing practical recommendations for reducing worker risks has been recognized through feedback from external partners, stakeholders, and workers. For example, reader response cards from TI outputs have provided positive feedback that the information is being used for prevention and the format of the documents has been well-received by end users.

External Factors:
A number of the hazards identified by TI exist in machinery used by small companies that lack the expertise and resources to adequately abate the hazards, even when known prevention strategies are available. Additionally, due to limited resources, the TI Program is not able to

conduct follow-back with companies to determine if recommended interventions to reduce identified injury hazards have been implemented. As well, given the resource limitations, TI is limited in the number, type, and geographic location of investigations that can be conducted. To minimize this resource limitation, after notification of a machine-related fatality, TI staff determine whether or not the case will be investigated by focusing on cases where potential emerging hazards or new technologies were involved in the fatal event.

What's Ahead:
TI will continue including machine-related fatalities as an investigative target under the FACE Program. One of the strengths of this program is the ability to adapt the investigative process to emerging hazards. TI can refocus the FACE Program to investigate potential hazards from new trends and technologies as they are identified. This can lead to the development and dissemination of prevention strategies and products targeted to address these emerging hazards. To ensure these materials are most useful, TI will continue collaborating with industry, machine manufacturers, trade associations, Federal and State agencies, unions, and other entities to help ensure that accurate injury prevention information is made widely available as timely as possible.

References:

1. Higgins DN, Casini VJ, Bost P, Johnson W, Rautiainen [2001]. *The fatality assessment and control evaluation program's role in the prevention of occupational fatalities. Injury Prevention 7* (Suppl 1): i27-33.

2. Penn State University [1999]. Safety and Health News, College of Agricultural Sciences, Cooperative Extension, Department of Agricultural and Biological Engineering, Volume 11, Number 1 (January/February 1999).

3. Bureau of Labor Statistics. Census of Fatal Occupational Injuries. Washington, DC: US Department of Labor, Bureau of Labor Statistics; 2006. Available at http://www.bls.gov/iif/oshcfoi1.htm

5. Reduce Acute Back Injury

Introduction

Back injuries account for nearly 20 percent of all injuries and illnesses in the workplace and cost the nation an estimated 50 billion dollars per year. Back injuries are the leading cause of disability in the United States for people younger than 45 years and are the most expensive healthcare problem for the 30- to 50-year-old age group.[1] Low back pain accounted for 23 percent ($8.8 billion) of total workers' compensation payments in 1995.[2] The Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics indicates that in 1998 there were 279,507 back injuries due to overexertion that resulted in lost work days (89 percent in material-handling).

TI has focused back injury research and prevention efforts upon the problems of patient handling in the healthcare sector, particularly nursing homes, and materials handling across all sectors, particularly the evaluation of back belts.

References:

1. Bigos S, Bower O, Braen G, et al. [1994]. Acute Low Back Problems in Adults. Rockville, Md: Agency for Health Care Policy and Research, Clinical Practice Guideline 14, AHCPR publication 95-0642.

2. Murphy PL, Volinn E [1999]. Is occupational low back pain on the rise? *Spine 24*:691-697.

Sub goal 5.1: Reduce acute injuries caused by patient handling

Issue:
Frequent lifting and repositioning of patients is the leading source of injury for healthcare workers.[1] Direct and indirect costs associated with back injuries in the healthcare industry are estimated to be $20 billion annually.[2] Among female workers in the United States, nursing aides and orderlies suffer the highest prevalence (18.8 percent) and report the most annual cases (n=269,000) of work-related back pain.[3] In 2000, 10,983 Registered Nurses (RNs) suffered lost-time work injuries due to lifting patients. Twelve percent of nurses report that they left the nursing profession because of back pain.[4] Employment for nurses is projected to increase by 25 percent by 2012, creating an expected shortage in the nursing labor pool of 20 percent by 2015 and 30 percent by 2020.[5] The high injury rate coupled with a critical nursing shortage[6] raises serious concerns about the nursing workforce's capacity to care for our nation's expanding population.

Principal factors that contribute to back injury risks for caregivers (nursing aides, orderlies, nurses, therapists, and restorative aides) include:

- The size, weight, balance problems, and combativeness of patients
- The confined areas (bathrooms and rooms cluttered with furniture and medical equipment) and beds in the nursing home environment which prevent caregivers from assuming proper lifting postures
- Caregivers' inability to lift patients (the weight of any adult exceeds the lifting capacity of most caregivers, 90 percent of whom are female)
- The forward bending required for most patient lifting and moving tasks, which places the spine in its most vulnerable position

The problem of lifting patients is compounded by the increasing weight of patients to be lifted due to the obesity epidemic in the U.S. and the rapidly increasing number of older people who require assistance with their activities of daily living.[7] Further, equipment to assist healthcare workers in lifting obese and frail patients is not always available or adequate. Finally, the absence of evidence-based training curriculum for student nurses and caregivers means that outdated books and curriculum, which promote unsafe patient handling practices among newly trained student nurses, continue to be used. As a result, schools of nursing continue to teach, and nurses' licensure exams[8] continue to include, outdated and unsafe manual patient handling techniques.

Approach:
Over the past 20 years, TI researchers with backgrounds in epidemiology, biomechanics, and psychology have conducted a comprehensive and diverse research program to prevent injuries to caregivers associated with patient lifting.

From its inception in the mid 1980s, TI nursing back injury research has examined the incidence and prevalence of nursing injuries by job title, age, gender, work exposures, and other demographic characteristics to highlight the magnitude of the injury problem and to raise awareness of the hazards.[9-12] TI researchers (intramural and extramural) have conducted lab and field research to study the biomechanics of patient lifting, the impact of nursing work schedules, the adequacy of student nursing curriculum, and the effectiveness of 'best practices' safe patient lifting programs. TI intramural and extramural researchers have conducted task analyses to

identify high-risk patient-handling tasks, lab studies to identify safer lifting methods through evaluation of patient lifting equipment, and intervention trials of "safe patient lifting programs" in nursing homes and hospitals.

For example, a NIOSH extramural research grant funded a landmark study that identified the most stressful patient handling tasks,[13] performed an ergonomic evaluation of these tasks,[14] conducted a laboratory study to select less stressful patient transferring tasks,[15] and conducted a field study that demonstrated the effectiveness of a safe patient lifting program that utilized mechanical lifting equipment.[16]

As a precursor to its own large-scale nursing home field study, TI conducted a biomechanical[17] and psychophysical evaluation.[18] Mechanical lifts were shown to reduce the compressive forces placed on the nursing assistants' backs by an estimated 60 percent, remove two-thirds of the lifting activities per transfer,[17] and increase residents' perceptions of comfort and security during transfers with mechanical lifts when compared to manual lifting.[18]

Because of the small sample size and 12-month follow-up period in the extramural field study,[16] TI researchers conducted a large intervention trial over a six-year period that demonstrated that a "best practices" safe patient lifting program can be highly effective in reducing resident handling injury incidence rates, workers' compensation costs, and lost workday injuries.[19] The initial investment of $158,556 for lifting equipment and worker training to establish the safe patient lifting program was recovered in fewer than three years based on post-intervention savings of $55,000 annually in workers' compensation costs. The "best practices" prevention program significantly reduced injuries for full-time and part-time nurses in all age groups, all lengths of employment, in all study sites.[7]

TI research, prevention and communication efforts have involved partners in industry, government, and academia, such as BJC Corporation, Johns Hopkins University, the Association of Schools of Public Health, the American Nursing Association, the Occupational Safety and Health Administration, and the Veterans Administration, among others. For example, TI researchers conducting the large-scale field study worked closely with BJC Health System, which provided the study population of 1,728 nursing staff at six nursing homes. TI worked with lifting equipment manufacturers—EZ Way, Inc. and Arjo, Inc.—by testing and evaluating their equipment in the laboratory, and using this equipment as a key component of the field study. These private-sector partners, along with Washington University and TI researchers, won the 2003 National Occupational Research Agenda Partnering Award for Worker Safety and Health.

Outputs and Transfer:
TI research results have been disseminated through peer-reviewed manuscripts, NIOSH numbered publications, NIOSH laymen's documents, and nursing student textbooks. TI has promoted more widespread implementation of safe patient lifting programs in the United States by developing business cases and providing research evidence to support safe patient lifting legislation. TI research results have been further disseminated by the American Nurses Association (ANA) and the Veteran's Health Administration.

Key findings from TI intramural and extramural research were published in a NIOSH numbered publication and disseminated by direct mail to 17,000 nursing homes in the United States. This guide—"Safe Lifting and Movement of Nursing Home Residents"[7]—presents a business case to nursing home owners, administrators, nurse managers, safety and health professionals and

workers who are interested in establishing a safe patient lifting program. The guide offers evidence that safe patient lifting programs can protect workers from injury, reduce workers' compensation costs, and improve the quality of care delivered to patients.[7]

In 1987, TI published (in partnership with the Association of Schools of Public Health and the Johns Hopkins University Injury Prevention Center) an annotated bibliography on nursing back injury research to raise awareness of the problem and to provide researchers and healthcare organizations the latest evidence-based research information on safe patient lifting programs.[21]

TI researchers wrote two chapters in the book, "Safe Patient Handling and Movement – A Practical Guide for Health Care Professionals"[22, 23] that present best practices for safe patient lifting. This book was written as a resource for hospital and nursing home administrators, nurse managers, caregivers, risk managers, and those involved in procurement of patient handling technology.

TI research staff participated on a Department of Labor, Occupational Safety and Health Administration (OSHA) committee to synthesize the evidence supporting safe patient lifting programs from 1998-2002. In 2003, OSHA published "Guidelines for Nursing Homes: Ergonomics for the Prevention of Musculoskeletal Disorders" (OSHA 3182).[24] This guidance can be accessed at: www.osha.gov/ergonomics/guidelines/nursinghome.

TI scientists are working with the National Council Licensure Examination (NCLEX) Board[8] to update the curriculum on safe patient lifting to include the latest research findings from TI and others in nursing licensure exams. The Safe Patient Handling and Movement (SPH&M) training presentation[19] can be downloaded at the NIOSH Website and the algorithms[20] can be downloaded at the VA Patient Safety Center Website.

Intermediate Outcomes:
TI researchers were asked to provide testimony at legislative hearings in two States, but had to decline since government scientists are prohibited from such activities. TI did provide copies of relevant peer-reviewed articles and laymen's publications on safe patient handling to Congressional staff members working on the legislation. Bill Borwegen (Safety and Health Director for the Service Employees International Union) actively participated in each of the State hearings, and personally communicated to TI researchers that without the TI research evidence, the State legislation would likely not have passed. TI research on safe patient lifting has been used in support of the passage of the following safe patient handling legislation in the United States:

1. Texas Senate Bill 1525 was signed into law on June 17, 2005.[26] Texas is the first State in the nation to mandate that hospitals and nursing homes implement policy for safe patient handling and movement programs, restricting "to the extent feasible with existing equipment and aids, of manual patient handling or movement of all or most of a patient's weight except in emergency, life-threatening, or otherwise exceptional circumstances."

2. Washington House Bill 1672 was signed into law on March 22, 2006.[27] Washington State mandates that hospitals provide lift equipment as part of their policy for safe patient handling, with the hospital's choice of three options for implementation of equipment, and with financial assistance by tax credits for the cost of lifting equipment and reduced

workers' compensation premiums for hospitals implementing safe patient handling programs.

3. Hawaii House Concurrent Resolution No. 16, 4-24-06.[28] Safeguards are to be instituted in healthcare facilities to minimize the occurrence of musculoskeletal injuries suffered by nurses; also calls for the Legislature of Hawaii to support policies in American Nurses Association "Handle with Care" Campaign.

4. Rhode Island House 7386 and Senate 2760, 7-7-06 passed in June 2006.[29] This legislation states that hospitals and nursing facilities need to "Implement a safe patient handling policy for all shifts and units of the facility that will eliminate manual lifting, transferring, and repositioning of patients, except in emergency, life-threatening, or otherwise exceptional circumstances."

5. Ohio House Bill 67 was signed into law on March 21, 2005.[30] Section 4121.48 creates a bureau of workers' compensation long-term care loan fund "to make loans without interest to…nursing homes…to purchase, improve, install, or erect sit-to-stand floor lifts, ceiling lifts, other lifts, and fast electric beds, and to pay for the education and training of personnel, in order to implement a facility policy of no manual lifting of residents by employees."

6. New York companion Bills A07641 and S04929 were introduced in April 2005, and signed into law on October 18, 2005. [30] These bills call for creation of a two-year study to establish safe-patient-handling programs and collect data on the incidence of nursing staff and patient injury with patient handling, manual versus lift equipment. Results will be used to describe best practices for improving health and safety of healthcare workers and patients during patient handling.

American Nurses Association's (ANA) Handle with Care Program.[25] The ANA used TI research findings in its "Handle with Care" Program. The "Handle with Care" Program is an industry-wide effort designed to prevent back and other musculoskeletal injuries among the nation's nurses. The campaign is helping reshape nursing education and Federal and State ergonomics policy by highlighting safe patient lifting research (by TI and others) that shows technology-oriented safe patient handling benefits both patients and the nursing workforce.

TI outputs, which have contributed to the passage of safe patient lifting laws in six States, have also informed proposed legislation in six additional States, as well as a Federal Bill that is being considered by Congress.

Progress toward End Outcomes:
Data from the U.S. Department of Labor, Bureau of Labor Statistics (BLS) indicate that the incidence rate for sprains and strains involving days away from work in nursing homes steadily decreased by 67 percent (from 482.7 to 159.7 per 10,000 workers) between 1992 and 2005 (see Figure 11), approximately five years after the TI comprehensive research program on safe patient lifting was implemented. Similarly, the incidence rate for sprains and strains in hospitals decreased 52 percent (from 222.4 to 106.1 per 10,000 workers) between 1992 and 2005.

The BLS data identified lifting healthcare patients as the leading source of injury. The BLS data depicted in Figure 12 show that from 1992 to 2005, there has been a 70 percent reduction (from 397.8 injuries to 121.2 injuries per 10,000 workers) in injury rates in nursing homes where healthcare patients were listed as the source of injury. Similarly, a 52 percent reduction in lost workday injuries (from 110.8 to 53.5 per 10,000 workers) occurred between 1992 and 2005 in hospitals where healthcare patients were listed as the source of the injury (Figure 13).

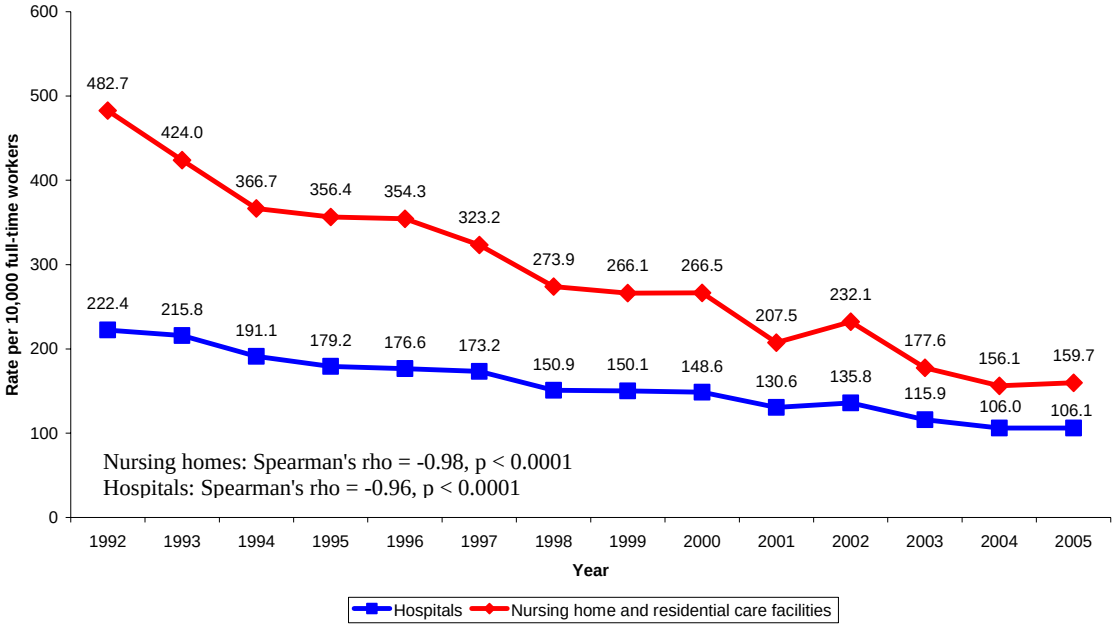

Figure 12. Rates of Sprains, Strains and Tears Involving Days Away from Work In Hospitals and Nursing Homes, 1990-2005

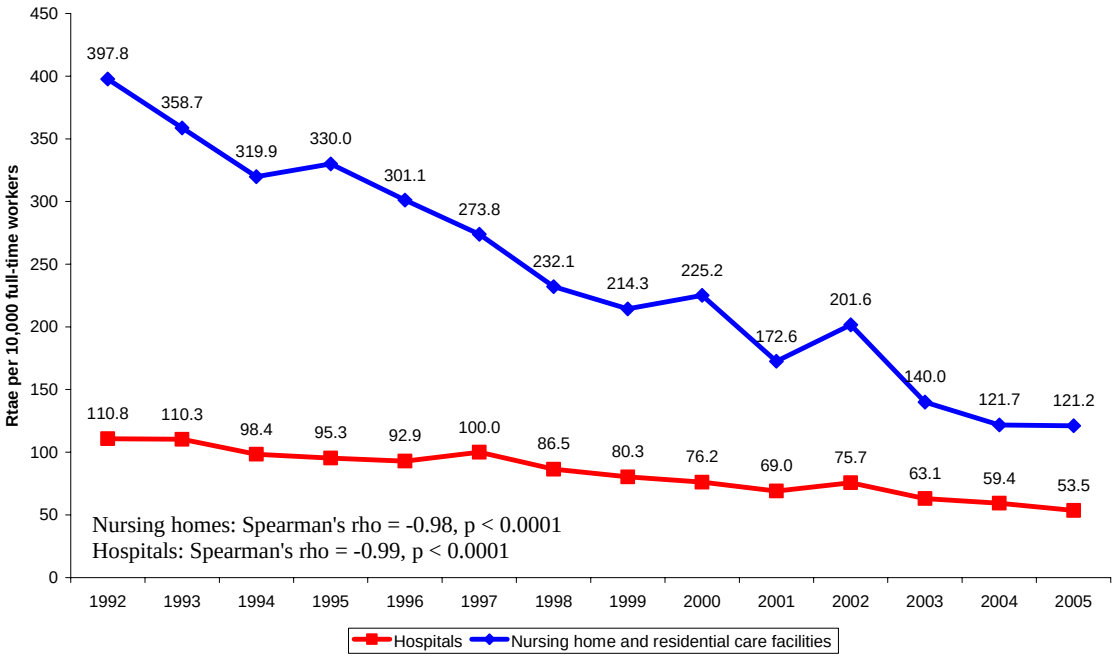

Figure 13. Rates of Nonfatal Injuries and illnesses Involving Days Away from Work in Hospitals and Nursing Homes, Health Care Patients as Source, 1992-2005

What's Ahead:
Translating TI research findings into practice is currently in progress on several fronts. The reductions in injuries and costs shown in the field research is promising, and can likely be replicated in nursing homes across the U.S. if similar safe patient lifting programs are adopted. Although TI has conducted extensive safe patient lifting research in nursing homes, the next phase of research will address acute care hospitals and home healthcare workers. TI recently funded an extramural research grant to conduct an intervention trial of a "best practices" safe patient lifting program institution-wide in a large tertiary acute care hospital over a 12-year period (1997-2008). TI is contributing, in partnership with the ANA and the VA, to the restructuring of nursing student curriculum to include evidence-based research. New student training curriculum, including a textbook and curriculum module, was developed in 2004 and evaluated in 26 schools of nursing. Data analysis is not complete. In support of this effort, patient lifting equipment manufacturers donated or loaned patient lifting equipment to the participating schools of nursing.

TI will continue intramural research to develop and evaluate methods to safely lift and move patients in home healthcare environments, and will continue to co-sponsor the Safe Patient Handling and Movement Conference that is attended by an estimated 800 healthcare professionals each year. TI staff members have participated in this conference since its inception seven years ago and will continue to present the latest TI research findings to this large audience of healthcare professionals.

TI researchers, in partnership with the ANA, are conducting research to determine if work schedules (long hours and shift work) are likely to play an important role in the development of safety and health problems for nurses.

External Factors:
Several external factors have affected the progress and the impact of this research. At a time when NIOSH TI researchers were seeking industry partners to conduct intervention trials, the industry was immersed in worker safety litigation regarding patient lifting. Soaring injury rates in nursing homes had led OSHA to target worker safety problems in nursing homes. However, an extensive legal battle led to a ruling in favor of Beverly Enterprises (the largest nursing home chain in the U.S.) against OSHA. The presiding Occupational Administrative Law Judge stated that epidemiological data did not exist to support OSHA allegations that patient lifting was associated with acute back injuries among caregivers. Nursing homes were not inclined to participate in NIOSH research that could ultimately lead to industry regulation. Battles between unions and nursing homes over safe patient lifting issues also created difficulties for NIOSH researchers seeking study partners. NIOSH TI researchers also had two potential study populations erode due to corporate mergers that resulted in the key study contacts losing their jobs.

At the end of the Clinton Administration in 2000, OSHA passed legislation creating ergonomic standards affecting more than 100 million workers. This legislation was promptly overturned in 2001 when the Presidential administration changed hands. This reversal was followed by a moratorium in all "ergonomics" enforcement activities by OSHA.

The first mechanical patient lifts, introduced in the 1940s, were prone to tip over and be uncomfortable for patients, and were resisted by caregivers and patients. It wasn't until the

late1990s that dramatic design improvements led to widespread availability and usage of mechanical lifts.

U.S. nursing schools still teach body mechanics to show nurses how to use their physical strength to "properly lift" patients. Each year, nursing students are graduating without being trained on how to use mechanical lifts to safely lift patients.

References:

1. U.S. Department of Labor, Bureau of Labor Statistics [2003]. Total Recordable Occupational Injury Cases in Nursing and Residential Care Facilities. Available on the Web at: http://www.bls.gov/data/home/htm (Accessibility verified 02/04/05).

2. Fragala G [1993]. Injuries cut with lift use in demonstration project. Provider 10: 39-45.

3. Guo HR, Tanaka S, Cameron LL, et al. [1995]. Back pain among workers in the United States: national estimates and workers at high risk. Am J Ind Med 28: 591-602.

4. Stubbs DA, Buckle PW, Hudson MP, Rivers PM, and Baty D [1986]. Backing out: nurse wastage associated with back pain. International Journal of Nursing Studies 23(4): 325-336.

5. American Nurses Association [2003]. Handle with Care. Available at www.NursingWorld.org/handlewithcare

6. Buerhaus P, Staiger D, Auerbach D [2000]. Implications of a rapidly aging nursing workforce. JAMA 283:2948-54.

7. Collins JW, Nelson A, and Sublet [2006]. Safe lifting and movement of nursing home residents, DHHS (NIOSH) Publication No. 2006-117. Cincinnati, OH: National Institute for Occupational Safety and Health.

8. National Council of State Boards of Nursing [2006]. National Council Licensure Examination (NCLEX)® Website. Accessible on Web at: https://www.ncsbn.org/245.htm. Last accessed on November 25, 2006.

9. Jensen RC [1985]. Events that trigger disabling back pain among nurses, in Proceedings of the Human Factors Society 29th Annual Meeting, Human Factors Society, Santa Monica, California, 799-801.

10. Jensen RC [1986]. Work-related back injuries among nursing personnel in New York. In Proceedings of the Human Factors Society 30th Annual Meeting. Human Factors Society, Santa Monica, California, 244-248.

11. Jensen RC [1986]. Disabling back pain among nursing personnel in North Carolina. Living with Change and Choice in Health. 337-340.

12. Jensen RC [1987]. "Disabling back injuries among nursing personnel: Research needs and justification." Research in Nursing and Health, 10(1):29-38.

13. Owen BD and Garg A [1989]. Patient handling tasks perceived to be the most stressful by nursing assistants. In: Mital, A. [Eds.), Trends in Ergonomics/Human Factors IV. North-Holland, Amsterdam, pp. 831-838.

14. Garg A, Owen BD, Beller D, Banaag J [1991]. A biomechanical and ergonomic evaluation of patient transferring tasks: bed to wheelchair and wheelchair to bed. Ergonomics 34:289-312.

15. Garg A, Owen B, and Carlson B [1992]. An ergonomic evaluation of nursing assistants' job in a nursing home. Ergonomics 35:979-95.

16. Garg A and Owen B [1992]. Reducing back stress to nursing personnel: an ergonomic intervention in a nursing home. Ergonomics 35:1353-75.

17. Zhuang Z, Stobbe TJ, Hsiao H, Collins JW, Hobbs G [1999]. Biomechanical evaluation of assistive devices for transferring residents. Applied Ergonomics 30:285-94.

18. Zhuang Z, Stobbe TJ, Collins JW, Hsiao H, Hobbs G [2000]. Psychophysical assessment of assistive devices for transferring patients/residents. Applied Ergonomics 31:35-44.

19. The Safe Patient Handling and Movement (SPH&M) training presentation. Available on-line at: http://www.cdc.gov/niosh/review/public/safe-patient/introduction.html. Last accessed: February 21, 2007.

20. Veterans Administration [2006]. Patient Care Ergonomics Resource Guide: Algorithms for Safe Patient Handling and Movement, Veteran's Administration Hospital. Available on the Web at: 12/11/2006 at: http://www.visn8.med.va.gov/patientsafetycenter/safePtHandling/SPHMAlgorithms.pdf. Last accessed on December 11, 2006.

21. Jensen RC, Myers AH, Nestor D, Rattiner J [1987]. Low Back Injuries among Nursing Personnel: An Annotated Bibliography. Published by Johns Hopkins University Injury Prevention Center, Baltimore, MD.

22. Collins JW and Menzel NN [2006]. Chapter 1: Scope of the problem – Moving and handling patients: A core function of Nurses. In Safe Patient Handling and Movement - A practical guide for health care providers. Audrey Nelson, ed., Springer Publishing Company, Inc. pp. 3-26.

23. Collins JW [2006]. Chapter 10 – Safe Lifting Policies. In Safe Patient Handling and Movement - A practical guide for health care providers. Audrey Nelson, ed., Springer Publishing Company, Inc. pp. 151-9, and 214-5.

24. OSHA [2003]. Guidelines for Nursing Homes: Ergonomics for the Prevention of Musculoskeletal Disorders, OSHA 3182. Washington, DC: Occupational Safety and Health Administration. Accessible on Web at: www.osha.gov/ergonomics/guidelines/nursinghome. Last accessed on November 24, 2006.

25. ANA [2004]. Handle with Care. Silver Spring, MD: American Nurses Association, 16 pages. Handle with Care Website accessible at: http://www.nursingworld.org/handlewithcare/ and program brochure accessible at: http://www.nursingworld.org/handlewithcare/hwc.pdf. Last accessed on November 24, 2006.

26. State of Texas [2005]. Texas SB 1535: An Act relating to safe patient handling and movement practices of nurses in hospitals and nursing homes. Accessible on Web at: http://www.capitol.state.tx.us/tlodocs/79R/billtext/pdf/SB01525I.pdf

27. State of Washington [2006]. An act relating to reducing injuries among patients and healthcare workers. Accessible on Web at: http://www.leg.wa.gov/pub/billinfo/2005-06/Pdf/Bill percent20Reports/House/1672.HBR.pdf

28. State of Hawaii [2006]. HCR16: Requesting Appropriate Safeguards Be Instituted in Health Care Facilities to Minimize the Occurrence of Musculoskeletal Injuries Suffered by Nurses. Accessible on Web at: http://www.capitol.hawaii.gov/session2006/status/HCR16.asp

29. State of Rhode Island [2006]. An Act Relating to Health and Safety—Safe Patient Handling Legislation. Accessible on Web at:http://www.rilin.state.ri.us/Billtext/BillText06/HouseText06/H7386Aaa.pdf

30. State of Ohio [2006]. House Bill 67. Accessible on Web at: http://www.legislature.state.oh.us/bills.cfm?ID=126_HB_67. Last accessed November 24, 2006.

31. State of New York [2006]. Bill No. A07641A. An Act establishing a safe patient handling demonstration program. Accessible on Web at: http://assembly.state.ny.us/leg/?bn=A07641&sh=t Last accessed on November 24, 2006.

Sub goal 5.2: Evaluate interventions used to prevent acute injuries caused by material handling

Issue:
Employers have attempted prevention of back injuries by providing, or requiring employees to wear, industrial back belts. In 1995, approximately four million back belts were purchased. Based on a review of the literature, a NIOSH working group found insufficient scientific evidence to support the use of back belts. The studies reviewed at that time had conflicting results, were often restricted in scope, and most suffered from serious design flaws. This finding was reported in two 1994 NIOSH publications entitled Workplace Use of Back Belts (NIOSH Publication Number 94-122)1 and "Back Belts - Do They Prevent Injury?" (NIOSH Publication Number 94-127).[2]

Following the NIOSH review in 1994, two additional major studies were completed, again with conflicting results and some important limitations.[3,4] To increase the science on the effectiveness of back belts, TI undertook a large study in collaboration with Wal-Mart. The report on the NIOSH-Wal-Mart study appeared in December, 2000 in the Journal of the American Medical Association.

Approach:
The aim of this TI research effort was to evaluate stretchable industrial-type back supporting belts in preventing initial and recurrent low back injuries in retail store employees.

To examine the effect of back belt use on back injuries in the workplace, a large, prospective cohort study was conducted among material handlers in a retail setting. The main study was conducted in workers with the highest lifting exposures from 160 Wal-Mart stores distributed across 30 States which ranged geographically from New Hampshire to Michigan in the North and from Florida to Texas in the South. Between April 1996 and April 1998, 50 new stores and 110 newly expanded stores (combination supermarket and merchandise) were enrolled in the study on the day they first opened for customer sales. Controlling for multiple individual risk factors, this study found that elastic support back belt use was not associated with reduced incidence of back injury claims or low back pain. Neither frequent back belt use nor a store policy that required belt use was associated with reduced incidence of back injury claims or low back pain. With the finding that back belts were not effective, TI reaffirmed the finding that back belts could not be recommended for general use as protective technology in the workplace.[5]

Two laboratory evaluations examined the physiological and human motion effects of the same belt used in the prospective cohort study. A laboratory evaluation of the physiological effects of belt use found a significant reduction in mean oxygen consumption, but no significant effect on heart rate, blood pressure, or breathing rate.[6] An evaluation of the effects of the elastic back belt on human body motion during box-lifting tasks found that use of the belt significantly reduced the distance of forward spine bending and the velocities of forward-and-backward-spine-bending among subjects in the laboratory setting.[7] Unlike the epidemiologic study, these laboratory evaluations did not examine the association between back belt use and the outcomes of back injury or back pain.

A number of partners were involved in this project including Wal-Mart Corporation (provided employees time to participate in the telephone surveys and provided data on injury reports and payroll), Battelle Corporation (conducted the telephone surveys and data management under

contract), University of Massachusetts at Lowell (conducted a direct observation task analysis in a limited number of workplaces), and University of Pittsburgh (consultant on design and analysis).

Outputs and Transfer:
The principal outputs of this study were the peer-reviewed journal articles that appeared in JAMA, Applied Ergonomics, and Spine in 2000 and 2001.[5-7]

A Website summarizes current knowledge about industrial back belts: http://www.cdc.gov/niosh/topics/ergonomics/#back.

Intermediate Outcomes:
This study found that an existing injury intervention in widespread use by industry was not effective in preventing back injury or pain. Such a finding would not be expected to directly result in a reduction of injury. However, subsequent to publishing the study results, a number of large retail establishments have ceased requiring their employees to wear back belts, and have shifted their safety resources towards more promising intervention strategies.

Wal-Mart no longer requires back belts to be worn by associates in their retail establishments, although they will provide them upon request. They have implemented other back injury prevention strategies such as reorganized stocking and display of heavy items and redesigned checkout stations to eliminate cashiers lifting of bagged merchandise. Home Depot no longer requires or even provides back belts upon request, despite having participated in a study prior to the NIOSH study that suggested a protective effect of back belts. Lowes has also eliminated their policy of requiring employees to wear back belts. There is anecdotal evidence that cost savings from employer-provided back belts are being redirected to pursue other injury prevention efforts.

External Factors:
In the past, some employers have provided back belts to employees and in some cases required employees to wear them in the attempt to prevent back injuries. It is known that approximately four million industrial back belts were purchased in 1995. Data, however, on back belt sales has not been available to assess sales trends as a proxy for back belt use in the workplace. Other data that might provide insight into the impact of the TI findings—such as any measure that could document a shift by employers away from back belts to other back injury prevention efforts (e.g. engineering controls to reduce lifting hazards)—have likewise not been available.
Other issues that have affected the trends in overexertion back injuries include the transient nature of the population of material handling workers. There is evidence that the risk of back injury is high among newly hired employees and employees with the least amount of work experience.[8] Employment trends with respect to these issues may account for some of the decreasing trend in back injuries.

References:

1. NIOSH [1994]. Workplace Use of Back Belts: Review and Recommendations, NIOSH Publication No. 94-122. Cincinnati, OH: National Institute for Occupational Safety and Health, 25 pp.

2. NIOSH [1994]. Back Belts: Do They Prevent Injuries?, NIOSH Publication No. 94-127. Cincinnati, OH: National Institute for Occupational Safety and Health.

3. Kraus JF, Brown KA, McArthur DL, et al. [1996]. Reduction of acute low back injuries by use of back supports. *Int J Occup Environ Health 2*:264-273.

4. van Poppel MN, Koes BW, van der Ploeg T, Smid T, Boulter LM [1998]. Lumbar supports and education for the prevention of low back pain in industry. *JAMA 279*:1789-1794.

5. Wassell JT, Gardner LI, Landsittel DP, Johnston JJ, Johnston JM [2000]. A prospective study of back belts for prevention of back pain and injury, Journal of the American Medical Association 284(21):2727-2732. [Alice Hamilton Award for Excellence in Occupational Safety and Health. April 25, 2001; Nominated for the 2001 Charles C. Shepard Science Award and the CDC/ATSDR Statistical Science Award.] *This study was reported in an Associated Press article that appeared in about 400 newspapers nationally and a video news release. In addition, CBS Evening News covered the back belt study on Dec. 5, 2000 including an interview with Acting NIOSH Director.*

6. Bobick TG, Belard J-L, Hsiao H, Wassell JT [2001]. Physiological effects of back belt wearing during asymmetric lifting, Applied Ergonomics 32(2001):541-547.

7. Giorcelli RJ, Hughes RE, Wassell JT, Hsiao H [2001]. The effect of wearing a back belt on spine kinematics during asymmetric lifting of large and small boxes, Spine 26(16):1794-1798.

8. Gardner LI, Landsittel DP, Nelson NA [1999]. Risk factors for back injury in 31,076 retail merchandise store workers, Am J Epidemiol 150(8):825-83.

6. Reduce injuries and fatalities among workers in Alaska

Introduction

In the late 1980s, TI identified Alaska as the highest-risk State for worker fatalities. For the decade from 1980 through 1989, the traumatic occupational fatality rate in Alaska was nearly 35/100,000—almost five times the U.S. average of 7.0 deaths per 100,000 workers per year.[1] The TI Program established the Alaska Field Station in Anchorage in 1991 with a goal of reducing this high rate of traumatic occupational fatalities.

Reference:

1. NIOSH [1993]. Fatal Injuries to Workers in the United States, 1980-1989: A Decade of Surveillance (National Profile), DHHS (NIOSH) Publication No. 93-108. Cincinnati, OH: US Department of Health and Human Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 27 pp.

Sub goal 6.1: Reduce injuries and fatalities in commercial fishing

Issue:
During the five-year period from 1990 through 1994, 118 Alaskan commercial fishermen died from trauma, a rate of 140 deaths per 100,000 workers per year.[1] Commercial fishermen in Alaska face extreme environmental risk factors, including cold weather, cold water (the coldest in the U.S.), and the remote location of many fishing grounds (and the consequent lack of nearby rescue teams and emergency response systems). As TI began to examine work-related fatalities in Alaska in 1991, early surveillance data showed that commercial fishing fatalities were primarily due to vessels sinking and crew members falling overboard.[1]

From 1991 through 1998, severe nonfatal injuries occurred in the Alaskan commercial fishing industry at a rate of 410 injuries per 100,000 fishermen.[2] Unlike fatal injuries, most severe nonfatal injuries among these workers occur on deck during the deployment and retrieval of fishing gear (67 percent). Not only is the deck of a fishing vessel an unstable work platform that is constantly moving, it is often congested with machinery and fishing equipment, which accounts for 40 percent of all nonfatal injuries. Much of the machinery and equipment used on commercial fishing vessels is rudimentary with inadequate guarding. Machinery-related injuries result from cables, chains, lines, winches, hydraulic "pot launchers" and other deck equipment. Workers getting caught in winches represent 35 percent of all of these severe machine-related injuries. [2]

When the TI was established in 1991, several barriers hampered researchers in their efforts to effectively address the problem of traumatic occupational injuries and fatalities among Alaskan workers. First, one of the essential prerequisites of an effective public health approach to prevention was missing—a comprehensive, effective occupational injury and fatality surveillance system. Further, no system was available to accurately count or estimate the number of workers at risk in the commercial fishing sector. This lack of denominator data prohibited the calculation and comparison of injury and fatality rates. Effective surveillance, including the ability to calculate rates, is needed to accurately identify and compare injury and fatality risks, to direct research and prevention efforts, to track changes, and to evaluate the results of interventions, programs, and policy changes. Also, effective partnerships between TI and other agencies with worker safety mandates and interests, including both governmental and private-sector organizations, had not been established. Finally, policies affecting the industry, including regulatory actions such as the Commercial Fishing Industry Vessel Safety Act of 1988 (CFIVSA),[3] had not been evaluated. Other regulatory constraints, such as the fishery management requirements in the Magnuson-Stevens Fishery Conservation and Management Act,[4] inadvertently created a negative impact on the safety of fisheries.*

* Fishery management provides a compelling illustration of how policies can adversely affect safety in an industry. To prevent the depletion of fish stocks as the competition for these stocks increases, each fishery (defined by species, time, and place) has its own management plan. The challenge is to keep fisheries at sustainable levels while preserving the economy of the fishing communities that depend on this resource. Fishery management plans can limit the number of participants; limit the type or amount of gear that can be carried; put geographic restrictions on fishing areas; limit the number of minutes, hours, or days fleets can fish; or place limits on the total eight of the catch across the fleet without the use of major time constraints. Fishery management regulations that result in short seasons sometimes cause fishermen to pursue fish in waters for which their vessels were not designed, or change to new, unfamiliar fishing gear, thereby increasing risks.

TI was well equipped to overcome each of these barriers through staff expertise in public health surveillance, case investigation, epidemiologic research, intervention evaluation, communications, and coordination with partners.

Approach:
The TI Program set a goal in 1994 to decrease the commercial fishing fatalities and fatality rate in Alaska by 50 percent by the year 2005 by establishing comprehensive occupational fatality and injury surveillance; coordinating the efforts of a variety of agencies and organizations; conducting collaborative research, evaluation, and prevention efforts; and communicating risk and prevention information.

TI designed and implemented a comprehensive surveillance system for occupational fatalities, the Alaska Occupational Injury Surveillance System (AOISS).[5] This was largely done by establishing data-sharing agreements with agencies such as the U.S. Coast Guard (USCG) and the Division of Alaska State Troopers, and through direct TI site investigations of fishing fatalities and interviews of survivors. In addition, the AOISS collects information from National Transportation Safety Board (NTSB) investigative reports, death certificates, medical examiner reports, and news media reports. Further, TI established a relationship with the State of Alaska to enable the development and use of Alaska Trauma Registry (ATR) data for surveillance of serious hospitalized injuries. TI now uses information from both AOISS and the ATR to identify and assess the hazards of commercial fishing and to track progress in attaining program goals. Through its surveillance efforts, TI has identified high-risk incidents such as vessel sinkings, falls overboard, and deck injuries; high-risk groups based on type of fishing (e.g., crab fishing); and high-risk gear used in fishing (e.g., deck winches).

To enable calculation of rates of fatalities and injuries in commercial fishing, TI designed a way to determine denominator data by estimating the number of full-time equivalent fishermen for each fishery and for the entire workforce. The fishery-specific rates allow TI to identify the most hazardous fisheries in Alaska and thereby focus prevention efforts, whereas the overall rates enable comparisons with fatality and injury rates faced by Alaskan workers in other sectors. These comparisons are used to monitor progress and assess and determine program direction and priorities.

TI scientists formed and facilitated an Interagency Working Group (IAWG) for the Prevention of Occupational Injuries. Members of this working group include experts from many organizations including:

- State agencies such as the Alaska Department of Health and Social Services (AKDHSS) and the Alaska Department of Labor
- Federal agencies such as OSHA, the U.S. Coast Guard (USCG), and the Federal Aviation Administration (FAA)
- Local entities such as the Municipality of Anchorage (MOA)
- Industry associations such as the Alaska Marine Safety Education Association (AMSEA) and the North Pacific Fishing Vessel Owners Association (NPFVOA
- The University of Alaska Anchorage (UAA).

The IAWG first met at the Alaska Governor's Safety and Health Conference in March 1991, where one of the first subgroups formed focused on commercial fishing safety issues.

Other subgroups have been formed to address deaths and injuries in the aviation and construction industries. The group includes agencies with jurisdiction and oversight of the highest-risk industry sectors in Alaska. The IAWG has served an important role in Alaska by collectively providing a broader understanding of occupational injuries in the State, and enabling rapid response to emerging occupational injury problems. It has also facilitated many of the efforts of TI, including the development of improved industry fatality and injury surveillance.

In addition to playing a central role in defining, describing, and disseminating commercial fishing risks through surveillance, TI has collaborated in research efforts to investigate injury causation and prevention, and evaluated major intervention strategies and programs. In 2000, TI initiated a study aimed at finding and disseminating practical solutions to fatal and nonfatal injuries that occur on fishing vessel decks. In collaboration with the North Pacific Fishing Vessel Owners Association (NPFVOA), TI conducted focus groups with crab fishermen to discuss deck safety problems and toured vessels to view problems and discuss potential modifications. After initial work that concentrated upon crab fishing vessels, researchers turned their attention to other types of fishing vessels.

A series of industry meetings revealed that fishermen were concerned about deck winches, which pose risk of entanglement. To address this hazard, engineers at the NIOSH Spokane Research Laboratory (SRL) designed an emergency stop (e-stop) system* that allows a fisherman to quickly stop a winch, even when entangled. A fishing vessel owner and captain in Seattle, Washington partnered with TI on the design and installation of the e-stop system, and successfully tested the system during the 2005-6 Alaska salmon seasons. Crew members praised the device as a significant safety and productivity improvement and they continue to use the system. TI researchers also collaborated with researchers from the Harvard School of Public Health in a study aimed at characterizing and reducing falls overboard from lobster vessels.

In the winter of 2005, the USCG requested TI's assistance by evaluating the USCG Dockside Pre-season Boarding Program. TI demonstrated that from the implementation of the USCG program in October 1999 until 2005, there had been only three fatalities (two fell overboard, one crushed) in the crab fishery that had averaged seven deaths per year in the prior five years.

Individual Fishing Quotas (IFQs), which were implemented as an element of fishery management for the halibut/sablefish fisheries in January 1995, set an allowable catch limit for vessel owners and a time frame (April to September) in which they had to catch their limit. In 1997, the Ocean Studies Board of the National Research Council asked TI to provide testimony regarding the safety implications of IFQs on the halibut/sablefish fishery. TI analyzed USCG data and showed that no fatalities had occurred since implementation of the IFQs, and that search and rescue missions had declined significantly.

Using AOISS, AFS conducted the first major assessment of commercial fishing fatalities since the passage of the Commercial Fishing Industry Vessel Safety Act of 1988 (CFIVSA).[3] NIOSH

*The emergency-stop (e-stop) system allows the winch to be quickly stopped by a worker, even if the worker is caught in the winch. The system can be retrofitted to any winch and consists of a sturdy pushbutton mounted on the winch housing, electronic controls, and a hydraulic valve interfaced into the existing hydraulic controls. A fisherman who becomes entangled can push the electronic button located on the winch. This in turn actuates a solenoid valve that stops the flow of hydraulic oil powering the winch, and the rotation stops. This allows the fisherman to be freed from the entanglement.

found that although there had been a decline in the fatality rate among commercial fishermen, there had not been a decline in the numbers of vessels sinking. NIOSH recommended augmenting the CFIVSA approach, which emphasized the use and availability of safety equipment during and after a disaster at sea, by focusing upon preventing these disasters in the first place.

TI has worked with partners to organize conferences and workshops on commercial fishing safety. Of particular importance have been two Fishing Industry Safety and Health (FISH) Workshops, the first conducted in 1992 (Anchorage), and the second in 1997 (Seattle). In October 2000, the first International Fishing Safety and Health (IFISH) Workshop was conducted at Woods Hole, Massachusetts, followed by IFISH II in 2003 (Sitka, Alaska) and IFISH III in 2006 (Chennai, India). These conferences have brought together researchers, industry representatives, government administrators and policymakers, safety practitioners, and others together from around the U.S. and the world to raise awareness, build coalitions, develop strategies, share research and policy information, and establish a forum for all the representatives and organizations that have a stake in commercial fishing safety.

The CFIVSA regulations include a requirement that fishermen participate in monthly emergency drills and that these drills be conducted by a Certified Drill Conductor.[3] In the early 1990's, AMSEA received its first NIOSH Training Program Grant (TPG) to help train fishermen to become qualified Drill Conductors for these required monthly drills. AMSEA and the TI have collaborated on many other projects on fishing vessel safety since the early 1990s, including conducting a dive safety workshop and preparing a deck-safety pamphlet. Since 1992, AMSEA has held more than 1,000 classes and trained more than 15,000 fishermen.

Outputs and Transfer:
TI has published scientific articles, NIOSH documents, MMWR articles, and industry trade articles describing injury and fatality risks and recommending strategies to prevent injuries and deaths among Alaskan commercial fishermen. In addition, TI has sponsored and published proceedings from domestic and international scientific conferences focusing on fishing vessel safety. The following information highlights the most important outputs and transfers to date:

Using results of data analyses conducted in support of the TI evaluation of the CFIVSA, TI prepared and published the NIOSH Current Intelligence Bulletin (CIB) "Commercial fishing fatalities in Alaska: risk factors and prevention strategies" (DHHS (NIOSH) Publication No. 97-163).[6] This CIB outlines risk factors and prevention strategies for commercial fishing deaths in Alaska, including a discussion of management regimes and the safety roles of the USCG in implementing CFIVSA. Recommendations call for more attention to improvement of vessel stability and hull integrity, licensing and training of skippers, training of crewmembers, avoidance of harsh sea and weather conditions, prevention of falls overboard, human factors associated with injuries, and deck safety.

Modifications identified in the study of deck safety on crab fishing boats as good solutions were published with illustrations and general installation instructions in the "Deck Safety Handbook for Crab Fishermen."[7] These potential solutions to deck safety problems included the installation of "pot guides" that decrease the swinging motion of full crab pots as they are being lifted from the water to the deck. Other proposed solutions included improved lighting and closed-circuit TVs to enable crew members and the skipper to see one another more easily. In addition to the Handbook, a 1/10-scale deck safety model was built for use at industry trade shows during

discussions of deck safety to illustrate the hazards and solutions presented in the deck safety booklet. More than 4,000 copies of the "Deck Safety Handbook" have been distributed to fishermen in the Northwest and a copy is posted on several safety Websites as a resource.

The previously mentioned emergency stop (e-stop) system—that allows a fisherman to quickly stop a winch, even when entangled—was demonstrated at Pacific Marine Expo in Seattle, the largest commercial fishing trade show in the U.S. Many vessel owners and operators requested information on how to obtain the device.

The findings from the TI-Harvard collaboration were compiled and published by Harvard in an industry-specific publication—"Lobstering Safety Secrets Revealed"[8]—and distributed to commercial lobsterman in Maine. This collaborative research also resulted in a NIOSH Workplace Solutions document entitled "Dangers of Entanglement During Lobstering," DHHS (NIOSH) Publication No. 2005–137, August 2005.[9] These documents report that lobster fishing is a hazardous occupation that has resulted in drowning from entanglement in trap lines and being pulled overboard. A survey of 103 lobstermen developed recommended work practices and controls to reduce entanglement, escape entanglement, and provide opportunities to reboard the vessel.

Proceedings documents were published for the two FISH conferences, and the first two of three IFISH conferences.[10-13]

Intermediate Outcomes:
The USCG in Alaska designed and implemented a Dockside Pre-season Boarding Program. USCG personnel had participated in the Vessel Loss Prevention Working Group at the November 1997 FISH Workshop in Seattle, and took the lead in designing a plan to prevent vessels from sinking. USCG vessel safety examiners developed the "at-the-dock" boarding program to identify and correct safety hazards known to exist in the Bering Sea crab fisheries. These fisheries were chosen based on NIOSH findings identifying the crab fishery with the highest fatality rate of any fishery in Alaska. Bering Sea crab fishing requires the use of crab "pots" that are 600- to 800-pound steel cages to catch crabs on the ocean floor. A vessel improperly loaded with crab pots may become dangerously unstable and capsize. This Dockside Pre-season Boarding Program examines a large number of vessels within the fleet prior to the opening of the crab fishery. The examiners review vessel stability information with vessel masters, and check life-saving equipment required by the CFIVSA. If the vessel is not loaded properly or if there is a lack of life-saving equipment, a Captain of the Port Order is issued and the vessel is not able to leave port until the discrepancy is corrected.

In addition, TI publications that documented the safety record of the Bering Sea crab fishery fleet (and which showed that this is a dangerous fishery) were used as foundational evidence for a recently implemented quota-based management system.

In 1998, the U.S. Coast Guard (USCG) convened a task force and used the NIOSH Current Intelligence Bulletin (CIB)[6] to develop a national plan for fishing vessel safety. In the final report called "Living to Fish, Dying to Fish,"[14] the USCG adopted eight of the 11 recommendations from the CIB to improve fishing vessel safety for the U.S.

The TI Current Intelligence Bulletin has been used by many organizations as a resource to discuss the dangers of the commercial fishing industry including the Alaska Department of Fish

and Game,[15] the Alaska Fishing Job Clearinghouse,[16] CareMarx consumer health,[17] The University of Vermont,[18] WorkSafe BC in British Columbia,[19] and Trident Marine Association.[20]

End Outcomes:
Since 1990, deaths of commercial fishermen in Alaska have declined by 74 percent, and the annual fatality rate has declined by 51 percent (see Figure 14 below).

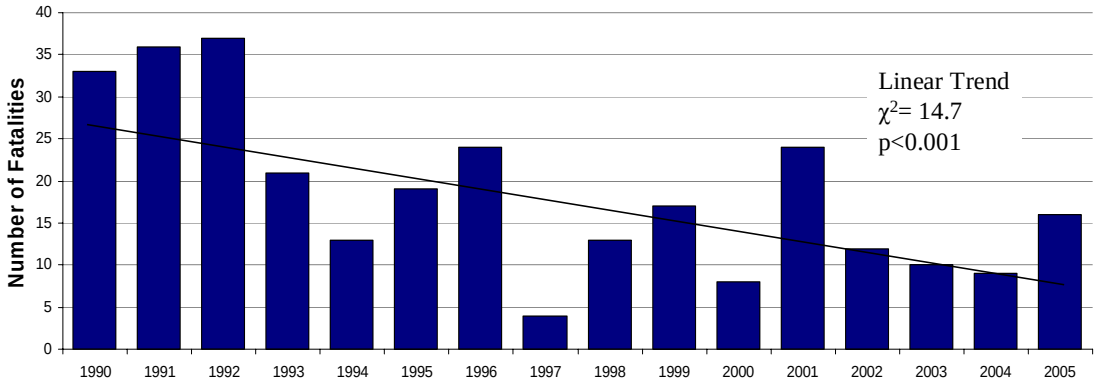

Figure 14. Commercial Fishing Fatalities in Alaska by Year, 1990-2005 (n=296)

In particular, fatalities declined among crab fishermen. Comparing fatality rates for the decade of the 1990s versus the rates since 2000, the rate has dropped by more than 50 percent among crab fishermen. (Note in Figures 15 and 16 below the difference in pre-2000 and post-2000 data. The USCG began the vessel-stability checks as part of its Pre-season Boarding Program in October 1999.)

The principal TI contributions to the reduction in crab fishery fatalities, and commercial fishing fatalities overall, have been in the areas of surveillance, coordination and collaboration, and evaluation research. For example, TI conducted the early assessment of the decline in commercial fishing fatalities after the implementation of the Commercial Fishing Industry Vessel Safety Act, and found that although fatalities had decreased, vessel sinking events had not. In addition, by identifying the fishery in which each fatal event occurred, TI showed that the crab fishery in the Bering Sea was the most hazardous fishery in the State, and that the principal problem was the loss of fishing vessels. Bringing partners together at the FISH II Workshop in Seattle in 1997, TI organized the working group to prevent vessels from sinking. This resulted directly in the 1999 USCG Dockside Pre-season Boarding Program, a program strongly supported by the crab industry. The overall reduction in fatalities in commercial fishing has been largely driven by the reduction in fatalities in the crab fishery.

Although TI had previously demonstrated that fatalities had been reduced in the crab fishery after implementation of the USCG Dockside Pre-season Boarding Program, in January 2005 another fall-overboard fatality occurred, and the fishing vessel “Big Valley” sank, resulting in five fatalities.

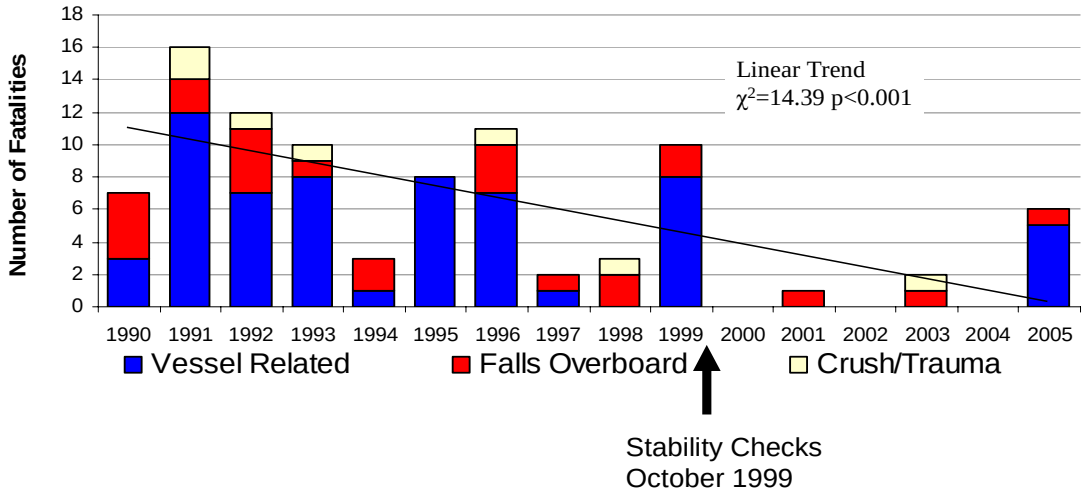

Figure 15. Commercial Crab Fishing Fatalities in Alaska by Year and Cause, 1991-2005 (n=91)

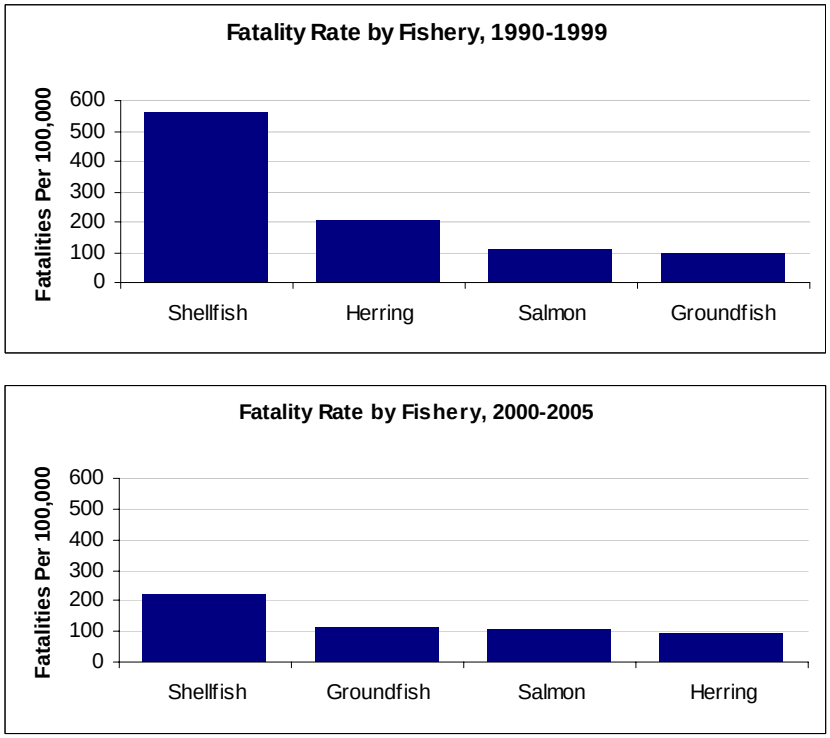

Figure 16. Comparison of Fatality Rates by Fishery in Alaska, 1990-1999 (top graph) and 2000-2005 (bottom graph)

External Factors:
Although collaborative research and communication efforts have developed and disseminated recommendations and promising interventions, the USCG, the agency with the regulatory authority for the safety of the fleet, has not yet addressed nonfatal injuries.

What's Ahead:
TI is producing a video on deck safety, developing a commercially available retrofit kit for the e-stop (in collaboration with the original switch manufacturer), and preparing a control technology publication aimed at increasing the distribution and impact of the e-stop.

TI has recommended that all current and proposed management regimes be examined for safety concerns.[6] Despite the assertion by fishery managers, industry leaders, and academicians that vessels operating in a quota-based fishery are generally safer, no systematic assessment to examine corresponding improvements in measures of safety has been conducted. TI scientists successfully competed for a grant in 2005 from the North Pacific Research Board to evaluate the impact of the changes in fishing management regimes on safety in the halibut/sablefish fleet and the Bering Sea Aleutian Island pollock fleet.

The NIOSH Alaska Field Station is expanding on the successful work in Alaska to include other commercial fishing regions of the country during FY07. This research program will apply classic epidemiologic and engineering analysis methods in order to better understand and prevent commercial fishing fatality and injury events in all geographic areas which comprise the U.S. coastline.

TI researchers will continue analysis of falls overboard to:

- Understand root causes and possible interventions
- Seek to develop improvements to deck designs or fishing equipment
- Evaluate commercially available crew overboard alarms, and tracking and rescue devices
- Design new, innovative crew overboard interventions that can prevent such incidents
- Continue development of e-stop and guarding technologies
- Consider new ways to detect, monitor, control, and prevent dangerous, uncontrolled downflooding that can sink an otherwise intact, seaworthy vessel.

References:

1. Conway, GA and Lincoln JL [1995]. "Preventing deaths in Alaska's fishing industry." *Public Health Reports 110*(6):700.

2. Thomas, TK, Lincoln, JM, Husberg, BJ, Conway, GA [2001]. "Is it safe on deck? Fatal and nonfatal workplace injuries among Alaska commercial fishermen." American Journal of Industrial Medicine *40*(6):693-702.

3. Title 46 Code of Federal Regulation, Part 28—Requirements for Commercial Fishing Industry Vessels. Commercial Fishing Industry Vessel Safety Act of 1988 (CFIVSA).

4. Title 16 U.S.C. 1801-1882 [1976]. Magnuson-Stevens Fishery Conservation and Management Act, Public Law 94-265 (As amended through October 11, 1996) Available on Web at: http://www.nmfs.noaa.gov/sfa/magact. Last accessed November 27, 2006.

5. Conway GA, Lincoln JM, Hudson DS, Bensyl DB, Husberg BJ, Manwaring J.C. Surveillance and Prevention of Occupational Injuries in Alaska: A Decade of Progress, 1990-1999. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2002. DHHS (NIOSH) Publication No. 2002-15.

6. NIOSH [1997]. Commercial Fishing Fatalities and Prevention Strategies in Alaska. Current Intelligence Bulletin (CIB) #58, DHHS (NIOSH) Publication No. 97-163. Cincinnati, OH: National Institute for Occupational Safety and Health (September 1997).

7. Jensen Maritime Consultants [2002]. Deck Safety for Crab Fishermen. Seattle, WA. Available on Web at: http://www.jensenmaritime.com/articles/crabdeck.pdf#search= percent22 percent22deck percent20safety percent20for percent20crab percent20fishermen percent22 percent22 Last accessed on November 30, 2006.

8. Harvard School of Public Health [2001]. Lobstering Safety Secrets Revealed! Boston, MA. abackus@hohpharvard.edu (617) 432-3327.

9. NIOSH [2005]. Workplace Solutions: Dangers of Entanglement During Lobstering, DHHS (NIOSH) Publication No. 2005-137. Cincinnati, OH: National Institute for Occupational Safety and Health. 4 pp. (August 2005).

10. NIOSH [1994]. Proceedings of the National Fishing Industry Safety and Health Workshop. Cincinnati, OH: DHHS (NIOSH) Publication No. 94-109. Cincinnati, OH: National Institute for Occupational Safety and Health.

11. NIOSH [2000]. Proceedings of the Second National Fishing Industry Safety and Health Workshop. DHHS (NIOSH) Publication No. 2000-104. Cincinnati, OH: National Institute for Occupational Safety and Health.

12. NIOSH [2002]. Proceedings of the International Fishing Industry Safety and Health Conference. DHHS (NIOSH) Publication No. 2002-147. Cincinnati, OH: National Institute for Occupational Safety and Health.

13. NIOSH [2006]. Proceedings, Second International Fishing Industry Safety and Health Conference. DHHS (NIOSH) Publication No. 2006-114. Cincinnati, OH: National Institute for Occupational Safety and Health.

14. USCG [1999]. Living to Fish; Dying to Fish: Fishing Vessel Casualty Task Force Report. Viewed at: http://www.uscg.mil/hq/gm/moa/docs/fvctf.pdf Last accessed on November 22, 2006.

15. Alaska Department of Fish and Game [2006]. Website available at: http://www.cf.adfg.state.ak.us/ Last accessed on December 27, 2006.

16. Alaska Fishing Jobs Clearing House [2006]. Website available at: http://www.fishingjobs.com/faq.htm Last accessed on December 27, 2006.

17. Caremark Pharmacies [2006]. Website available at: http://healthresources.caremark.com/topic/fishers Last accessed on December 27, 2006.

18. L-Soft Listserv [2006]. Website available at: http://list.uvm.edu/cgibin/wa?A2=ind0005d&L=safety&P=13818 Last accessed on December 27, 2006.

19. WorkSafe BC [2006]. Website available at: http://www2.worksafebc.com/Portals/Fishing/Prevention-GeneralSafety.asp Last accessed on December 27, 2006.

20. Trident Marine Associates [2006[. Available on Website at: http://www.tridentmarine.net/fishing percent20vessel percent20safety.htm. Last accessed on December 27, 2006.

Sub goal 6.2: Reduce injuries and fatalities in helicopter logging operations

Issue:
Because of the unique capabilities of helicopters, their use in hauling logs and recently felled trees (also known as "helicopter logging," helicopter long-line logging," or "heli-logging") has steadily increased worldwide since the late 1980s. Unfortunately, helicopter logging in some areas, such as Southeast Alaska, has been an extremely high-risk operation. A series of crashes in Alaska during 1992 and 1993 brought these operations to the attention of TI. Amid the rapid growth of this new industry in Alaska—between January 1, 1992 and June 30, 1993—six (16 percent) of the 25 helicopters flying in logging operations crashed, killing nine workers (including four pilots) and severely injuring 10 workers.1 National Transportation Safety Board (NTSB) investigations revealed that all crashes involved improper operation and/or maintenance practices.

Approach:
This first major focused prevention effort of the TI Program at the Alaska Field Station came early after the establishment of the State-wide occupational surveillance system—the Alaska Occupational Injury Surveillance System (AOISS)—in 1992. After the occurrence of two serious helicopter logging crashes during one week in May 1993, and the recognition that these crashes were only the latest in a series of crashes dating back to 1992, TI began a series of urgent consultations, and organized an emergency meeting of the Alaska Interagency Working Group (IAWG) for Prevention of Occupational Injuries. Representatives from the various governmental agencies participated in this meeting on July 8, 1993. Each agency either had jurisdictional responsibilities or shared an interest in preventing helicopter logging crashes. In addition to TI, participating agencies included the Federal Aviation Administration (FAA), the National Transportation Safety Board (NTSB), the U.S. Forest Service, the U.S. Coast Guard (USCG), OSHA, and the Alaska Departments of Labor (AKDOL) and Health and Social Services (AKDHSS).

At this meeting (which was chaired by TI leadership), participants discussed prevention measures and identified a list of recommendations for the prevention of logging helicopter crashes. Included were recommendations for heli-logging companies to provide specific long-line logging operations training for both pilots and ground crews, to adopt limits on crew flight time and duty periods, to follow manufacturer recommendations for more frequent maintenance, and to use multi-engine helicopters for long-line logging. They also called for the development of industry-wide standards and procedures. Additional recommendations included the need for more vigorous oversight and development of rigorous voluntary industry standards for equipment, maintenance, and training.

Prompted to action by the emergency meeting, by the end of July 1993, the jurisdictional agencies (FAA and AKDOL) had visited and inspected all helicopter logging sites and ramps in the State, and shut down or curtailed a number of these operations for irregularities.

Subsequently, TI co-sponsored three Helicopter Logging Safety Workshops in Ketchikan, Alaska in March 1995, February 1996, and March 1997 in order to increase safety awareness, build coalitions, share information and experiences, and encourage action to prevent injury in the helicopter logging industry. Attendees and participants at the workshops consisted of more than

150 representative participants from government agencies, industry (including 27 companies that conduct helicopter logging operations), academia, and insurance organizations. At the workshops additional preventive measures were developed and refined and provided to the industry as recommended safety countermeasures.

Outputs and Transfer:
The IAWG disseminated the initial prevention recommendations that were produced from discussions at the emergency July 1993 meeting. These recommendations were published in a CDC MMWR article1 and discussed in subsequent meetings with the State and Federal participating agencies, and with the helicopter logging companies. This resulted in a joint enforcement effort by FAA, USFS, and AKDOL. Within two weeks these agencies shut down the least desirable operations in Southeast Alaska. The IAWG disseminated additional prevention recommendations that emerged from discussions at the three heli-logging workshops conducted each year from 1995 to 1997. These recommendations were then adopted by the Helicopter Association International (HAI) Helicopter Logging Committee as HAI standards. Helicopter hull manufacturers and re-insurer companies then adopted these standards for all helicopter logging operations.

Three publications ultimately resulted from TI helicopter logging safety research, including a 1994 MMWR article,[1] a 1997 chapter in the book "Safety and Health in Agriculture, Forestry, and Fisheries,"[2] and a 1998 NIOSH report entitled "Helicopter Logging Safety."[3]

Also, proceedings of the first Helicopter Logging Safety Workshop in 1995 were published and disseminated to all participants.[4]

Intermediate Outcomes:
In July 1993, TI convened and led the collaborative efforts of the Alaska Interagency Working Group for the Prevention of Occupational Injuries. These efforts directly resulted in six tangible intermediate outcomes for preventing helicopter logging crashes and fatalities:

The U.S. Forest Service and the AKDOL shared information on the timber sale locations and the ramp (maintenance) and hangar locations for helicopter logging operations with the FAA. The three agencies collaborated in making site visits to each location to enforce FAA and AKDOL regulations pertaining to helicopter logging.

1. These joint site inspections in Southeast Alaska during the late summer of 1993 noted serious violations involving operations of the two helicopter logging companies that had experienced the fatal helicopter crashes during 1992-1993. Because of the serious nature of these violations, FAA and AKDOL closed down these helicopter logging operations immediately.

2. The Helicopter Logging Safety Committee was formed under the auspices of the Helicopter Association International (HAI) in June 1996. The mission statement of the committee is "...to help promote the safe use of helicopters in all aspects of the helicopter logging industry." The committee has established its own "Helicopter Logging Guidelines," which address four issues: 1) general helicopter safety for forestry operations, 2) integration of ground and flight activities, 3) helicopter specific planning, and 4) a pre-accident plan (HAI, 1997). More detailed accounts of these data, events, and interventions have been published in the above three documents.

3. The Helicopter Logging Safety Committee of HAI disseminated these guidelines to all helicopter logging companies, and all 27 major helicopter logging companies agreed to adopt them as a part of their operational procedures at the 1997 HAI Conference in Portland, Oregon. As noted by the Draft HAI Helicopter Logging Safety Manual (contained in NIOSH Publication Number 98-147, "Helicopter Logging Safety" on pages 238-254),[2] these companies agreed that implementing the guidelines would help reduce fatal crashes in the helicopter logging industry worldwide.

4. The insurance industry played a major role in helicopter logging safety by substantially discounting helicopter insurance costs for helicopter logging operators adhering to standards developed by the Helicopter Logging Safety Committee.

The partnership developed among government agencies, HAI, and insurance underwriters has demonstrated the value of joint efforts to address specific occupational safety problems to workers in Alaska.

End Outcomes:
Since the emergency IAWG meeting in July 1993, the subsequent site visits by AKHSS, AKDOL and FAA later the same month, the immediate shutdowns of helicopter logging operations that were in violation of helicopter logging regulations, and the dissemination of the IAWG recommendations all of which occurred during July 1993 (following the emergency IAWG session called by TI), there were no further helicopter logging crashes or fatalities in Alaska until July 1996, when a single helicopter crash occurred with one fatality. Since 1996, there have not been any additional helicopter logging crashes (through December 2006), despite large-scale helicopter logging in Alaska from 1994 through 1999 (see Figure 17).

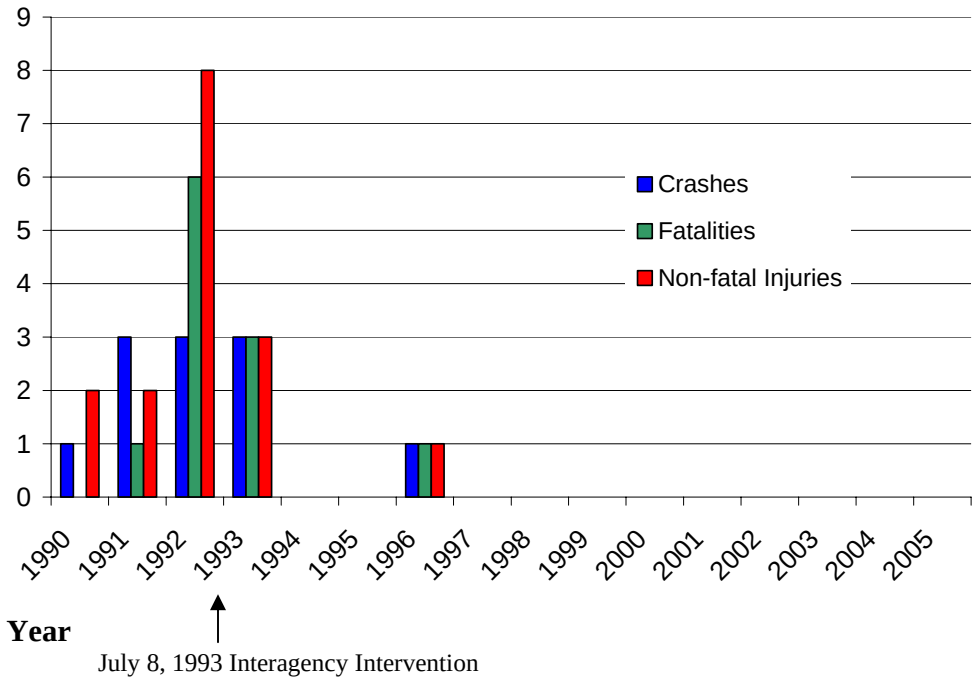

Figure 17. Crashes, Fatalities, and Nonfatal Injuries in Alaskan Helicopter Logging Operations, 1990-2005 Source: AOISS (2005 data provisional)

References:

1. CDC [1994]. Risk for Traumatic Injuries from Helicopter Crashes during Logging Operations -- Southeastern Alaska, January 1992-June 1993. MMWR Volume 43(26); 472-5, July 8, 1994.

2. CDC [1998]. Helicopter Logging Safety, (NIOSH Publication No. 98-147), July 1998.

3. R. Langley R, et al. [1997]. Epidemiology and Prevention of Helicopter Logging Injuries, Chapter 12, Safety and Health in Agriculture, Forestry, and Fisheries.

4. NIOSH, AIWG [1996]. Proceedings of the Helicopter Logging Safety Workshop, March 1-2, 1995 in Ketchikan, Alaska. Anchorage, AK: National Institute for Occupational Safety and Health, 43pp.

Sub goal 6.3: Reduce injuries and fatalities in Alaska aviation

Issue:
Among U.S. States, Alaska is uniquely dependent upon air transportation. Commuter and air taxi operators serve as the main link connecting more than 250 villages—which are located off the road system—with regional hubs. These operators provide a critical service by transporting people, cargo, and mail. This critical mode of transportation has also proven dangerous. Of the 401 people who died in aviation crashes in Alaska during 1990-1999, 157 (39 percent) were on-the-job at the time of their death. The majority of these workers (106) were commercial pilots. This is equivalent to a rate of 420 deaths per 100,000 pilots per year, approximately 100 times the mortality rate for all U.S. workers and nearly five times the rate for all U.S. pilots (88/100,000).[1]

There are several reasons why this mode of transportation has been so dangerous in Alaska. The State has a challenging terrain for air travel, including 17 of the 20 highest peaks in the United States and more than 47,000 miles of coastline. The weather can change quickly, and most of the State is covered with snow and ice for half of the year. Only 60 percent of Alaska had radar coverage over 10,000 feet above mean sea level in the 1990s, and of the more than 200 airports with International Air Transport Association codes in 1998, well over 50 percent were unpaved and did not have instrument approach procedures published.

The leading cause of commercial aviation crashes worldwide is controlled flight into terrain (CFIT) accounting for 24 percent of all fatal commercial airline crashes.[2] CFIT is a causal category of unintentional crashes where a pilot unknowingly flies an airworthy aircraft into terrain (e.g., a mountainside, flat ground, or water), usually due to loss of situational awareness. CFIT crashes accounted for an average of five fatal occupational crashes per year in Alaska from 1990 to 1999.

Approach:
When TI opened the Alaska Field Station in 1991, several industries in Alaska had a history of high fatality rates. Commercial aviation was one of these industries, with the fatalities occurring in air taxi and commuter operations that deliver people and goods across the State to small villages. NIOSH TI activities in Alaska are based on the public health model. Using this model, NIOSH staff began to study the problem scientifically, focus on the worst problems, build consensus for change, and then evaluate interventions for success.

Early work focused on studying the risk factors for pilot fatalities, identifying the most common fatal events, and establishing key partners for ongoing collaboration. Activities included scientific study and publication of research articles and sharing of information with aviation regulatory agencies.

In 2000, TI, the Federal Aviation Administration, the National Transportation Safety Board, and the National Weather Service collaborated to improve air safety through the Alaska Interagency Aviation Safety Initiative. This collaboration was supported by Congressional funding (Public Law 106-69). The TI Aviation Safety in Alaska Project was designed as part of this Initiative to reduce the number of work-related aircraft crash fatalities in Alaska. The concept is that TI, in cooperation with other regulatory and industry groups, can contribute to a 50 percent reduction in

occupational aircraft crash injuries and fatalities in Alaska by the end of 2009. The Initiative is part of the process of focusing on the worst problems and building consensus for change.

TI staff have conducted many activities aimed at transferring scientific research findings to the target audience. These include public workshops for aviation passengers; funding, co-organizing and speaking at aviation safety seminars for pilots and industry; and organizing and speaking at scientific aviation panel discussions.

In an attempt to reduce the number of aviation-related occupational fatalities in Alaska, TI offered two free Aviation Passenger Safety Seminars associated with the 2000 and 2001 Alaska Governor's Safety and Health Conferences. The first Seminar, in March of 2000, was well attended (~100 people). TI staff presented updates on aviation safety including information about what passengers can do prior to take-off and while in-flight to make their flight safer, and during and after a crash to increase their chances of survival. Additionally, seminar attendees learned about available training that can teach them the basics of flying and landing a small aircraft should the pilot suddenly become incapacitated, and information regarding how to incorporate safety measures into a company's contract with an air carrier to transport its employees. Finally, information on preventing passengers from pressuring pilots to fly into bad weather was discussed. The success of this seminar led to the second seminar the following year. The March 2001 seminar was smaller and more focused, with an attendance of approximately 40 people.

TI has been a leader in presenting aviation safety information to pilots and industry. In 2003-2006, NIOSH sponsored, co-organized, and presented at the annual Aviation Safety Alliance meeting in Anchorage, Alaska. This event is part of the annual Alaska Air Carrier's Association meeting which has an attendance of approximately 250 people each year.

TI has also provided information for safety organizations and regulatory agencies to develop their safety programs. TI designed and funded a survey of Alaska air taxi and commuter operations to study pilot and company practices and attitudes in order to develop intervention strategies that would reduce aviation fatalities. An analysis of the results was conducted to examine the practices and attitudes of Alaskan commuter and air taxi operators and their pilots as they relate to company fatal accident rates. Pilots of operators with high fatal accident rates differed from those working for the other operators, both in experience and working conditions. The combination of pilot inexperience and longer work hours and work weeks may contribute to Alaska's high aviation crash rate.[3]

As part of the public health model activity of evaluating interventions, TI helped design and fund an independent evaluation of the Aviation Initiative. While many of the interventions have only been in place for a few years, there has been a decline both in the number and rate of fatal aviation accidents in Alaska since the start of the Initiative.

Outputs and Transfer:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

Outputs of the Aviation project include public presentations, research articles, and less formal transfers involving industry conferences, data summaries, and Alaska media coverage.

Aviation Safety Alliance Meeting. NIOSH has used this forum to present updated information on safety and scientific findings presented in industry-appropriate terminology. NIOSH has also sponsored the Aviation Safety Seminar at the public Alaska Aviation Show, which has a weekend attendance of over 19,000 people.

Aerospace Medical Association Annual Meeting. As part of the Aerospace Medical Association Annual Meeting in Anchorage Alaska in 2004, TI organized a panel discussion of safety experts including TI safety scientists and safety professionals from the Medallion Foundation and the National Weather Service. The Aerospace Medical Association is the largest professional organization in the fields of aviation, space, and environmental medicine.

Research articles. NIOSH researchers have published articles on the epidemiology of work-related aviation fatalities, CFIT among commuter and air taxi operators, attitudes and practices of high-risk versus low-risk air carriers, and safety practices and attitudes of Alaska air carrier operators and pilots in the scientific journal of aerospace research—Aviation, Space and Environmental Medicine. Other descriptive epidemiologic studies have been published on factors associated with pilot fatalities in Alaska, human error as a cause of occupant mortality in air taxi and commuter crashes, and deaths of scientific workers and licensed professionals in Alaska. TI researchers have written and published two NIOSH documents, one presenting results of analysis of survey data entitled "Survey and Analysis of Air Transportation Safety among Air Carrier Operators and Pilots in Alaska," which are available both in hard copy and on the Web. Research on aviation safety by TI staff has also been published in Morbidity and Mortality Weekly Report (MMWR) and the American Journal of Epidemiology. This last journal has a general epidemiology focus, and a journal impact factor of 4.9 (ISI index, 2004) which indicates that it is a leading journal for the field. Also, five abstracts of presentations given at national and international conferences have been published in journals or proceedings, including one in the American Journal of Epidemiology.

Copies of these research articles have been distributed at industry meetings, to Federal agencies, and to pilots and operators through aviation organizations such as the Alaska Air Carrier's Association. The research itself has been used to create presentations such as those listed in the previous section, and to create data summaries and displays presented at industry conferences.

During 1990 to 2004, at least 25 percent of the 352 fatal accidents involving commuter/air taxi aircraft in the U.S. were survivable (there were 87 cases where at least one person lived).[4] TI staff researched and published results about several critical risk factors for pilot fatalities in Alaska including post-crash fire, shoulder restraint use, instrumental meteorological conditions (poor visibility), and distance from airport. Recommendations from this research included the use of shoulder restraints, fire resistant clothing to enable pilots to escape post-crash fire, and training in case of unexpected instrument meteorological conditions.

TI staff members regularly create displays presenting up-to-date safety information for pilots and industry at regional industry meetings, including the Alaska Airmen's Association annual meeting, and the well attended Alaska Air Trade Show. TI staff members participate in local safety committees as part of these organizations and regularly pass on aviation safety research information through these committees, making safety information available to pilots and operators.

During the last 15 years, TI has worked with the local media to make safety information publicly available. The largest paper in the State, the Anchorage Daily News, has featured four articles of more than 600 words about TI work on safety in the Alaskan aviation industry. These articles include quotes from nonprofit safety groups, industry, and regulators who joined with TI to form a team working on aviation safety issues.

A Website dedicated to aviation safety in Alaska is available on the NIOSH Website TI Topic Page (http://www.cdc.gov/niosh/injury/traumaaviation.html). This page contains recent statistics on aviation crashes and fatalities as well as links to published aviation research by TI staff.

Intermediate Outcomes:
FAA Circle of Safety Program. The information presented by TI staff at the two passenger safety seminars associated with the Alaska Governor's Conferences in 2000 and 2001 was used by the FAA in designing and creating the Circle of Safety consumer education program.*

FAA Pilot Training. A summary of the information presented in the two passenger safety seminars and CFIT research findings and recommendations from TI staff were combined into an informational handout for pilots. These handouts have been used by the FAA in its training at an Alaskan flight standards district office.

Educational PSAs and Video. The Alaska Airmen's Association and the FAA have used TI findings and recommendations in public service announcements and in a crash survival training video.[5]

Pilot and Operator Survey Results Used by FAA and Medallion Foundation (for Intervention Evaluation and Pilot Training). TI published the results of the surveys of air taxi and commuter pilots and operators, and in the process made several recommendations including allowing adequate rest periods for pilots, increasing regional training, and providing supervision for less experienced pilots. These results have been used by the FAA, Flight Standards Division in reviewing intervention programs, and by the nonprofit Medallion Foundation to focus their training for pilots.

End Outcomes:
Through concerted efforts by TI; other Federal agencies such as NTSB, NWS, and FAA; nongovernmental organizations; and industry, aviation fatalities in Alaska have decreased (See Figure 18 below). Comparing the 1990s to the years since the start of the initiative (2000 to 2005), the number of occupational fatalities in aviation crashes has decreased by 44 percent and the pilot fatality rate has decreased by 53 percent (NIOSH Alaska Occupational Injury Surveillance System). A recent evaluation of the effects of the Alaska Interagency Aviation Safety Initiative found that fatal accident rates have declined since the start of the Initiative and are likely the result of the combined efforts to create a "culture of safety."[6]

* FAA Circle of Safety Program: http://www.alaska.faa.gov/flt_std/index.cfm?template=circle_of_safety

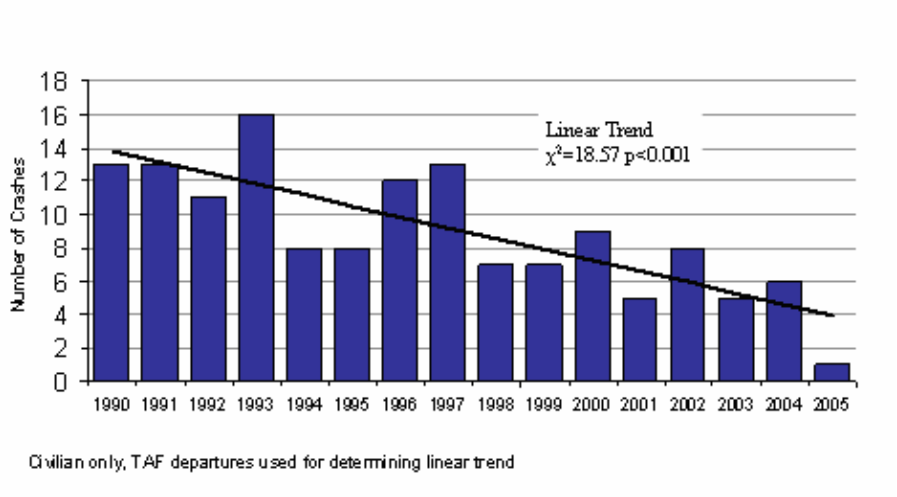

Figure 18. Fatal Occupational Aviation Crashes in Alaska, 1990-2005 (n=142)
Source: AOISS

Since the start of the initiative in 2000, the average number of fatal occupational crashes per year decreased by 45 percent (11 per year during 1990-1999 to six per year during 2000-2005). The average number of fatal occupational accidents due to CFIT declined by 60 percent from five per year during 1990-1999 to two per year during 2000-2005. The Aviation Safety in Alaska Project has worked to reduce the number of work-related aircraft crash injuries in Alaska by studying the problem scientifically, focusing on the worst problems, building consensus for change, and evaluating interventions for success. This strategy has proven effective.

The project has created outputs including scientific articles, public presentations, and direct transfer of information to the aviation community through displays and brochures at industry conferences. The evidence is clear that this information has been used. Research about pilot safety and controlled flight into terrain risk factors have been integrated into public service announcements by the FAA, and put into practice through an increase in weather cameras by the National Weather Service. The ideas and concepts about weather awareness and corporate safety policies presented in the passenger awareness seminars by TI staff were adopted by the FAA into the Circle of Safety Program. TI research is also used in the Circle of Safety Aviation Coordinator Handbook to recommend policies for companies which use air taxi and commuter operators in Alaska. Pilot and operator survey results were used by the Medallion Foundation to improve its training.

What's Ahead:
NIOSH researchers are reviewing CFIT crashes in Alaska to examine how recent improvements in safety are related to the decline in crashes. The improvements seen in the Alaska aviation industry may provide useful insight into how to decrease crashes in other parts of the country with a history of air taxi and commuter crashes involving controlled flight into terrain, such as New Mexico and Colorado.

References:

1. Conway GA, Lincoln JM, Hudson DS, Bensyl DB, Husberg BJ, Manwaring JC. Surveillance and Prevention of Occupational Injuries in Alaska: A Decade of Progress, 1990-1999. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2002. DHHS (NIOSH) Publication No. 2002-15.

2. Boeing. Statistical Summary of Commercial Jet Airplane Accidents: Worldwide Operations 1959-2004. Available on Web at: http://www.boeing.com/news/techissues/pdf/statsum.pdf. Last accessed January 3, 2007.

3. Conway GA, Mode NA, Berman M, Martin S, Hill A [2005]. Flight safety in Alaska: comparing attitudes and practices of high- and low-risk carriers. Aviat Space Environ Med 76(1):52-57.

4. National Transportation Safety Board. Aviation Accident Database. Available on Web at: http://www.ntsb.gov/ntsb/query.asp.

5. Alaska Aviation Safety Foundation [1998]. Passenger Safety. Anchorage: Alaska Aviation Safety Foundation.

6. Berman M, Martin S, Hill A [2005]. Evaluation of the Alaska Interagency Safety Initiative. Anchorage, AK: Institute of Social and Economic Research.

7. Reduce Injuries and Fatalities to Emergency Responders

Police officers, fire fighters, emergency medical technicians (EMTs), public health professionals, and other emergency response professionals are typically the first workers to arrive at the scene of personal, community, and national crises, and are therefore often called "first responders." The United States currently depends on approximately 1.1 million fire fighters—three out of four are volunteers—to protect its citizens and property from losses caused by fire. Estimates of EMS workers—both professional and volunteer—range from 750,000 to 900,000.[1, 2] Approximately 850,000 police and detectives were employed in the U.S. in 2004.[3] In recent large-scale disasters, both natural disasters and terrorist attacks, workers other than traditional emergency responders played important roles in response, rescue and recovery operations—for example, utility workers and construction laborers, and equipment operators.

Workers responding to emergency situations face unique and sometimes unknown risks, and must often rely upon personal protective equipment, well practiced standard operating procedures and protocols, effective communications, and especially one another, to protect themselves.

The TI Program's involvement in fire fighter safety, principally carried out in the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP), was directed by Congress at the request of the fire fighter community. The special hazards faced by EMTs who must ride in the patient compartments of ambulances and care for emergency patients was largely identified through investigations of ambulance crashes through FFFIPP. TI also conducted a study of safety management at large-scale disaster sites in the aftermath of 9/11 attacks on the World Trade Centers and the Pentagon. These TI efforts are described below.

References:

1. Maguire BJ, Walz BJ (2004). Current Emergency Medical Services Work-force Issues in the United States. Journal of Emergency Management (2):17-26.

2. Bureau of Labor Statistics (1999). Current Population microdata files for 1998 cf Employment and Earnings. Washington DC: US Department of Labor.

3. BLS (2004). Emergency Medical Technicians and Paramedics, in Occupational Outlook Handbook. Available on Web at: http://www.bls.gov/oco/ocos160.htm#emply.

Sub goal 7.1: Reduce injuries and fatalities to fire fighters

Issue:
According to the National Fire Protection Association (NFPA), data from recent years indicate that approximately 54 fire fighters die each year from fatal traumatic injuries and another 48 die from cardiovascular-related disease (CVD) in the line-of-duty.[1] Approximately 95,000 fire fighters are injured at work each year.

In fiscal year 1998, Congress recognized the need for further efforts to address the continuing national problem of occupational fire fighter fatalities, and appropriated funds to NIOSH for a fire fighter safety initiative.

Approach:
As a result, NIOSH developed the TI Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) and hired new and trained existing staff to conduct on-site investigations of fire fighter line-of-duty deaths.

When notified of a traumatic line-of-duty fire fighter death, TI investigators interview fire department personnel, take photographs and measurements at the site, and review all applicable records (e.g., standard operating procedures and guidelines, dispatch records, training records, medical records, and coroner/medical examiner reports). In cases in which the performance of self-contained breathing apparatus (SCBA) may have been a factor, personnel in the National Personal Protective Technology Laboratory (NPPTL) are asked to evaluate SCBA performance. Since 1998, NPPTL has evaluated 53 SCBAs which were involved in 37 fatalities. In select cases, TI seeks expert evaluation of other types of fire service equipment that may have malfunctioned, including oxygen regulators, diving suits and other equipment related to underwater incidents, and personal alert safety system (PASS) devices. TI has also supported the National Institute of Standards Technology (NIST) in its development of computerized fire simulation models for some investigations. These computerized models are useful tools in efforts to explain or verify fire behavior and conditions, or test and reinforce the validity of recommendations.

A report is completed for each investigation summarizing the sequence of events that led to the fire fighter death or injury and making recommendations for preventing future deaths and injuries under similar circumstances. The investigations do not seek to place blame on fire departments or individual fire fighters or officers; rather, the goal is to identify steps that could be taken for prevention in the future. No identifiers are included in the report, because inclusion of such information might discourage the willing participation of fire departments and personnel in TI investigations. All finalized reports can be viewed at: http://www.cdc.gov/niosh/fire/.

Since the inception of the FFFIPP in 1998 through July 2006, TI investigators have conducted 366 investigations of incidents that resulted in 409 fire fighter deaths (both trauma and CVD) in 48 States. TI investigated 44 percent of all fire fighter line-of-duty deaths for the period 1998 to 2004 (excluding fire fighter deaths associated with the 2001 World Trade Center attacks). Traumatic injury incidents accounted for 187 of the investigations (81 structure fires, 65 motor-vehicle-related, 15 training, nine wildland fires, six explosions, and 11 other incidents—e.g., helicopter crash, falls, homicide, drowning, struck-by, etc.).

Cardiovascular incidents accounted for the other 179 investigations. Additionally, TI investigated nine nonfatal injury incidents that resulted in 19 injuries.

TI has often worked collaboratively with other agencies and fire service organizations to leverage resources when addressing fire fighter safety issues of common interest. For example, in 1998, the IAFF requested that TI investigate a number of flash fires in regulators used to control the flow of oxygen in oxygen resuscitation systems. Such fires had resulted in burn injuries to fire fighters and emergency medical technicians. TI worked collaboratively with the Food and Drug Administration (FDA)—FDA regulates these devices—and with the National Aeronautics and Space Administration (NASA) due to its expertise in oxygen safety. Investigations revealed that aluminum in the regulator was a contributing factor to the flash fire incidents, and that there were a number of safe handling techniques which fire fighters and emergency medical technicians could use to reduce the risk of regulator flash fires. Most of the reported flash fire incidents involved a single manufacturer who voluntarily recalled regulators and offered trade-ins with non-aluminum regulators.

In the early 2000s, after identifying the collision hazard caused by the need for fire/emergency apparatus to cross railroad tracks during emergency response, TI contacted the Federal Railroad Administration (FRA) and Operation Lifesaver (a nongovernmental program dedicated to eliminating injuries from train collisions). The TI consulted with the FRA during investigations of incidents where trains collided with fire apparatus at railroad crossings, and ultimately collaborated with FRA and Operation Lifesaver on a safety publication.

TI partnered with the International Association of Fire Chiefs (IAFC) in a June 2005 and 2006 “stand down” for safety. The purpose of this initiative was to encourage fire departments to set aside time specifically for safety and health training to raise awareness within the fire service community. The IAFC recommended the use of TI fatality investigation reports for the training.

The TI has conducted outreach efforts to the fire service which include the formation of partnerships with fire service and other Federal agencies to increase the use of the TI reports, findings, and prevention recommendations. The TI staff members also provide information and participate on committees developing standards and tools for fire fighter safety.

TI recently entered into a memorandum of understanding (MOU) with the USFA to identify collaborative efforts to improve safety and health conditions for fire fighters throughout the United States. The primary focus of the memorandum involves fostering the use of TI products and recommendations in USFA fire fighter training materials and programs. The TI also recently entered into a letter of agreement with the State of Pennsylvania, Office of the Fire Commissioner to identify collaborative efforts to improve safety and health conditions for fire fighters throughout the State of Pennsylvania. The primary focus of the agreement involves the use of TI products and recommendations in Pennsylvania State fire fighter training materials and programs.

The TI held a fire service stakeholders meeting in March 2006 in Washington, D.C. to request stakeholder input on possible ways to improve the program and enhance impact on fire fighter safety and health. TI has compiled and considered all comments received at the meeting and through the NIOSH docket, and used them in writing a draft summary document outlining the immediate next-steps of the program. This summary will be posted to the NIOSH Website in 2007.

Several intramural research projects have been initiated based on the findings of the FFFIPP. Research topics include fire fighter personal protective equipment (PPE) such as boots, gloves, and apparel (bunker gear and driving and physiological factors of PPE). TI investigations of fire fighters/emergency medical service workers fatally injured in the patient compartments during ambulance crashes helped to show that occupants in the patient compartment of an ambulance are inadequately protected. This led to the research effort reported in this evidence package in *Sub goal 7.2:* Improve protection for ambulance workers in patient compartments.

A proposal was submitted recently through the TI that would include an anthropometry survey of career and voluntary fire service personnel, and the collection of a minimum set of body size and shape measurements to validate the appropriateness and the accuracy of the range of sizing dimensions described in SAE, ASTM, FAMA and NFPA sizing schemes mandated for use in fire vehicle and fire fighter PPE/apparel design.

In November 2005, TI was granted approval by the Office of Management and Budget to proceed with an evaluation of the TI Fire Fighter Fatality Investigation and Prevention Program. The study, largely funded by CDC, was conducted in conjunction with RTI International (a nonprofit research organization). The evaluation included a survey of a stratified random sample of 3,000 fire departments across the U.S. in the spring of 2006, and a number of focus groups consisting of front-line fire fighters. The evaluation study has been completed, and TI has received a DRAFT report of the findings from RTI. When finalized, this evaluation report will document the extent to which the program's reports, recommendations, and other products are being utilized by the fire service for training, policies, practices, and other prevention efforts. The evaluation will provide additional insight into the impact of the TI Program and help to identify enhancements that might further the program's impact.

Outputs and Transfer:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence)

In April 2005, the TI notified the NFPA by letter of several fatality investigations in which PASS devices were not heard by fire fighters working near fallen fire fighters or by rapid intervention teams searching for the fire fighters. The PASS alarms had been certified as compliant to NFPA 1982, 1998 Edition, and involved both stand-alone PASS and SCBA-integrated PASS. The TI identified potential reasons why the PASS devices may not have performed as designed, and recommended that the NFPA committee revising NFPA 1982 Standard on Personal Alert Safety Systems (PASS) consider modifications in testing and performance criteria. TI staff members from NPPTL who participate on this committee provided technical support to address these issues in the revision. TI also contacted other organizations representing fire fighters and rescue workers, such as the IAFF, to tell them that exposure to high temperature environments may cause the loudness of Standard on Personal Alert Safety Systems (PASS) alarm signals to be reduced, causing the alarm signal to become indistinguishable from background noise at the incident scene.

Each finalized report from fire fighter fatality investigations includes prevention recommendations. When multiple TI investigations identified common safety and health concerns, the TI developed educational documents (including four Alerts, two Workplace Solutions, four Hazard IDs, and one fact sheet), as well as journal articles, that summarize hazards and recommend prevention measures. Examples of hazards addressed by the educational

documents include preventing injuries and deaths of fire fighters due to truss system failures, live-fire training in acquired structures, training dives (SCUBA), electrical hazards, tanker truck rollovers, working along roadways, structural collapse, propane tank fires, motor-vehicle related crashes, general prevention of injuries and deaths of fire fighters, and exploding flashlights. Fire fighter safety and health issues addressed in TI-authored journal articles include flashing of oxygen regulators and risk factors for injury in structure fires.

A primary venue for transfer of TI fire fighter-related outputs is the TI-FFFIPP Website (355,429 hits in FY 2004, and 444,147 visits in FY 2005), which is available at: www.cdc.gov/niosh/fire/. The Website contains links to all investigative reports and TI publications. The Web page provides a section where users can subscribe and be automatically notified (currently 1,707 subscribers) when a new product is available.

TI has partnered with a number of fire service trade journals including *Firehouse*, *Fire Rescue*, *Fire Chief*, *NFPA Journal*, *Responder Safety*, and *Responder Magazin*e to transfer investigative findings and recommendations to their readers. The total monthly combined circulation for the six magazines is approximately 300,000, reaching a potential audience of more than 1,400,000 fire service professionals per month.

TI conducts periodic mass-mailings to all 30,000+ fire departments in the United States. The mass mailings are typically done once per year and usually contain a packet of five to six reports addressing a variety of situations in which fire fighters have died in the line-of-duty, or a single report thought to be of particular importance for the fire service as a whole.

TI also disseminates findings and products at meetings and conferences. TI staff members have given 61 oral presentations at national and international fire service conferences in order to provide an overview of the TI Program, report on current findings, and share information on specific cases. In addition, TI regularly sets up informational booths with products for distribution at many of the fire service conferences. TI personnel have presented investigation findings at public health, occupational medicine, and safety conferences (e.g., annual meetings of the American Public Health Association, American Occupational Health Conference, National Safety Congress, American Society of Safety Engineers, and the NIOSH National Occupational Injury Research Symposia). Examples of specific traumatic injury topics presented at these meetings include safety hazards with oxygen systems, motor-vehicle incidents, structural fire incidents, and ambulance safety.

TI recommendations have also been disseminated to manufacturers to enhance safety aspects of fire service equipment, municipalities to address organization and coordination of fire services as well as safety requirements related to buildings and structures, standard-setting bodies to modify or develop new standards, and research organizations to enhance and develop technologies to improve fire fighter safety.

The TI collaboration with the FRA and Operation Lifesaver on the issue of collisions between trains and emergency vehicles at railroad crossings resulted in a joint publication entitled “Your Safety- 1st--- Railroad Crossing Safety for Emergency Responders” (NIOSH Pub. No. 2003-121).

As an outgrowth of their collaboration on the issue of flash fires in oxygen regulators, TI and FDA developed a joint public health advisory that was widely distributed to the fire service (http://www.fda.gov/cdrh/oxyreg.html), and a training video on safe handling of oxygen systems. The release of the advisory led to this issue being highlighted on the FDA's Patient Safety News satellite broadcast (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/psn/index.cfm).

TI personnel have been actively involved in various National Fire Protection Association (NFPA) and ASTM standards which support fire fighter health and safety. On October 31, 2005 NFPA and NIOSH entered into an MOU that focuses on emergency responder safety and protective clothing and equipment. The goal of the collaboration is to provide the research and technology so that NIOSH regulations and NFPA standards can give leadership for protective clothing and equipment to aid the protection of emergency responders. In December 2005, NIOSH and ASTM International signed an MOU to support the ASTM International Committee F23 on Protective Clothing and other standards developing committees related to protective clothing. The agreement highlights the role of the NIOSH to support standards development work related to personal protective clothing and equipment. The purpose of the MOU is to facilitate cooperation between NIOSH and ASTM International involving the determination of performance requirements and cooperation in the development of test methods, product specifications, practices, guides, classifications and terminology related to worker and emergency responder protective clothing and equipment. In support of these MOUs, TI personnel actively attend the various ASTM and NFPA committee meetings as voting members.

TI staff participate on several safety-related NFPA technical committees, including

- NFPA 1500: Standard on Fire Department Occupational Safety and Health Programs[2]
- NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services[3]
- NFPA 1982: Standard on personal alert safety systems (PASS),[4] and
- NFPA 1989: Standard on Breathing Air Quality for Fire and Emergency Services Respiratory Protection.[5]

TI personnel have also actively participated on the IAFC Safety and Survival Section Executive Board since 2006.

In 2005, NIOSH was asked to participate in Project HEROES (Homeland Emergency Response Operational Equipment Systems). Project HEROES is funded by the Technical Support Working Group (TSWG) and managed by the International Association of Firefighters (IAFF). The goal of the project is to develop a prototype PPE ensemble for fire fighters that provides improved protection against chemical and biological agents. The NIOSH role on the team is to conduct physiological/ergonomic testing of the ensemble, select test methods, and interface with the NFPA and ASTM. Key design features include a moisture/chemical/biological barrier that provides the same level of breathability as current moisture barriers; seals at the wrist, ankle and collar areas; and an innovative system for capturing the SCBA exhalation to provide positive pressure against exterior penetration, and an upper torso cooling system. NIOSH developed an ergonomic and physiological testing protocol to compare the new prototype versus a standard ensemble. The protocol was successfully peer-reviewed and approved by the NIOSH human subject review board. Subjects have been recruited and testing is underway. An ASTM working group was formed to develop a standard test practice based on the physiological testing portion of

the NIOSH protocol (ASTM F23 Work Item WK8818 Standard Practice for the Physiological Evaluation of Protective Clothing). As part of the Project HEROES team, NIOSH provided comments to the NFPA technical committees working on revisions to the NFPA 1971 (structural fire fighter ensembles)[6] and NFPA 1994 (CBRN ensembles)[7] standards. NIOSH chaired the task group that wrote the CBRN option for the NFPA 1971 standard and was instrumental in ensuring the CBRN option was included in the revised edition. The 2007 Editions of NFPA 1971 and 1994 became effective in August 2006.

Intermediate Outcomes:
The NFPA 1982 PASS standard was recently revised and issued (effective December 20, 2006).[8] TI provided information from its investigations of four fire fighter fatalities that occurred from 2001 to 2004 in which PASS alarms were not heard or were barely audible. The PASS alarms had been certified as compliant to NFPA 1982, 1998 Edition, and involved both stand-alone PASS and SCBA-integrated PASS. TI communicated this information to NFPA by direct participation in Technical Committee meetings, and by an April 2006 letter which outlined TI technical findings and recommendations, as well as a request that this information be considered in a revision of the 1982 standard.

Both the NFPA and the International Association of Fire Fighters recently posted notices regarding PASS devices on their Websites warning fire fighters that PASS devices may not function as intended under high temperature conditions based on issues raised by the

TI investigations and initial testing by the National Institute for Standards Technology.
An encouraging preliminary finding from the evaluation of the FFFIPP is that TI recommendations have been used by approximately 11,000 fire departments to update the content of their training programs on personal protective equipment (PPE), self-contained breathing apparatus (SCBA), personal alert safety system (PASS) devices, incident command (IC), traffic hazards, radio communications and other topics.

Prior to the evaluation, TI had received anecdotal feedback on a variety of ways in which the fire service, public safety departments, and universities have been using TI fatality investigation reports to improve fire fighter safety. For example, several fire departments across the country reported using TI fatality investigation reports in their fire fighter safety training (as the evaluation study found). These fire departments include Baltimore City, Maryland; Howell Township, New Jersey; Mentor, Ohio; and, Portland, Oregon. State fire training academies, including those in Pennsylvania, West Virginia, and Tennessee, also consider findings and recommendations when reviewing and developing new curriculum. For example, in Pennsylvania, the training academy instructed 1,200 local instructors to incorporate training on "accountability" into their classes based on a series of TI investigations making recommendations for improving accountability on the fire scene. TI is also aware of fatality investigative reports being used as case studies in university fire safety curriculums, including courses at West Virginia University and Northern Virginia Community College.

Findings from TI fatality investigations have been referenced or used to develop State legislation aimed at improving fire fighter safety and health. For example, the TI investigation of the 2001 death of a fire fighter in New York (FFFIPP report number 2001-F38) was cited in the justification for a 2003 New York law called Bradley's Law. Bradley's Law prohibits the use of people to play the role of victims in live-fire training. In addition to the NFPA 1982 PASS standard, TI findings and recommendations have been used in the development and revision of

other current NFPA consensus standards. Mr. Richard Duffy, the Secretary of the Technical Committee that developed NFPA 17109 and 1720,10 reported that NIOSH fatality investigation reports were used extensively in the development of NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments. This standard recommends staffing based on the types of emergency response fire departments are likely to encounter. Many provisions of this standard are also included in a counterpart for volunteer departments, NFPA 1720. TI findings were shared with each of these committees in both electronic and hard-copy form.

The TI partnership with fire service trade journals including *Firehouse*, *Fire Rescue*, *Fire Chief*, *NFPA Journal*, *Responder Safety*, *Responder Magazin*e, and *Wildland Fire* journal resulted in the reprinting of more than 70 fire fighter fatality report summaries in the past 18 months.

Starting in 1999, the NIOSH Chemical, Biological, Radiological and Nuclear (CBRN) respirator standards program began work on a series of new equipment standards for fire fighters and first responders. In 2001, NIOSH published the CBRN Standard for Open-Circuit Self-Contained Breathing Apparatus (SCBA). This standard establishes performance and design requirements to certify SCBA for use in CBRN exposures for use by emergency responders. In 2002, NIOSH published the Standard for CBRN full facepiece Air Purifying Respirator (APR). The purpose of this standard is to specify minimum requirements to determine the effectiveness of full facepiece APR, commonly referred to as gas masks, used during entry into CBRN atmospheres not immediately dangerous to life or health (IDLH). In 2003, NIOSH published the CBRN Air-Purifying Escape Respirator and CBRN Self-Contained Escape Respirator. The purpose of this standard is to specify minimum requirements to determine the effectiveness of escape respirators that address CBRN materials identified as inhalation hazards from possible terrorist events for use by the general working population. In 2004, the U.S. Department of Homeland Security's (DHS) Science and Technology division adopted these standards to protect emergency responders against CBRN threats. The NFPA also adopted the NIOSH respirator standards into private-sector consensus standards (NFPA 1500, 1991,[11] 1994, and 1981). DHS requires that all respirators purchased through its grant program be NIOSH CBRN certified. Through September 2006, NIOSH certified 79 CBRN-approved respirators (67 for SCBA, nine for APR, and three for escape).

External Factors:
The number of fire fighter deaths has not exhibited a steady downward trend. Several external factors impede the widespread implementation of TI recommendations, including what has been identified as the “culture” of the fire service. Simply put, this “culture” or occupational behavior involves a willingness to assume a high level of risk for minimal or no return or gain. Local government budget shortages also have a negative impact, as TI recommendations are frequently costly to implement. Further, TI recommendations are all voluntary, not mandatory, and the TI Program has no authority to create regulations or to enforce them. Other concerns of fire service administrators are that implementation of certain TI recommendations might decrease the recruitment and retention of volunteer fire fighters, or might infringe upon labor agreements. In addition, the lack of accurate data on the number of active fire fighters (career and volunteer) and number of hours of exposure precludes the statistically sound calculation of accurate fatality rates, which would provide the TI better estimates of changes in risk over time.

Lastly, other causes of death, such as aircraft crashes and homicide, are outside the scope and influence of TI research and outreach.

What's Ahead:
The NORA program is currently funding a pilot TI project to evaluate and compare the effects of wearing bunker boots/bunker pants with wearing a station uniform in manipulating the accelerator and brake pedals of a mock-up emergency apparatus cab, and to determine if future research is needed in this area. This pilot project was proposed based on hypotheses that bulky turnout gear may negatively impact the ability of drivers to operate fire apparatus, contributing up to 25 percent of all fire fighter deaths. It is hypothesized that heavier, bulkier, more restrictive apparel (bunker pants/boots) will increase braking reaction time, therefore increasing fire apparatus stopping distances, possibly leading to a crash. This project is ongoing.

Through its personal protective technology program, NIOSH also funds research that can be considered part of the TI Program. Some examples include NIOSH work on Project HEROES, fire fighter cooling garments, and EMS protective clothing.

References:

1. Fahy R [2003]. NFPA data on fire fighter deaths. Personal communication email message (rfahy@NFPA.org) to Robert E. Koedam (rok2@cdc.gov), December 13th, 2006.

2. NFPA [2002]. NFPA 1500: Fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

3. NFPA [2002]. NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services. Quincy, MA: National Fire Protection Association.

4. NFPA [1998]. NFPA 1982: Standard on personal alert safety systems (PASS). Quincy, MA: National Fire Protection Association.

5. NFPA [2003] NFPA 1989: Standard on Breathing Air Quality for Fire and Emergency Services Respiratory Protection. Quincy, MA: National Fire Protection Association.

6. NFPA [2007]. NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting. Quincy, MA: National Fire Protection Association.

7. NFPA [2007] NFPA 1994: Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents. Quincy, MA: National Fire Protection Association.

8. NFPA [2007]. NFPA 1982: Standard on personal alert safety systems (PASS). Quincy, MA: National Fire Protection Association. Available on Web at: http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=1982. Last accessed January 12, 2007.

9. NFPA [2004]. NFPA 1710: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments. Quincy, MA: National Fire Protection Association.

10. NFPA [2004]. NFPA 1720: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments. Quincy, MA: National Fire Protection Association.

11. NFPA [2005] NFPA 1991: Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies. Quincy, MA: National Fire Protection Association. (http://www.nfpa.org/itemDetail.asp?categoryID=136&itemID=26606&URL=Codes percent20and percent20Standards/NFPA percent20News and http://daily.iaff.org/113005pass.htm, respectively)

Sub goal 7.2: Improve protection for ambulance workers in patient compartments

Issue:
Emergency medical service (EMS) workers in ambulance patient compartments are at risk of vehicle crash-related injury. Protection from crash-related injury for patient compartment occupants is provided by lap belts, which do not allow EMS workers the needed mobility to access the patient or EMS equipment at all times. Consequently, EMS workers tend not to use the lap belts at all. This places them at risk for serious injury or death during vehicle crashes. Secondary to the lack of occupant restraint use, EMS equipment is commonly carried unsecured in ambulance patient compartments posing additional risk for injury when crash forces cause them to become projectiles.

Current Federal standards do not address either occupant safety or crashworthy equipment mounting for ambulance compartments. In fact, some States specifically exempt EMS workers in patient compartments from using occupant restraints. Previous intervention efforts have focused on crash avoidance through development of safe operating procedures and vehicle operator training. These approaches have no doubt yielded positive results, however little or no effort has been focused on injury intervention if crash avoidance fails.

Researchers have estimated that the injury rate for EMS is 12.7 per 100,000 workers.[1] This issue also affects fire fighters since 45 percent of all EMS is fire department-based.[2] While there have been significant advances in the protective technology for automobiles and aircraft, similar research and development addressing the patient compartment of an ambulance is lacking.[3]

Approach:
TI has focused efforts on quantifying the scope of the problem, identifying injury mechanisms and work procedures that expose EMS workers to risk of crash-related injury, and identifying engineering solutions that would allow EMS workers the mobility required to care for patients, while protecting them from injury due to ambulance crashes.

TI implemented two projects to address the issue. Beginning in 2001, TI formed a project team comprised of public and private-sector partners to implement the Evaluation of Emergency Service Vehicle Occupant Safety Project. Under TI leadership, this project team identified circumstances and injury risks for EMS workers during ambulance crashes, evaluated engineering interventions, and began technology transfer to TI customers. The team included 15 public and private-sector partners. Together, these partners pooled staff, facility, and financial resources to implement a comprehensive project that evaluated the crash performance of four mobile occupant restraint systems.*

In 2004, TI began implementation of a phase two effort, the Ambulance Crash Survivability Improvement Project. Under this project, scheduled to end in the fall of 2007, TI is working with 11 public and private-sector partners to describe the scope of nonfatal injury risk for EMS, identify human factors-related obstacles to occupant restraint use in patient compartments,

* Mobile occupant restraints employ worker-worn harnesses that are tethered to the structure of the patient compartment. The tethers are stored on retractor reels which unwind as the occupant moves away from the seat and wind up as the occupant moves back into the seat. In the event of a crash, the retractor reels automatically lock, providing restraint against crash forces. This arrangement allows EMS workers the mobility needed to access patients while simultaneously providing crash protection.

develop test recommendations for crashworthy EMS equipment storage and mounts, and provide selection criteria for energy absorbing foam padding. (For a list of all TI partners who participated in these two projects, and a short description of the role each played, see Appendix I: Supporting Evidence.)

To describe the scope of the problem, TI conducted analysis of the National Highway Traffic Administration (NHTSA) Fatality Analysis Reporting System (FARS) database. Published results of this analysis identified 300 fatal ambulance crashes resulting in the death of 27 EMS workers occurring between the years 1991 to 2000. While conducting this analysis, TI identified a lack of public health surveillance data that could be used to quantify nonfatal EMS crash-related injuries.[4]

TI and American Medical Response (AMR), a large EMS service provider in 36 States, are jointly analyzing AMR's employee injury and compensation database in an attempt to quantify the scope of nonfatal EMS crash-related injury. TI and AMR expect to publish the results of this ongoing effort in 2007.

TI and various partners engaged in several approaches to the study of the circumstances and characteristics of ambulance patient compartments in simulated and actual ambulance crash scenarios. To describe circumstances present in the patient compartment work environment that could lead to increased risk of crash-related injuries, TI and partners are analyzing results of a survey of emergency medical technicians (EMTs). The survey data have confirmed anecdotal data indicating user acceptance of potential interventions.

TI conducted investigations of five fatal ambulance crashes and developed reports that document crash-related injury risk and incident circumstances, and provide recommendations for preventing future similar occurrences. These reports are available to the public and other researchers at the FACE Program Website at: http://www.cdc.gov/niosh/face/ and at the Fire Fighter Fatality Investigation and Prevention Program Website at: http://www.cdc.gov/niosh/fire/.

TI also funded and participated in six ambulance crash reconstructions. The reconstruction reports documented environmental circumstances, operator actions, vehicle crash mechanisms, and occupant injury mechanisms. Five of these reports are available to other researchers at http://www-nass.nhtsa.dot.gov, while the other report is not yet in the pubic domain.

After identifying occupant restraint systems that offered potential to provide mobility as well as crash protection for EMS workers, TI and partners then evaluated the systems through computer modeling and dynamic testing. Dynamic tests were conducted using both a system that simulated ambulance crashes (with a sled, simulated patient compartment, and instrumented crash test dummies) and four actual ambulances also equipped with instrumented crash test dummies. Twenty-nine tests were conducting using the sled, in which the instruments collected kinematic (high-speed video), force, moment, and acceleration data. In addition to these data, four full-scale ambulance crash tests enabled collection of data that described crash pulses for the vehicles. Previous to these tests, vehicle crash pulses (acceleration vs. time trace) specific to ambulances were generally not available to public or private-sector entities. The only similar data that the TI project team could access were from 1990 Canadian tests that had not been publicly disseminated.

TI is currently working to finalize the test reports and data analysis. In the meantime, TI engineers presented post-test briefings to each partner. TI engineers provided each partner participating in the crash tests with appropriate data packages for use in further development of systems and refinement of ambulance designs. Public sector partners received copies of all test data, while each private-sector partner received a similar data package containing only the test data for their restraint system. These data packages can be used to support continued development of the systems at each partner's discretion. TI has presented preliminary analytical results at EMS conferences and meetings.

TI has also conducted, and used a contractor to conduct, engineering evaluations of the performance of energy absorbing foams. The evaluations involve computer modeling and impact testing at 10, 15, 20, and 30 mph using simulated human head forms to gather data describing the performance of selected foams. Energy absorbing foams have application for padding of bulkhead and other surfaces within the ambulance patient compartment that can be sources of struck-by injury for EMS during a crash. Data from this effort will be used to support recommendations to the EMS industry, ambulance manufacturers, and standard-setting bodies. These test data will yield a comprehensive data set to support recommendations for foam selection criteria.

TI has used a contractor to conduct evaluations of the crashworthiness of EMS equipment commonly carried in ambulance patient compartments. To date, contract engineers have identified the physical characteristics of common EMS equipment and are working toward development of test procedures that can be used to quantify crash performance of the mounting systems.

TI hired a contractor to construct an ambulance to meet the GSA Federal Specification for the Star of Life Ambulance—KKK-1822E (June 1, 2002). The patient compartment of this vehicle was specially configured to allow mounting of two types of mobile restraint systems. Upon receipt, TI outfitted the vehicle with video cameras and monitors to collect vehicle operating data. The vehicle is used as a Mobile Emergency Medical Service (EMS) Work Environment Laboratory to study the efficacy of patient compartment design changes and occupant restraint use through human subject testing. Then TI, along with EMS and manufacturing partners, conducted human subject testing to identify obstacles to occupant restraint use in the patient compartments. Eight Paramedic and EMT Basic volunteers from the EMS performed simulated patient care tasks in an ambulance patient compartment while using the lap belts and a high mobility restraint system. On a pilot test basis, TI researchers collected heart rate, video footage, and reach measurement data from each subject using each restraint system. The data are currently being analyzed in preparation for a larger study to be conducted in spring 2007.

Outputs and Transfer:
(For those outputs not specifically cited, see Appendix I: Supporting Evidence.)

In February 2004, a TI engineer presented "A Review of NIOSH Research to Support Ambulance Worker Safety," to the National Truck Equipment Association's (NTEA) Ambulance Manufacturers Division (AMD) winter business meeting in Tampa, Florida. NTEA/AMD is a trade association involving truck chassis and ambulance manufacturers, component and supply manufacturers, and those involved in buying and selling ambulances. The winter business meeting had about 50 high-level attendees including corporate principals, engineering managers, sales managers and ambulance service managers. The group works with GSA to maintain the

Star of Life Ambulance Specification, GSA KKK-1822E. An open dialogue with this group is a major key to effectively transferring new research findings and technologies into industry practice.

In September 2005, a TI engineer met with the Chief and the EMS Supervisor of the Winter Park Florida Fire Department. At the time, the department was developing specifications for procurement of new ambulances and was working with one of the TI research partners, a safety products manufacturer. During the meeting, the TI engineer provided a briefing on the TI sled and vehicle crash test results to the fire department representatives, including preliminary test results and video footage of the tests.

In November 2004 and May 2006, TI staff participated in the American Ambulance Association's Mobile Medical Transport Safety Symposium. TI presented a project brief to the attendees. Attendance was by invitation and included 25 persons involved in EMS safety research representing government, academia, EMS service providers, and equipment manufacturers.

During June 2006, a TI engineer met with representatives of vehicle and equipment manufacturers to provide a project briefing that included preliminary results of the dynamic ambulance and occupant restraint tests.

TI has presented research findings at 12 international, national, and regional conferences and meetings. TI has published two journal articles reporting on research findings. Additionally, a TI presentation has been included in published conference proceedings.

National Highway Traffic Safety Administration crash reconstruction reports funded by TI documenting environmental and vehicular circumstances and the injury mechanisms for patient compartment occupants present during an ambulance crash are available to the public at http://www-nass.nhtsa.dot.gov.

Intermediate Outcomes:
As a result of the TI projects, one of the TI manufacturing partners—Schroth Safety Products—is actively marketing restraints to ambulance manufacturers and has developed collaborations with several ambulance manufacturers, and a seat manufacturer to incorporate Schroth restraints into new ambulances.

American Medical Response (AMR) and American Emergency Vehicles' (AEV) concept ambulance incorporates restraint systems influenced by TI sled and crash test results. AMR, in cooperation with AEV, has incorporated the Schroth restraints, as tested by the TI project, into one concept vehicle. This vehicle incorporates several innovations intended to increase patient compartment safety, including improved occupant restraints. The vehicle is being used as a demonstrator at various EMS conferences throughout 2005 and 2006, gauging AMR employee acceptance of its features.

As a result of TI collaboration with EVS Ltd, the company has developed first-generation seats that replace the standard three-point lap and shoulder belt with mobile occupant restraints manufactured by Schroth Safety Products or Allied Services Systems.

EVS is currently working to refine its seat design to better utilize the capabilities of the restraints and has embarked on its own testing program to explore the crash performance of mobile restraints in side-facing and swiveling seats intended as upgrades to ambulance patient compartments.

After being briefed on the TI project In the fall of 2005, the Winter Park Fire Department of Winter Park, Florida, in the spring of 2006, took delivery of two new ambulances that had design changes incorporated in the patient compartment based in part on TI sled and crash test results.[5] The department, in cooperation with the ambulance manufacturer, developed patient compartments that minimize the need for emergency medical technicians (EMTs) to move around the patient compartment. Of note, the Winter Park Fire Department eliminated the CPR seat location and adjacent equipment cabinet based on information contained in TI crash test videos. The new ambulances also incorporate an improved five-point occupant restraint manufactured by Schroth Safety Products. Use of the Schroth five-point restraint resulted from the Schroth marketing campaign to ambulance manufacturers. TI is currently working with the department to evaluate the ergonomics and user acceptance of the new design.

GSA and the Ambulance Manufacturers Division (AMD) of the National Truck Equipment Association have used NIOSH project results and TI-supplied anthropometric data to support development of revision F to the KKK 1822 Specification for the Star-of-Life Ambulance. This specification, which has been adopted by 34 State EMS departments, is the principal driver of U.S. ambulance design. Nearly every U.S. ambulance and EMS equipment manufacturer is a member of AMD. The KKK 1822 F specification—which includes specifications for increased head clearance above seats, based in part on NIOSH project results—is currently undergoing industry and public comment. Revision F is scheduled for full implementation during the third quarter (April through July) of FY 2007.

As a result of presenting preliminary results at the 2005 NFPA World Safety Conference and Exposition, TI received a request from the International Association of Fire Fighters (IAFF) for copies of crash test videos. The videos were incorporated into an emergency vehicle operators training DVD and course curriculum developed by IAFF for its membership. Other professional and volunteer EMS services and fire departments have also requested TI crash test footage to support their local training programs. All of these requests resulted from TI presentations at EMS conferences and meetings.

What's Ahead:
TI is currently working with its contractor ARCCA Inc. to finalize and publish the data analysis and test reports for the sled and crash testing. Upon publication the data will be available for use by other researchers, ambulance manufacturers, standard-setting bodies, EMS services, and fire departments to support improvements in ambulance design that will lead to a safer EMS work environment. TI and ARCCA Inc. are also developing a series of papers for peer-review publication that will provide a comprehensive discussion of crashworthiness issues related to the ambulance patient compartment.

TI will develop and transfer additional recommendations to the General Services Administration and the Ambulance Manufacturers Division of the National Truck Equipment Association to support revision of KKK 1822 Specifications for the Star-of-Life Ambulance.

These recommendations will include test procedures to improve the crashworthiness of EMS equipment and mounting systems, selection criteria for energy absorbing foam padding, and recommendations for occupant protection systems.

TI and AMR will publish results of their joint analysis of AMR employee injury and compensation data. The results should help to provide a clearer picture of the scope of nonfatal injury for EMS workers in ambulance patient compartments.

TI's collaboration with the Winter Park Florida Fire Department to evaluate the effectiveness of the newly designed ambulance patient compartment is expected to provide information that can be used to guide similar developments by other researchers, ambulance manufacturers, and EMS providers.

The TI human factors evaluation results will be shared with the restraint manufacturers to support restraint system refinement, and with the EMS industry to promote acceptance of improved restraint systems and patient compartment redesigns.

External Factors:
In 2004, the year for which the most current data are available, the general motoring public experienced 33,134 motor-vehicle crash-related fatalities.[6] During the period 1991 to 2002, 27 EMS workers lost their lives in ambulance crashes.[5] Because of this disparity, the bulk of NHTSA resources are focused on an overall reduction in motor-vehicle crashes and on vehicle crashworthiness issues affecting the general public rather than EMS workers. Federal Motor Vehicle Safety Standards (FMVSS) promulgated by NHTSA do not apply to vehicle manufacturers producing fewer than 5,000 vehicles annually. No single ambulance manufacturer in the U.S. produces 5,000 vehicles annually; in fact, the total production from all U.S. ambulance manufacturers is about 5,500 vehicles per year. Thus, ambulance manufacturers are not required to address crashworthiness issues in the patient compartment. The only applicable Federal standard is the non-mandatory GSA KKK-1822E Specifications for the Star-of-Life Ambulance. While this purchase specification has significant impact on ambulance patient compartment design, it contains minimal crashworthiness standards. Therefore, if TI research results are to be implemented, ambulance manufacturers must be convinced to adopt them. TI staffers have had numerous personal contacts with manufacturers' representatives and have presented preliminary results before manufacturer organizations, such as NTEA's AMD. Although ambulance manufacturers are individually supportive of improving the safety of their vehicles, TI believes that lack of uniformly applied Federal crashworthiness regulations and specifications significantly impedes improvements in ambulance crashworthiness.

TI financial and staff resources available to address the problem are limited. TI initially perceived this to be a negative influence for which TI was required to compensate by developing partnerships with private and public sector entities that could provide the additional financial and staff resources to the effort. These partnerships have had a positive effect on the research serving to broaden its impact and facilitate the introduction of TI research products into the workplace. Lack of resources also forced TI and its partners to narrow the research scope to issues that could be solved within a short time and to focus on developing research products that provide a foundation for others to expand upon without TI assistance. Nevertheless, lack of staff and funding resources remains an impediment to continued ambulance safety research, and many ambulance crashworthiness issues will remain unanswered by TI research efforts.

National level ambulance crash injury and EMS population data, currently lacking, are needed to drive research and policy decisions. The FARS database from NHTSA provides national level information regarding fatalities due to ambulance crashes, but similar data to adequately assess the scope of nonfatal injury are not available at the national level. Such data reside within the custody of private and public entities at State and local level. These databases are not uniform regarding reporting protocol and are not generally available to Federal researchers. While some researchers and EMS advocates believe that the injury problem is substantial because of the large numbers of crashes occurring, there is no national level validation of the numbers of injuries to EMS resulting from these crashes. Because volunteers make up a large portion of the EMS community, understanding of injury rates is further hampered by lack of accurate population data.

Knowledge of the vehicle acceleration vs. time trace (or vehicle crash pulse) generated during a crash is basic to development of engineering interventions to prevent injury. The crash pulse provides a basis for conducting computer modeling and dynamic testing. The pulse also indicates the magnitude of the crash forces against which occupants must be protected and the level of structural strength required for vehicle chassis. Because of the historical emphasis on motor-vehicle crash safety for the general population, vehicle crash pulse data are available for automobiles and light trucks. However, similar ambulance crash pulse data are generally lacking. Few tests have been conducted that would provide ambulance crash pulse data, and they are not current because of the age of the vehicles tested as well as by the test methodology. Further, to TI's knowledge the most recent tests were not fully instrumented and the resulting crash pulses have not been made publicly available. TI had to obtain these data from their own crash tests, which consumed a large amount of resources that could have been focused on intervention development. The testing resulted in a set of vehicle crash pulses obtained from uniform testing that will reside in the public domain and will be available to other researchers.

To evaluate potential interventions, TI and its partners conducted a series of tests using crash test dummies. Vehicle manufacturers and Federal regulators use data from crash test dummies that predict the likelihood of crash-related injury to humans as a basis for standards and intervention development. This is done by comparing the crash test dummy data to injury assessment reference values (IARV) derived from human cadaver testing. However, most human cadaver testing has been related to front- or rear-facing seated occupants. There are few IARVs for side-facing occupant seats and IARVs for standing occupants is nonexistent. This is especially true for criteria addressing the potential for neck injury in humans. Ambulance patient compartments contain four side-facing seats, and EMS workers may need to leave their seats to provide patient care. Likewise, at the time TI conducted its testing, crash test dummies which could measure lateral neck loads and moments were not available. TI attempted to overcome this limitation by using the most advanced crash test dummies available and by comparative evaluations of test data. However, the lack of appropriate IARVs and test equipment poses a limitation to the full application of the study results that may not be overcome until further research is conducted on the relationship between crash test dummy response and the potential for human injury.

Public criticism from other researchers has posed a minor obstacle for the TI project staff. There is some debate regarding the appropriateness of TI involvement in vehicle crashworthiness. TI believes that this is due in part to the personal agendas of a minority of researchers, the perception that the mandated NIOSH mission and the public health methodology should be focused solely on epidemiologic studies of work-related injury, and that vehicle crashworthiness studies and development of engineering interventions should be left to the automotive industry.

This obstacle is further compounded because the TI research has not yet achieved an endpoint and final project results have not been published. TI's strategy for dealing with this criticism has been to partner with external researchers and engineers who possess vehicle occupant survivability expertise and credentials and to present preliminary data to EMS providers, ambulance manufacturers, and Federal agencies with responsibility for EMS. Based upon the amount of requests for information and invitations to present at conferences received from the EMS community, TI views this as a minor impediment that will be overcome upon publication of the study's final results.

References:

1. Maguire BJ, Hunting KL, Smith GS, Levick NR (2002). Occupational Fatalities in Emergency Medical Services: A Hidden Crisis. Annals of Emergency Medicine 40:6, December 2002.

2. University of North Carolina—Chapel Hill (2003). National EMS Survey. Available on-line at: http://www.emspic.org/ems_toolkits/ov_survey.htm (Last viewed on October 31, 2006).

3. Levick NR, Guohua L, Yannaccone J (2001). Biomechanics of the Patient Compartment of Ambulance Vehicles, Under Crash Conditions: Testing Countermeasures to Mitigate Injury. Society of Automotive Engineers, Technical Paper 2001-01-1173, March 2001.

4. Proudfoot, SL, Romano, NT, Bobick, TG, Moore, PH [2003]. Ambulance Crash-Related Injuries Among Emergency Medical Services Workers, United States, 1991 – 2002. Division of Safety Research, National Institute for Occupational Safety and Health, CDC. MMWR 52(8): February 28, 2003.

5. Kyle SN (2006). Florida Rescuers Design Safety Ambulance. EMSResponder.Com News, June 15, 2006. Available on-line at: http://www.emsresponder.com/article/article.jsp?id=3519&siteSection=1. (Last viewed on October 31, 2006).

6. Traffic Safety Facts 2004 A Compilation of Motor Vehicle Crash Data From the Fatality Analysis Reporting System and the General Estimates System, National Highway Traffic Safety Administration, National Center for Statistics and Analysis, U.S. Department of Transportation, Washington, DC, 20590. http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSFAnn/TSF2004.pdf

Sub goal 7.3: Improve protection for emergency workers responding to large-scale disasters and terrorist attacks

Issue:
In 1990, TI investigated a series of electrocutions that occurred in Puerto Rico during recovery efforts in the aftermath of Hurricane Hugo. Several of the cases involved utility crews working on power lines thought to be de-energized that were actually "live" due to the presence of feedback electrical current produced by portable generators. Since then, information about the hazard of feedback electrical current, along with information on other disaster response hazards, has been included in fact sheets and on CDC and NIOSH disaster-response Websites. The availability of this disaster-specific safety information has been especially promoted and communicated at times when workers have been actively involved in response and recovery operations in large-scale disasters. In addition to information on electrical safety and generators, TI has contributed information to CDC and NIOSH fact sheets and disaster response Websites on topics such as entry to confined spaces, carbon monoxide poisoning, and chainsaw injuries.

The terrorist attacks of September 11, 2001 resulted not only in the deaths of thousands of World Trade Center (WTC) workers, but also in the deaths of hundreds more fire fighters, police, EMS, and other first responders at the WTC site who were killed performing their jobs trying to rescue people, control fires, etc. Over the course of the lengthy rescue and recovery efforts, more responders were injured, exposed to serious hazards (including respiratory insults that resulted in permanent disability for many), and subjected to physical and emotional stresses associated with their activities.

Several major safety issues emerged in the aftermath of the terrorist attacks of 9/11—including, the need for improved personal protective equipment (PPE) and related technologies and strategies for emergency responders, the need for rapid development and dissemination of information on specific safety topics as the need arises, the need for improved surveillance of responder injuries during rescue and recovery operations, and the need for overall improvements in safety management during response to large-scale disasters and terrorist attacks.

Approach:
In mid-September 2001, TI was asked to prepare eye safety information for rescue and recovery workers at the WTC site. TI staff—in collaboration with Prevent Blindness America, the International Safety Equipment Association, and a well-known ophthalmologist specializing in eye safety—prepared a tri-fold information brochure that describes common eye injury hazards, various eye protection options for recovery workers, first aid for eye injuries, and a four-point eye safety plan. The brochure was distributed at the WTC site through the Disaster Medical Assistance Teams (DMATs). TI also posted the information on the NIOSH Website (http://www.cdc.gov/niosh/eyesafe.html). An updated eye safety publication is currently being prepared for printing.

In recent years DSR staff has provided injury surveillance assistance to national and international rescue and recovery operations resulting from natural and human-caused disasters. Active surveillance of emergency responder injuries is an important component of ensuring their safety that often receives little attention compared to the injuries and illnesses of the primary disaster victims. During the rescue and recovery operations at the WTC, TI staff facilitated dissemination

of rescue worker injury and illness data, obtained from DMATs, to other NIOSH divisions for analysis. Additionally, TI staff designed data collection tools for capturing responder injuries and illnesses as a part of a disaster response worker registry. TI staff also provided modular surveillance data collection tools that could be used or adapted to monitor injuries and illnesses of rescue and mortuary workers following the December 2004 tsunami in Southeast Asia and for evacuation shelter workers following Hurricane Katrina in September 2005 (http://www.cdc.gov/niosh/topics/flood/pdfs/KatrinaShelterWorkerSurveillance.pdf).

TI staff has worked in the field with the CDC team supporting the New Orleans and Louisiana State Public Health Departments after Hurricane Katrina and during Hurricane Rita to provide assistance with injury and illness surveillance of residents and response workers; and to identify hazards and provide safety recommendations for people within the disaster zones. An important component of the latter effort was developing targeted and effective health communication messages for a diverse population. Being present in the field played a key role in understanding and responding to the local needs.

In 2001 the NIOSH National Personal Protective Technology Laboratory (NPPTL) contracted with the RAND Corporation to develop a national program of collaboration, research, service, and communications directed at providing personal protective technologies to fire fighters, emergency medical service personnel, and specialized teams responding to and mitigating emergencies. RAND conducted a series of workshops and meetings in support of this contract and authored several widely read reports.[1-5]

Under this contract, the TI Program engaged RAND in a collaborative study of occupational safety and health management practices associated with major disaster response. Researchers from RAND and TI gathered input directly by means of individual and group interviews of workers and managers involved in response and recovery activities during the 9/11 terrorist attacks in New York City and Arlington, Virginia; the Anthrax investigation in Boca Raton, Florida and New York City; the Northridge, California earthquake; and Hurricane Andrew in Central Florida.

A workshop conducted in Arlington, Virginia on February 27, 2003 assembled more than 100 responders and experts in emergency response and occupational safety and health to obtain expert comment and opinion on

- Integration of safety management into incident command and incident management systems
- Preparation for disaster response through training and multi-organizational planning
- Hazard assessment and monitoring, healthcare and surveillance targeting emergency workers
- Numerous related issues

Additional information was obtained from literature related to disaster response and safety management.

Outputs and Transfer:
In 1994, TI published a Fact Sheet on the hazards of flood cleanup work. This publication is available on the NIOSH Website at: http://www.cdc.gov/niosh/flood.html.

The eye safety brochure developed by TI was distributed at the WTC site through the Disaster Medical Assistance Teams (DMATs). TI also posted the information on the NIOSH Website at http://www.cdc.gov/niosh/eyesafe.html. An updated eye safety publication is currently being prepared for printing.

CDC and NIOSH have both developed extensive Web-based resources devoted to disaster response worker safety. TI has contributed extensively to these sites, which can be accessed at: http://www.bt.cdc.gov/disasters/ and http://www.cdc.gov/niosh/topics/, respectively.

In May 2003, during the course of the study, two briefings were conducted to share preliminary results of the TI/RAND Disaster Safety Management Study. One briefing was provided for agencies of the Department of Homeland Security (DHS) and Department of Defense (DoD), including:

- Federal Emergency Management Administration (FEMA)
- United States Coast Guard (USCG)
- U.S. Army Corps of Engineers

The other briefing was provided to the task force engaged in revising the National Response Plan (NRP) and developing the National Incident Management System (NIMS).

To formally report the findings from the study, RAND and TI co-authored the report: "Protecting Emergency Responders, Volume 3: Safety Management in Disaster and Terrorism Response," which was released in June 2004.[4] This report was the third in the series of NIOSH-RAND reports on protecting emergency responders. The 2004 report was officially launched by press releases from NIOSH and RAND on June 14, 2004, and was presented at a Congressional Briefing held June 16, 2004 in Washington, D.C.

The report was disseminated by direct mailings to:

1. More than 3,500 local (municipal and county) and State emergency management and public safety officials
2. Federal agencies with NRP roles and responsibilities, particularly DHS and the NRP/NIMS Task Force to consider for integration into national disaster response planning efforts
3. Public health agencies
4. State OSHA programs and
5. Academic institutions (38) with emergency management degree programs
6. National and international emergency managers' associations, and
7. Response organizations and associations and unions that represent them

In all, 5,032 copies of the report were directly mailed to targeted mailing lists. The reports that were directly mailed included a cover letter from Dr. John Howard, NIOSH Director, and a reader response card soliciting feedback on the quality and utility of the publication. An

additional 11,057 copies have been mailed in response to customer requests that came in by phone, fax, mail, email, and through the NIOSH Website. NIOSH distributed another 834 copies at conferences, trade shows and exhibits, and 39 copies were requested by visitors to the NIOSH Publications Office. Of the 19,500 copies of the report that were printed, a total of 16,923 copies have been distributed.

In addition, Web versions of the report were made available on both the NIOSH (http://www.cdc.gov/niosh/docs/2004-144/) and RAND (http://www.rand.org/pubs/monographs/MG170/) Websites.

RAND and TI staff members presented results of the NIOSH-RAND study and details of the dissemination strategy to the National Advisory Committee on Occupational Safety & Health (NACOSH) meeting on August 18, 2004.

TI Staff briefed the Federal Interagency Committee on Emergency Medical Services (FICEMS) on September 2, 2004 at the National Emergency Training Center (NETC) in Emmitsburg, Maryland. FICEMS also provided a mailing list targeting agencies and organizations with emergency medical services (EMS) responsibilities. TI staff also briefed a meeting of the Occupational Safety and Health State Plan Association in 2004.

Intermediate Outcomes:
To obtain a glimpse of users' response to, and the utility of, the NIOSH-RAND report on disaster safety management, reader response cards were included with the documents mailed directly to emergency management agencies. Two hundred sixteen of the recipients of the report filled out the reader response card and mailed it back to NIOSH. Findings included:

- 94 percent (203 of 216) of those who returned response cards are using the report to inform planning (81 percent), change plans (39 percent), change training (39 percent), implement specific recommendations (five percent), or "other" uses, such as share with colleagues (seven percent).
- Most of those who returned reader response cards were Emergency Directors/Administrators for local (county and municipal) agencies.

As previously mentioned, the NIOSH-RAND report recommendations were presented to the national task force commissioned to update the National Response Plan and to develop the National Incident Management System at briefings in May of 2003. The report recommendations received positive feedback. The NIMS, which was released in March 2004, three months before the RAND-TI report was published, provides the best "current" practices in incident management and provides for the development of the NIMS Integration Center established to facilitate "additional development and refinement." The role of the Safety Officer, as described in the NIMS, echoes some of the primary concerns expressed by the TI-RAND report, particularly the need to coordinate safety among the multiple agencies and organizations that come together in response to a major disaster or terrorist incident. According to the NIMS, the responsibilities of the Safety Officer include the "ongoing assessment of hazardous environments, the coordination of multiagency safety efforts, and implementation of measures to promote emergency responder safety." The NIMS goes on to say that the Safety Officer "must also ensure the coordination of safety management and functions and issues across jurisdictions, across functional agencies, and with private-sector and nongovernmental organizations."

NIMS can be accessed on the Web at:
(http://www.fema.gov/pdf/emergency/nims/nims_doc_full.pdf). NRP, released in January 2005, is an all-discipline, all-hazards plan that provides a single, comprehensive framework for incident management. The NRP can be accessed on the Web at:
(http://www.dhs.gov/interweb/assetlibrary/NRP_FullText.pdf). It coordinates Federal support to State, local, and tribal incident managers. The Worker Safety and Health Support Annex of the NRP outlines the Federal safety and health management role, and was developed by OSHA in collaboration with NIOSH**.**

Although neither the NIMS nor the NRP (released in 2005) references the RAND-TI report, it is likely that the briefing on the study in May 2003 and ultimately the published report were considered among many other inputs to the Task force's deliberations. The RAND-TI recommendations largely reflected the thinking of the emergency response community.

The AIHA based a 2005 White Paper "Role of the Industrial Hygienist in Emergency Preparedness & Response" on recommendations from the NIOSH-RAND report. The text of the White Paper can be obtained at:
(http://www.aiha.org/1documents/GovernmentAffairs/EPRWhitePaper_Final.pdf) (Last viewed on October 31, 2006).

What's Ahead:
The report on Disaster Safety Management,[4] along with a proposal for facilitating the implementation of report recommendations in the nation's municipal, county, and State emergency management offices, has been conveyed to the Department of Homeland Security. No further work on this project is planned.

The NIOSH Emergency Preparedness and Response Program continues to work with OSHA in carrying out responsibilities for Worker Safety and Health Support during large scale disasters. TI will continue to be responsive in rapidly preparing and disseminating worker safety information following disasters.

References:

1. Jackson BA et al. [2002]. Protecting Emergency Responders: Lessons Learned from Terrorist Attacks. Santa Monica, CA: RAND Science and Technology Policy Institute. 89 pp. Available on RAND Website at: http://www.rand.org/pubs/conf_proceedings/CF176/index.html, and the NIOSH Website at:http://www.cdc.gov/niosh/npptl/guidancedocs/rand.html

2. LaTourrette T, et al. [2003]. Protecting Emergency Responders, Volume 2: Community Views of Safety and Health Risks and Personal Protection Needs. Santa Monica, CA: RAND Science and Technology Policy Institute. 142 pp. Available on RAND Website at: http://www.rand.org/pubs/monograph_reports/MR1646/index.html and on the NIOSH Website at: http://www.cdc.gov/niosh/npptl/guidancedocs/rand.html

3. Houser A et al. [2004]. Emergency Responder Injuries and Fatalities: An Analysis of Surveillance Data. RAND Publication No. TR-100-NIOSH. Santa Monica, CA: RAND Science and Technology. 92 pp. Available on RAND Website at: (http://www.rand.org/pubs/technical_reports/TR100/).

4. Jackson BA et al. [2004]. Protecting Emergency Responders, Volume 3: Safety Management in Disaster and Terrorism Response. NIOSH Publication No. 2004-144; RAND Publication No. MG-170. Cincinnati, OH: National Institute for Occupational Safety and Health. 119 pp.

5. Willis H et al. [2006]. Protecting Emergency Responders, Volume 4: Personal Protective Equipment Guidelines for Structural Collapse Events. Santa Monica, CA: RAND Infrastructure, Safety, and Environment.

8. Reduce injuries and fatalities to working youth

Introduction

Approximately 2.3 million youth aged 16 to 17 years worked in the US in 2005.[1] Official employment statistics are not available for youth younger than 15 years of age who are also known to work, especially in agricultural settings. Although work can have positive benefits for youth, there are also safety risks, with 54 deaths of youth younger than 18 years of age in 2005,[2] and an estimated 54,800 emergency department treated injuries in 2003.[3] Youth occupational injury death rates are comparable to those of young adult and middle-aged workers (18 to 54 years of age).[4, 5] The comparability of these rates is cause for concern. Rates of nonfatal injuries treated in emergency departments generally decrease with age, with the rates for youth 15 to 17 years of age exceeded only by the rates for workers 18 to 19 years of age.[6]

Youth have unique risks for work injuries based on their biologic, psychosocial, and economic characteristics. A number of specific factors contribute to the high incidence and rates of young worker injuries, including:

- inadequate abatement of recognized hazards in youth workplaces
- absence of meaningful training for youth on the hazards in the work environment inexperience of youth
- physical, cognitive, and emotional characteristics related to youth development
- lack of appropriate supervision
- inappropriate work assignments that are illegal or otherwise exceed the capabilities of working youth.[7]

References:

1. BLS (Bureau of Labor Statistics) [2006]. Household data annual averages: Table 3. Employment status of the civilian noninstitutional population by age, sex and race. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. Table available at http://www.bls.gov/cps/cpsaat3.pdf

2. BLS [2006]. National census of fatal occupational injuries in 2005. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, USDL 06-1364.

3. NIOSH [2006]. Unpublished data from the National Electronic Injury Surveillance System. Morgantown, WV: National Institute for Occupational Safety and Health, Division of Safety Research, Injury Surveillance Team.

4. Windau and Meyer [2005]. Occupational injuries among young workers. Monthly Labor Review, 128 (10): 11-23.

5. Castillo DN, Malit BD [1997]. Occupational injury deaths of 16 and 17 year olds in the US: trends and comparisons with older workers. Inj Prev 3:277-281.

6. Marsh SM, Derk SJ, Jackson LL [2006]. Nonfatal occupational injuries and illnesses among workers treated in hospital emergency departments--United States, 2003. MMWR 55(16):449-52.

7. Castillo DN, Davis L, Wegman DH [1999]. Young Workers. Occ Med: State of the Art Reviews 14(3): 519-536.

Sub goal 8.1: Influence legislative changes to protect young workers

Issue:
Child labor laws are designed to ensure the health and educational welfare of children and would be expected to afford additional protection to youths compared to adults. These laws place limits on the types of work that youth can do, including prohibiting youth from conducting work considered to be especially hazardous. The U.S. Secretary of Labor has authority to prohibit work considered especially hazardous for youth under the Fair Labor Standards Act (FLSA). These regulatory prohibitions are termed "Hazardous Orders" (HOs) and have been largely unchanged for decades despite changes in how work is conducted and increased knowledge about occupational safety and health.

A number factors contribute to outdated child labor laws, including: previous minimal attention to youth less than 18 years of age by occupational safety researchers, an absence of linkages between occupational safety researchers and child labor regulators, and the political context in which legislation and regulations are promulgated. The TI Program undertook specific efforts to increase awareness of the importance and need for updating child labor laws.

Approach:
TI researchers collected and analyzed data to describe the magnitude and circumstances of young worker injuries. TI researchers also provided technical assistance to State-based young worker injury and illness surveillance systems in Massachusetts (Teens at Work Project) and Wisconsin under cooperative agreements.

TI researchers actively participated and later assumed leadership of the NIOSH Child Labor Working Team, established in 1994 by the Acting NIOSH Director. The Team included representatives of other Federal agencies, including the U.S. Department of Labor, Employment and Standards Administration, Wage and Hour Division (ESA/WHD), which has responsibility for promulgating and enforcing child labor laws. TI researchers established effective working relationships with ESA/WHD representatives, providing technical assistance in injury statistics, conducting special analyses on request, and sharing relevant TI research and recommendations.

TI researchers played a key role in NIOSH co-sponsoring a National Research Council (NRC) study on the health and safety implications of child labor, which was initiated by the NIOSH Director. TI researchers provided support in seeking co-sponsors (including several represented on the NIOSH Child Labor Working Team), provided background materials for the committee, and responded to committee inquiries.

In response to research recommendations in the 1998 NRC study report, "Protecting Youth at Work,"[1] and specific comments about the value of Fatality Assessment and Control Evaluation (FACE) investigations in "providing contextual information that is unavailable in other systems and can be vital to prevention efforts," the TI Program added youth less than 18 years of age as a specific target for fatality investigations by the FACE Program in 1999. TI researchers developed investigative guidelines and provided technical support and assistance to States with NIOSH cooperative agreements to conduct FACE Programs. Since 1999 when the TI Program added youth as a specific target for fatality investigations, TI researchers have conducted 29 FACE investigations of young worker deaths, and States with FACE cooperative agreements have conducted 42 young worker fatality investigations.

These investigations frequently identified that work tasks which are not currently prohibited by existing child labor laws have resulted in fatal injuries to young workers.

Also in response to recommendations in the NRC report, "Protecting Youth at Work,"[1] the TI Program and ESA entered into an interagency agreement in which ESA provided the TI Program with funds to 1) review the adequacy of existing child labor laws that prohibit youth from work identified as especially hazardous (HOs), and 2) develop and oversee an extramural research program on young worker safety and health risks in the construction industry. Established relationships with ESA/WHD were instrumental in the development of the interagency agreement.

TI researchers led the review of the adequacy of existing child labor laws, analyzing multiple data sets, reviewing FACE reports, and reviewing hundreds of articles in the scientific literature. TI researchers developed a request for applications (RFA) for research that would provide empirical data that could guide efforts to prevent deaths and injuries of youth less than 18 years of age working in construction, with a focus on data required to determine if changes were needed in existing child labor laws. This RFA resulted in two NIOSH cooperative agreements addressing youth construction injuries and prevention, and funding for a grant investigating hearing loss in newly hired construction workers.

TI researchers also developed RFAs for childhood agricultural injury research. These RFAs resulted in 24 grants characterizing the incidence and risks for childhood agricultural injury, and a grant specifically looking at the potential impact on childhood agricultural injuries of removing the farm family exemption from Federal child labor laws.

Outputs and Transfer:
(For outputs not specifically cited, see Appendix I: Supporting Evidence)

TI researchers have provided ESA/WHD with science-based recommendations for revisions to Federal child labor laws by submitting NIOSH comments in response to public comment periods on proposed rule changes, and a comprehensive 2002 NIOSH report developed through the TI/ESA interagency agreement. The 2002 report recommended revisions to 21 hazardous orders and 17 new hazardous orders. TI provided these recommendations directly to ESA/WHD. The 2002 comprehensive report was posted on the NIOSH Website and provided to requestors such as the Child Labor Coalition and International Labour Organization. TI researchers also participated in stakeholder meetings organized by ESA/WHD to seek input on the scope and prioritization of NIOSH recommendations.

The Teens at Work project contributed to the development of a Massachusetts Young Worker Initiative, a community led coalition of stakeholders that developed a State blueprint for action to protect working teens.[8] This State blueprint cited statistics from the Teens at Work project and included recommendations for revisions to Massachusetts State child labor laws.

Since 1988, TI researchers have published 20 articles in the peer-reviewed literature and Morbidity and Mortality Weekly Report (MMWR)[*] identifying the magnitude and patterns of young worker injuries and deaths.

[*] Centers for Disease Control Publication with wide dissemination to the medical and public health fields and the media.

Fifteen of these articles were published in 1996 or later. These articles identified young worker deaths and injuries not addressed by current child labor laws.

External researchers who conducted young worker injury and illness research through cooperative agreements and grants have communicated findings in at least 25 articles in the peer-reviewed literature. These reports helped identify the magnitude and patterns of young worker injuries and illnesses, and identified the need for revisions to child labor laws and increased enforcement of existing child labor laws.

TI researchers authored 11 NIOSH documents since 1995 featuring data on young worker injuries. Seven of these documents included data collected by TI researchers which were not previously available from any existing data system, to quantify the magnitude and patterns of work injuries of youth who live and work on farms.[2] TI researchers constructed targeted mailing lists to ensure that these NIOSH publications were distributed to relevant researchers, safety practitioners, and safety groups. TI researchers enlisted the support of partners including the Child Labor Coalition, Interstate Labor Standards Association, and OSHA to distribute copies of two of these publications which were NIOSH Alerts broadly addressing young worker safety. The TI Program maintains a NIOSH Website that compiles, organizes, and contains links to all NIOSH products on young workers. This Website may be accessed at www.cdc.gov/niosh/topics/youth/.

The TI Program posts FACE reports on the NIOSH Website, with a specific link for young worker fatality investigations, and provides copies to ESA/WHD and the Occupational Safety and Health Administration (OSHA). These reports may be accessed at: http://www.cdc.gov/niosh/injury/traumayouthface.html. State FACE Programs disseminate reports within their own States, and frequently provide copies to State child labor regulatory agencies.

The NRC study on the health and safety implications of child labor culminated in a 1998 publication "Protecting Youth at Work."[1] This publication included the following recommendation: "The U.S. Department of Labor should undertake periodic reviews of its hazardous orders in order to eliminate outdated orders, strengthen inadequate orders, and develop additional orders to address new and emerging technologies and working conditions. Changes to the hazardous orders should be based on periodic reviews by the National Institute for Occupational Safety and Health of current workplace hazards and the adequacy of existing hazardous orders to address them." NRC Committee members held briefings with sponsoring organizations, including NIOSH and ESA/WHD, and also presented findings and recommendations at conferences, such as the annual meeting of the American Public Health Association. This specific recommendation was the impetus for the TI/ESA interagency agreement discussed in the "Approach" section.

Intermediate Outcomes:
New Federal child labor regulations went into effect on February 14, 2005.[3] Research and recommendations from the TI Program were cited among the justifications for the rule changes. These changes have the potential to reduce young worker deaths and injuries associated with working on roofs, compactors and balers, driving, and the manufacture of explosives. ESA/WHD reports that they continue to consider NIOSH recommendations for child labor law changes and will be proposing additional rule changes in the future.

The 2002 NIOSH report recommending changes to Federal child labor laws has been used by others advocating for changes in child labor regulations. The Child Labor Coalition made numerous references to the report in a June 28, 2006 letter to Secretary of Labor Elaine Chao requesting action on child labor regulations for agriculture.[4] In the current and previous Congressional sessions, Representative Lantos introduced the Youth Worker Protection Act (H.R. 2870), which, among other provisions, would require the Department of Labor to implement changes to child labor laws recommended by NIOSH.[5] The Child Labor Coalition has cited the report in a document it produced questioning if the United States is in compliance with International Labour Organization (ILO) Convention 182 (Convention Concerning the Prohibition and Immediate Action for the Elimination of the Worst Forms of Child Labor), particularly as concerns children working in agriculture.[6] This is now being considered by the ILO Conference Standards Committee which has requested that the U.S. Government report on measures taken or envisaged to address these concerns.[7] In March 2003, the Young Worker Health and Safety Network, a subcommittee of the Occupational Safety and Health Section of the American Public Health Association, provided ESA/WHD with a recommended prioritization of NIOSH recommendations. A peer-reviewed journal article summarizing these recommendations was subsequently published.[8] And, in 2003, the Farmworker Justice Fund referenced the NIOSH recommendations in a press release calling for the Department of Labor to revise HOs in agricultural occupations.[9]

On January 3, 2005, a new child labor law became effective in Oregon prohibiting youth less than 18 years of age from working in occupations involving the use of explosives. This new rule was based on recommendations in an Oregon FACE investigation "Youth camp counselor killed when cannon burst into pieces" (OR2003-20-01).

A bill to strengthen child labor laws was introduced into the Massachusetts legislature in July 2006, and recently signed into law. News coverage of this proposed legislation cited TI statistics and statistics from the Massachusetts Teens At Work project.[10]

NIOSH Alerts on young worker safety have been repeatedly reprinted based on requests for more copies, and statistics on young worker deaths and injuries included in NIOSH publications are routinely cited in the press and by groups advocating for child labor law changes. Findings from NIOSH-funded extramural research have also been cited in the press. Recent examples include press coverage of results from the Wisconsin young worker injury surveillance project and young worker construction safety research funded through the TI/ESA cooperative agreement.[11-14]

TI-authored peer-reviewed journal articles and NIOSH publications that identify the incidence and circumstances of young worker injuries have been cited more than 250 times in the scientific literature. (Citation frequency is provided in Appendix I: Supporting Evidence for selected publications).

What's Ahead:
The TI Program is not currently actively engaged in efforts to encourage legislative or regulatory change to improve young worker safety. The 2002 NIOSH report recommending changes to Federal child labor laws was comprehensive and should serve as a resource for years to come. Because recent FACE investigations of young worker deaths are less frequently identifying new prevention strategies, including recommendations for new or revised child labor laws, the TI Program is considering scaling back or removing youth as a target for FACE investigations. The

TI Program will develop a report summarizing findings from FACE investigations of youth, with an emphasis on gaps identified in existing child labor laws. The TI Program will seek input from stakeholders on the scope and format of this document to ensure it meets their needs and to garner support for their use and dissemination of the report.

The TI Program will continue to analyze existing data on young worker injuries and deaths, and report on data trends. TI researchers will continue to provide technical support to the ESA/WHD, including responding to requests for technical information and sharing new scientific findings from NIOSH cooperative agreements and grants. The TI Program will lead the development of NIOSH comments on future proposed rulemaking by the Department of Labor.

External Factors:
The TI/ESA interagency agreement for the TI Program to develop recommendations for changes to Hazardous Orders was initiated in 1998. As work progressed and the report neared completion, there were changes in the leadership at ESA. New leadership had no investment in the TI recommendations, and reacted somewhat defensively to the efforts of NIOSH and other stakeholders to promote it as an important tool for guiding future rulemaking. As well, in general, regulatory actions have slowed and become increasingly difficult to initiate, with recent increased requirements for regulatory agencies to evaluate the economic impact of new regulations. It is possible that the increased complexity of the rulemaking process has contributed to inaction by DOL/ESA.

Statutory provisions of the Fair Labor Standards Act (FLSA) limit the potential impact of regulatory changes. Large numbers of working youth are not covered by the FLSA, including youth who work on their parents' farms, and youth 16- and 17- years of age who work on any farm.

References:

1. NRC (National Research Council/Institute of Medicine) [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States. Washington, DC: National Academy Press.

2. Lee BC [2005]. NIOSH fills void with surveillance of injuries to youth living on U.S. farms. J Agromedicine 10(4): 3-4.

3. DOL (Department of Labor, Employment and Standards Administration, Wage and Hour Division) [2004]. Child Labor Regulations, Orders and Statements of Interpretation; Child Labor Violations—Civil Money Penalties; Final Rule. Federal Register, December 16, 2004 (Volume 69, Number 241). Available at: http://frwebgate1.access.gpo.gov/cgi-bin/waisgate.cgi?WAISdocID=882859482193+5+0+0&WAISaction=retrieve

4. Child Labor Coalition [2006]. Letter from Child Labor Coalition (signed by co-chairs Antonia Cortese, Executive Vice President, American Federation of Teachers; and Linda F. Golodner, President, National Consumers League) to Secretary of Labor Elaine Chao. June 28, 2006.

5. Lantos T [2006]. Youth workers need legal actions. San Francisco, CA: San Francisco Examiner, June 19, 2006.

6. Adkins D, Leonard J, Maki R et. al. [2005]. Protecting Working Children in the United States: Is the Government's Indifference to the Safety and Health of Working Children Violating an International Treaty?. Washington, DC: Child Labor Coalition. Available at http://www.stopchildlabor.org/pressroom/clc percent20report.pdf

7. ILO (International Labour Organization) [2006]. Report of the Committee of Experts on the Application of Conventions and Recommendations (articles 19, 22 and 35 of the Constitution). Third item on the agenda: Information and reports on the application of conventions and recommendations; Report III, Part 1A; General Report and observations concerning particular countries. Pages 229-233. Available on Web at: http://www.ilo.org/public/english/standards/relm/ilc/ilc95/pdf/rep-iii-1a.pdf. Date last accessed: July 18, 2006.

8. Miller ME, Bush D [2004]. Review of the Federal child labor regulations: Updating hazardous and prohibited occupations. American Journal of Industrial Medicine 45:218-221.

9. Farmworker Justice Fund, Inc [2003]. Children employed in agriculture need stronger laws to protect them against hazardous working conditions [press release]. Washington, DC: Farmworker Justice Fund, Inc., December 4, 2003.

10. Lewis D [2006]. Overhaul to toughen State child labor laws: AG would get more enforcement power. Boston, MA: Boston Globe, July 20, 2006.

11. Bowman L [2006]. Study: 1 in 6 working teens injured on the job. Scripps Howard News Service, August 24, 2006.

12. The News & Observer [2006]. Editorial: Shielding teen workers. Raleigh, NC: The News & Observer, July 14, 2006. Available at: http://www.newsobserver.com/579/story/460252.html

13. Vollmer S [2006]. Study: Teens in construction jobs at risk. Raleigh, NC: The News & Observer, July 3, 2006. Available at: http://www.newsobserver.com/104/story/457205.html

14. Weier A [2006]. Working 2 jobs': 15 percent of state's teens are injured. Madison, WI: The Capital Times, September 4, 2006.

Sub goal 8.2: Reduce child agricultural injuries

Issue:
Official employment statistics identify an estimated annual average of 50,000 youth aged 16 to 17 years who worked in agriculture and related industries in 2005, with an estimated annual average of 6,000 youth working as unpaid family workers.[1] Official employment statistics are not available for youth younger than 15 years of age, and therefore provide a very different picture of the size of the youth working population in agriculture than data collected in periodic surveys of farm operators by the TI program. A TI survey of farm operators estimated 790,000 youth younger than 18 years of age who worked on U.S. farms at some point during 2004 (not averaged across the year), with 591,000 of these youth living in the farm household and 199,000 hired youth who did not live in the farm household.[2]

Although work can have positive benefits for youth, there are considerable safety risks in the agriculture setting. There were 125 deaths of youth less than 18 years of age working in the agriculture, forestry, and fishing industry sector between 1998 and 2002, accounting for 41 percent of all young worker deaths during this period.[3] Almost 60 percent of these deaths occurred among youth who worked on the family farm, and almost two-thirds of the deaths occurred to workers less than 16 years of age. Using official employment statistics from the Bureau of Labor Statistics (BLS) to calculate rates, young worker fatality rates in the agricultural production sector are highest for 15-year-olds (18.5 deaths per 100,000 full-time equivalent workers for the years 1992 to 2002), and rates for youth working in agricultural production are more than 3.5 times greater than rates for youth working in other industries.[4] An estimated 5,700 youth sustained nonfatal work injuries on farms in 2004, at a rate of 7.3 work injuries per 1,000 youth working on farms.[2]

In addition to factors that contribute to youth work injuries generally (e.g., inadequate training and supervision, and factors related to physical and psychosocial development), several factors are unique to agricultural production which contribute to the high incidence and rates of young worker injuries in agriculture. These include:

- Elevated injury risks for agriculture compared to other work settings
- The involvement of younger youth in work (e.g., children less than 14 years of age)
- Work by youth that would typically be performed by adults in other work settings (e.g., operation of heavy machinery such as tractors)
- Common use of older equipment without safety features
- Virtual irrelevance of occupational safety and health regulations
- Limited child labor laws that do not cover youth 16 and 17 years of age, and exempt children working on their family's farm (these provisions are different from child labor laws in nonagricultural occupations)
- Social norms and unsafe traditional practices in agricultural communities, and
- Economic pressures and challenges in small farm operations.[5-7]

The TI Program undertook a comprehensive effort to fill surveillance gaps, identify risk factors, evaluate interventions, and communicate findings and injury prevention recommendations to stakeholders.[8]

Approach:
TI researchers actively participated on the National Committee for Childhood Agricultural Injury Prevention (NCCAIP) that developed a national action plan to prevent childhood agricultural injuries.[5] The National Farm Medicine Center (NFMC) led the development of the national action plan with funding support from NIOSH and the Maternal and Child Health Bureau (MCHB) of the Health Resources and Services Administration. The 42-member multidisciplinary NCCAIP included researchers, farmers, agricultural groups, safety and health professionals, and government officials (including two from the TI Program). Over a 16-month period, the NCCAIP developed the national action plan using a consensus process and actively seeking review and input from stakeholders. The national action plan identified 13 objectives and 43 recommended action steps to maximize the safety and health of children and adolescents exposed to agricultural hazards. The national action plan called for leadership, surveillance, research, education, and public policy, and specifically called for NIOSH to serve as the lead Federal agency in preventing childhood agricultural injury.

In Fiscal Year 1997, NIOSH received a $5 million Congressional appropriation to lead a national childhood agricultural injury prevention initiative.* TI researchers drafted an implementation plan that built on previous TI research and recommended action steps in the NCCAIP national action plan, and held a public meeting in February 1997 to seek stakeholder input.[8] Based on input received at this meeting, TI researchers revised the implementation plan and conducted a separate peer-review process in October 1997 to receive expert input on TI plans for routine and ongoing surveillance of childhood agricultural injuries. The TI surveillance plan was modified based on this expert input to use a combination of surveillance methods to ensure adequate data collection for different youth populations of concern, including minority and Hispanic working youth.

In September 1999, the TI Program held a midcourse review of the childhood agricultural injury prevention initiative, summarizing progress and seeking input on proposed future directions.[9] The TI Program made revisions to the initiative based on input, including developing a Website to better communicate information from the initiative (www.cdc.gov/niosh/niosh/childag/). TI researchers also helped plan and participated in the 2001 Summit on Childhood Agricultural Injury Prevention, led by the National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) with funding by NIOSH, to assess progress and update the 1996 national action plan.[6] Nearly 100 individuals representing farmers and farm organizations, researchers, safety and health professionals, and governmental agencies participated in the development of the updated action plan. The updated action plan included three broad goals and 12 recommendations, including a recommendation to maintain Federal funding for childhood agricultural injury prevention initiatives, including funding a Federal interagency working group and a National Children's Center to provide leadership and coordination between the public and private-sector.[6]

The TI- developed childhood agricultural injury prevention initiative includes intramural surveillance and coordination efforts (approximately 25 percent of appropriation), and a large extramural research and outreach program (approximately 75 percent of appropriation). TI researchers periodically analyze data from the Census of Fatal Occupational Injuries and National Electronic Injury Surveillance System to describe the magnitude, patterns, and trends in

* The childhood agricultural injury prevention initiative includes efforts addressing non occupational injuries. Efforts described here focus on occupational injuries.

occupational injuries of youth in agriculture. TI researchers piloted new methods and survey mechanisms to fill gaps in young worker agricultural injury surveillance, and considered new methods undertaken by extramural researchers. The TI Program subsequently established periodic surveys of farm operators in collaboration with the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA), and in collaboration with the U.S. Department of Labor (DOL), incorporated childhood agricultural injury questions into field-based surveys of seasonal and migrant farm workers as part of the National Agricultural Workers Survey.

TI researchers developed a series of Requests for Applications (RFAs). These RFAs resulted in cooperative agreements to fund the National Children's Center for Rural and Agriculture Safety and Health (NCCRAHS), and 50 research grants since 1997 to characterize young worker agricultural injuries, risk factors, outcomes, and to develop and evaluate interventions. The NCCRAHS, which also receives funding from MCHB, leads and organizes groups to develop consensus recommendations, and conducts research and outreach to facilitate the use of state-of-the-art information and consensus guidelines by program planners, agribusiness, educators, safety and health professionals and advocates, farm media, farmers, and farm families. TI researchers provide technical assistance and work collaboratively with NCCRAHS, and between 1999 and 2004, convened annual meetings of research grant recipients to provide a forum for sharing findings and discussing common problems and solutions in conducting childhood agricultural injury research.

The TI Program formed a Federal Interagency Working Group on Preventing Childhood Agricultural Injuries in 1997, and reorganized the group in 2004. The group currently includes 11 agencies that have an interest, mission, or mandate in childhood agricultural injury prevention, including MCHB, the national FFA Advisor and Office of Migrant Education in the U.S. Department of Education, the Occupational Safety and Health Administration (OSHA) and the Employment Standards Administration (ESA) in the DOL, the Cooperative State, Research, Education, and Extension Service of the USDA, and, the National Institute of Child Health and Human Development in the National Institutes of Health. A TI researcher chairs the working group and convenes bi-annual meetings of the group to share information on ongoing activities, and to facilitate new findings and products on young agricultural worker safety being incorporated into safety efforts.

Since 1999 when the TI Program added youth as a specific target for fatality investigations, TI researchers have conducted three FACE investigations of young worker deaths in agriculture, and States with FACE cooperative agreements have conducted 17 young agricultural worker fatality investigations. These investigations frequently identified inadequate training, inadequate supervision, a mismatch between equipment and physical characteristics of youth, the use of equipment without safety features, and work assignments that were prohibited by child labor laws (or would be without the family farm exemption).

As previously discussed in Sub goal 8.1, TI researchers led the review of the adequacy of existing child labor laws, analyzing multiple data sets, reviewing FACE reports, and reviewing hundreds of articles in the scientific literature. TI researchers had previously led the development in 1994 of NIOSH comments to DOL on an advanced notice of proposed rulemaking on child labor laws, which included numerous recommendations specific to agriculture.

Outputs and Transfer:
(For outputs not specifically cited, see Appendix I: Supporting Evidence.)

In finalizing the 1996 national action plan, NCCAIP committee members briefed stakeholders on the plan and sought commitments to move forward on NCCAIP recommendations. Nearly 80 organizations were identified as providing support to the 1996 national action plan, including professional groups such as the American Academy of Pediatrics, trade groups such as the American Farm Bureau Federation, farm worker groups such as the Association of Farmworker Opportunity Programs, manufacturers such as Deere & Company, research centers such as the University of Minnesota Agricultural Engineering Department, and governmental agencies, such as MCHB.[5]

Since 1988, TI researchers have published 28 articles in the peer-reviewed literature and Morbidity and Mortality Weekly Report (MMWR)[*] addressing the incidence, risks and prevention of young worker injuries in agriculture. Twenty-three of these articles were published in 1996 or later. Findings were presented at professional and scientific conferences, including annual meetings of the National Institute for Farm Safety, Agricultural Safety and Health in a New Century, National Occupational Injury Research Symposiums, Annual Childhood Injury Prevention Conferences, and the North American Guidelines for Children in Agriculture Symposium.

TI researchers contributed to nine NIOSH and three USDA documents since 1995 featuring young agricultural worker injury data and prevention recommendations. All of these documents are included on a NIOSH "Childhood Agricultural Injury Prevention Initiative" Website (http://www.cdc.gov/niosh/childag/). TI researchers constructed targeted mailing lists to ensure that these publications were distributed to relevant researchers, safety practitioners, safety groups, and stakeholders. For example, the TI Program has worked with NASS to provide NIOSH pamphlets to 100,000 farm operators participating in the NIOSH/NASS farm operator surveys. The pamphlets summarize data collected in the surveys on common causes of childhood farm injury and recommend steps that farmers can take to foster safe farm environments for youth. Finally, TI researchers share findings and outputs with the NCCRAHS and at bi-annual meetings of the Federal Interagency Working Group on Preventing Childhood Agricultural Injuries.

The TI-supported NCCRAHS has published consensus-based action plans and guidelines. These outputs have been directly disseminated to stakeholders. Information on these outputs is presented at professional conferences and farm organization events, and provided to the farm media. NCCRAHS researchers have also published research in the peer-reviewed literature. NCCRAHS communicates information about major childhood agricultural safety programs through a quarterly newsletter, Nurture, which is distributed in print copy to about 2,000 recipients and posted on the Internet. NCCRAHS maintains a general Website that provides an overview of NCCRAHS activities and offers downloadable reports and resources such as fact sheets: http://www.marshfieldclinic.org/nfmc/pages/default.aspx?page=nccrahs welcome. NCCRAHS maintains another Website devoted to the National Agricultural Guidelines for

[*] Centers for Disease Control Publication with wide dissemination to the medical and public health fields and the media.

Children's Agricultural Tasks, which were developed under the leadership of NCCRAHS, using a consensus-based process: www.nagcat.org.

The NRC report, "Protecting Youth at Work,"[10] discussed in Sub goal 8.1 included recommendations that child labor laws in agriculture be changed to be consistent with child labor laws in nonagricultural settings, encompassing 16- and 17-year-olds and removing the family farm exemption. NRC committee members held briefings with sponsoring organizations, including ESA/WHD, and presented findings and recommendations at conferences and published them in the public health literature.[11, 12]

TI researchers provided ESA/WHD with science-based recommendations for revisions to Federal child labor laws by submitting NIOSH comments in response to public comment periods on proposed rule changes, and a comprehensive 2002 NIOSH report developed through the TI/ESA interagency agreement described in the "Approach" section in Sub goal 8.1. In 1994, NIOSH comments on proposed rulemaking recommended that DOL raise the minimum age for hazardous work in agriculture from 16 to 18 and remove the family farm exemption. The 2002 report recommended revisions to eight of the 11 HOs in agriculture, retention of the remaining three HOs, and a new HO in agriculture and nonagricultural industries that would prohibit youth from work requiring respirators. TI researchers also participated in stakeholder meetings organized by ESA/WHD to seek input on the scope and prioritization of NIOSH recommendations, including a meeting centered on the NIOSH recommendations specific to agriculture. The NCCRAHS provided DOL with written comments on the NIOSH recommendations specific to agriculture.

External researchers who conducted young worker agricultural injury research through cooperative agreements and grants have communicated findings in at least 31 articles in the peer-reviewed literature. These reports helped identify the magnitude and patterns of young agricultural worker injuries, and made recommendations for prevention measures.

Intermediate Outcomes:
TI surveillance efforts have provided previously unavailable data on the number of youth working in agriculture, and the numbers and patterns of injury.[13] NCCRAHS, Farm Safety for Just Kids, the National Safe Kids Campaign, USDA and others have used these data to guide their prevention efforts, and the media now routinely use these data in news stories. An example is a recent USDA news release announcing more than $400,000 in grants to train young people who work on farms about safety rules, noting a TI Program statistic from 2001 that more than a third of all agricultural injuries of youth were associated with work.[14] TI estimates of youth farm injuries were also cited in proposed Congressional legislation, which has not been acted upon. The Children's Act for Responsible Employment of 2005 (CARE Act of 2005, HR 3482), submitted in the House of Representatives by Representative Roybal-Allard in July 2005, proposed changes to child labor laws in agriculture, and identified the TI Program youth farm injury data collected through farm operator surveys as one source of data that would be used to develop an annual report on occupational injuries to youth working on farms in the U.S.

As discussed in Sub goal 8.1, the 2002 NIOSH report recommending changes to Federal child labor laws has been used by others advocating for changes in child labor regulations in the agriculture industry, including the Child Labor Coalition, Young Worker Health and Safety Network, and the Farm Workers Justice Fund.

TI-authored peer-reviewed journal articles and NIOSH publications that identify the incidence and circumstances of young agricultural worker injuries have been cited more than 260 times in the scientific literature (Citation frequency is provided in Appendix I: Supporting Evidence for selected publications).

End Outcomes:
Data on nonfatal agricultural work-related injuries of youth are available from the TI/NASS surveys of farm operators for the years 1998, 2001, and 2004.[2] These data suggest a steady decline in the number of work-related injuries among youth less than 18 years of age from an estimated 11,970 injuries in 1998 to an estimated 7,490 injuries in 2001, and an estimated 5,740 injuries in 2004. This represents a greater than 50 percent decrease in the number of agricultural work-related injuries in a seven-year period. These data also suggest a decrease in the rate of nonfatal agricultural work-related injuries among youth, though the decline is not as large as suggested by the numbers of injuries, since the number of youth working in agriculture has declined over the last seven years. Rates of nonfatal agricultural work-related injuries among youth declined from 10.5 injuries/1,000 working youth in 1998 to 8.8 in 2001, and to 7.3 in 2004, a 30 percent decline.

What's Ahead:
The TI Program will continue to collect and analyze data on young worker injuries and deaths in agriculture, report on data trends, provide leadership in childhood agricultural injury prevention, and seek to address recommendations in the 2001 updated national action plan. The TI Program is planning a public meeting and symposium to assess progress and new emphasis areas in FY 2008.

External Factors:
A number of external factors impede progress in reducing young worker injuries and deaths in agriculture, including:

- Social norms and unsafe traditional practices in agriculture
- Economic pressures of small farm operations
- Decreasing private-sector investments in childhood agricultural injury prevention outdated child labor laws
- Exclusions of 16- and 17-year-olds working in agriculture from Federal child labor laws
- The family farm exemption in Federal child labor laws
- Limited enforcement of child labor laws at the Federal and State level
- Absence of OSHA standards or enforcement in agriculture.

References:

1. BLS (Bureau of Labor Statistics) [2006a]. Household data annual averages: Table15. Employed persons in agriculture and related and in nonagricultural industries by age, sex, and class of worker. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. Table available at: http://www.bls.gov/cps/cpsaat15.pdf.

2. NIOSH [2006]. Unpublished data from the Childhood Agricultural Injury Survey. Morgantown, WV: National Institute for Occupational Safety and Health, Division of Safety Research, Special Studies Team.

3. Windau and Meyer [2005]. Occupational injuries among young workers. Monthly Labor Review 128 (10): 11-23.

4. Hard DL, Myers JR [2006]. Fatal work-related injuries in the agriculture production sector among youth in the United States, 1992-2002. Journal of Agromedicine 11(2):57-65.

5. NCCAIP (National Committee for Childhood Agricultural Injury Prevention) [1996]. Children and agriculture: Opportunities for safety and health: A national action plan. Marshfield, WI: Marshfield Clinic.

6. Lee B, Gallagher S, Marlenga B, Hard D (Eds) [2002]. Childhood agricultural injury prevention: progress report and updated national action plan from the 2001 summit. Marshfield, WI: Marshfield Clinic.

7. NRC (National Research Council/Institute of Medicine) [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States. Washington, DC: National Academy Press.

8. Castillo D, Hard D, Myers J, Pizatella T, Stout N [1998]. A national childhood agricultural injury prevention initiative. Journal of Agricultural Safety and Health (Special Issue 1):183-191.

9. NIOSH [1999]. NIOSH Childhood Agricultural Injury Prevention Initiative: Progress and proposed future activities. Morgantown, WV, July 1999. Available at: http://www.cdc.gov/niosh/childagz.html

10. NRC (National Research Council/Institute of Medicine) [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States. Washington, DC: National Academy Press.

11. Wegman and Davis [1999]. Protecting youth at work. American Journal of Industrial Medicine 36(5): 579-83.

12. Wegman [1999]. Work should help teens, not hurt them. Pediatrics 103:821-2.

13. Lee BC [2005]. NIOSH fills void with surveillance of injuries to youth living on U.S. farms. Journal of Agromedicine 10(4): 3-4.

14. USDA (US Department of Agriculture [2006]. USDA announces four grants for youth farm safety education. Agriculture Department Documents and Publications, Release No. 0367.06, September 21, 2006.

15. Child Labor Coalition [2006]. Letter from Child Labor Coalition (signed by co-chairs Antonia Cortese, Executive Vice President, American Federation of Teachers; and Linda F. Golodner, President, National Consumers League) to Secretary of Labor Elaine Chao. June 28, 2006.

16. Lantos T [2006]. Youth workers need legal actions. San Francisco, CA: San Francisco Examiner, June 19, 2006.

17. Adkins D, Leonard J, Maki R et. al. [2005]. Protecting Working Children in the United States: Is the Government's Indifference to the Safety and Health of Working Children Violating an International Treaty?. Washington, DC: Child Labor Coalition. Available at http://www.stopchildlabor.org/pressroom/clc percent20report.pdf

18. ILO (International Labour Organization) [2006]. Report of the Committee of Experts on the Application of Conventions and Recommendations (articles 19, 22 and 35 of the Constitution). Third item on the agenda: Information and reports on the application of conventions and recommendations; Report III, Part 1A; General Report and observations concerning particular countries. Pages 229-233. Available:http://www.ilo.org/public/english/standards/relm/ilc/ilc95/pdf/rep-iii-1a.pdf. Date accessed: July 18, 2006.

19. Farmworker Justice Fund, Inc [2003]. Children employed in agriculture need stronger laws to protect them against hazardous working conditions [press release]. Washington, DC: Farmworker Justice Fund, Inc., December 4, 2003.

20. BLS [2006b]. Unpublished data from the national census of fatal occupational injuries. Provided by personal communication from Janice Windau to Dawn Castillo on August 21, 2006.

Sub goal 8.3: Foster the development and widespread use of safety materials and intervention strategies to protect young workers

Issue:
The risk of fatal and nonfatal occupational injuries to the nation's youth is not fully understood nor appreciated by employers, parents, the youth themselves, nor the general public. A general lack of awareness exists of the hazards of working environments in which young workers are employed, the factors that contribute to higher risk for youth, the types of work and specific tasks that are illegal or exceed the capability of working youth, and the prevention options for protecting young workers. The TI Program undertook specific efforts to increase awareness of the need to improve the safety and well-being of working youth, and to develop and evaluate intervention strategies and materials that could be widely used. This section focuses on these efforts in nonagricultural workplaces.

Approach:
TI led the efforts of the NIOSH Child Labor Working Team, which identified research needs, including intervention research to identify effective prevention strategies, and refinement and expansion of community-level interventions. TI researchers developed a Request for Applications (RFA) for community-based demonstration projects and a subsequent RFA for an extension of the community-based approach to regions and States. The first RFA resulted in three cooperative agreements for community-based demonstration projects in Los Angeles, California, Oakland, California, and, Brockton, Massachusetts. The subsequent RFA resulted in two cooperative agreements. The first extended the work of the Los Angeles, California community-based project to a larger area within Los Angeles. The second used a State-team approach in Northeastern States. TI researchers provided technical assistance to the grantees in the execution of these projects, and modified materials developed by these cooperative agreement programs for national use (See Appendix I: Supporting Evidence for information on these cooperative agreements and products modified for national use). For example, TI researchers modified curricula developed by the community-based demonstration projects and worked with State educational agencies to pilot test this core curricula. The curricula were found to be effective in teaching students basic information to keep them safe and healthy on the job.

TI researchers established working relationships with partners in the public and private-sector. Relationships with Federal partners were facilitated by TI leadership of the Child Labor Working Team, and later TI participation on the Federal Network for Young Worker Safety and Health (FedNet) led by the Occupational Safety and Health Administration (OSHA) (http://www.cdc.gov/niosh/fedNet/). The NIOSH Child Labor Working Team, active from 1994 to 2000, included six representatives from other Federal agencies, including the Wage and Hour Division of the Department of Labor responsible for child labor laws, and the School-to-Work Office in the Departments of Education and Labor responsible for implementing the School-to-Work Opportunities Act. The FedNet, organized in 2003, includes 11 Federal agencies who work collaboratively to reduce injuries and illnesses among young workers up to 24 years of age. TI researchers provide these other Federal agencies with technical expertise on young worker injury statistics and research findings, seek input on TI products, and collaborate in outreach efforts.

TI researchers established relationships with private groups actively involved in educational efforts to reduce the incidence of young worker injuries, including the Child Labor Coalition, vocational and technical education groups, and the Young Worker Safety and Health Network, a

subcommittee of the Occupational Safety and Health Section of the American Public Health Association. TI researchers provide technical assistance in interpreting young worker injury statistics and research findings, and seek input from these groups on TI products and activities, and their assistance in disseminating TI findings and products.

Outputs and Transfer:
(For outputs not specifically cited, see Appendix I: Supporting Evidence.)

Since 1988, TI researchers have published 15 articles in the peer-reviewed literature and Morbidity and Mortality Weekly Report (MMWR)[*] identifying the magnitude and patterns of young worker injuries and/or prevention strategies Ten of these articles were published in 1996 or later. These articles identified workplaces with the greatest numbers and rates of young worker injuries, common hazards and events resulting in young worker injury, inadequate youth safety and health training, inadequate supervision of young workers, inappropriate youth work assignments, and promising prevention strategies.

TI researchers contributed to 13 NIOSH documents since 1995 featuring young worker injury data and prevention recommendations. All of these documents are included on a NIOSH Young Worker Safety and Health Website (www.cdc.gov/niosh/topics/youth/.) TI researchers constructed targeted mailing lists to ensure that these NIOSH publications were distributed to relevant researchers, safety practitioners, safety groups and stakeholders. For example, over several years, TI researchers mailed a fact sheet, brochure and poster to more than 25,000 high schools in the United States, requesting that information be posted on school bulletin boards and distributed to parents, teachers and students.[2] Additionally, the TI Program participated in collaborative educational outreach efforts with the Wage and Hour Division and OSHA. TI researchers provided materials for inclusion in Department of Labor "Work Safe this Summer Campaigns" in the 1990s, collaborated on joint mailings of materials related to forklift safety and youth work in construction, and collaborated on Internet guidance on safe work for youth.[3-5]

As noted in Sub goal 8.1, the TI Program provides copies of FACE reports to WHD and the Occupational Safety and Health Administration (OSHA) and State FACE Programs disseminate reports and associated prevention materials within their own States. One specific example is widespread distribution by the Massachusetts FACE Program and partners of safety information on young workers and forklifts, including a sticker developed by the Massachusetts FACE Program that could be affixed to forklifts noting that they should not be operated by workers less than 18 years of age.

External researchers who conducted young worker injury and illness research through cooperative agreements and grants have communicated findings in at least 23 articles in the peer-reviewed literature. These reports helped identify the magnitude and patterns of young worker injuries and illnesses, and made recommendations for prevention measures by regulators, employers, parents, educators and youth.

The extramural community-based demonstration projects developed numerous young worker safety and health educational materials. These included stand-alone curricula, educational activities for integration into existing high school curricula (e.g. science, English, history), and

[*] Centers for Disease Control Publication with wide dissemination to the medical and public health fields and the media.

educational materials targeted to parents, employers, healthcare providers, and youth. These materials are highlighted in a NIOSH publication, "Promoting Safe Work for Young Workers: A Community-based Approach." The projects worked with community, State and Federal level groups to transfer findings and products to regulators, employers, parents, educators, and youth.

The TI-supported Massachusetts young worker injury surveillance project described in Sub goal 8.1, Teens at Work, revised and updated materials developed in the Protecting Young Workers in Brockton community-based demonstration project, and uses them in surveillance-driven outreach efforts. Outreach includes train-the-trainer workshops on curricula developed in the community-based demonstration project for vocational and general education teachers, OSHA compliance assistance specialists, and peer leaders. Since 2004, the Massachusetts Teens at Work project has coordinated the Massachusetts Interagency Work Group on Youth Employment, a group of State and Federal agencies that meets quarterly to coordinate government activities to protect young workers in Massachusetts. The Teens at Work project also contributed to the development of a Massachusetts Young Worker Initiative, a community led coalition of stakeholders that has developed a State blueprint for action to protect working teens.[8]

Intermediate Outcomes:
Young worker safety efforts initiated under the TI-supported community-based demonstration projects have continued on, in large part, without subsequent NIOSH funding. At least three State-based teams initiated in association with TI-supported community-based demonstration projects have continued. The Outputs and Transfer section includes information on the Massachusetts team. In 2000, the California legislature established the California Resource Network for Young Worker Safety and Health based on a consensus recommendation from a State group including representatives from both TI-supported California-based demonstration projects.[15] A recent newsletter reporting that the Connecticut Department of Health is undertaking a focused intervention and training program for young restaurant workers based on surveillance findings noted continued collaborative work by the Connecticut Young Worker Safety Team.[16] This team was established through the Northeast Young Resource Center Cooperative Agreement. Additionally, the work of investigators with the Oakland, California community-based demonstration project and Northeast Young Worker Resource Center has been extended through the Young Worker Safety Resource Center funded by OSHA (http://socrates.berkeley.edu/percent7Esafejobs/nation/index.html#contactinfo). This center, a project of the Education Development Center and University of California, Berkeley Labor Occupational Health Program, provides services that can help State and local agencies and organizations protect young workers.

In response to targeted follow-up by the Massachusetts Teens at Work surveillance project, a national retail bakery chain undertook specific safety efforts that likely had an impact beyond the Massachusetts borders. The Massachusetts Teens at Work surveillance project pinpointed hot coffee/slurry from coffee brew baskets as a common source of injury for teens in Massachusetts, and presented these findings to owners, managers, and corporate staff of this national retail bakery chain. In 2001, corporate headquarters, which specified the equipment to be used in franchise stores, required owners purchasing new equipment to install brew baskets with shields to prevent spillage. A retrofit kit was also designed and available to owners not purchasing new equipment. Most recently, this national chain has reported new efforts to implement requirements that supervisors be on-site when teens are working.

NIOSH Alerts on young worker safety have been repeatedly reprinted based on requests for more copies (See the Supporting Evidence section for numbers of copies distributed), and statistics on young worker deaths and injuries included in NIOSH publications are routinely cited in the press. Findings from NIOSH funded extramural research have also been cited in the press. Recent examples include press coverage of results from the Wisconsin young worker injury surveillance project and young worker construction safety research conducted by Runyan, et al.[9-12]

The TI Program has received information on how some recipients of TI young worker safety and health products have used these materials. For example, following mailings of materials to high school principals, thousands of additional copies were requested, and some principals reported inserting copies in high school report cards and signed work permits, and incorporating the information into school-based occupational safety and health training.[13] Following a joint TI/Wage and Hour Division mailing of packets on forklift safety and young workers to more than 10,000 retail warehouses and storage facilities in December 2002, recipients requested an additional 2,000 information packets and 7,000 stickers. (This sticker was a modification of the sticker developed by the Massachusetts FACE Program discussed in the Outputs and Transfer section above.) Requests for these stickers continue. In September 2005, the Wage and Hour Division received a request for 300 stickers from the Crown Equipment Corporation, a forklift manufacturer. This firm noted that customers wanted the stickers affixed to forklifts that they sold.[14]

Statistics, findings, and prevention recommendations from TI products are routinely cited in safety efforts and programs of others. An exhaustive search has not been conducted, but some illustrative examples follow. In 2001, the American Public Health Association (APHA) issued policy statement 2001-9, Protection of Child and Adolescent Workers, that referenced NIOSH research and included a specific recommendation for the incorporation of comprehensive health and safety training modules in school curricula.[17] In a recent announcement by the Michigan Occupational Safety and Health Administration (MIOSHA) of a multi-year campaign focusing on youth worker safety and health, the MIOSHA acting director cited statistics reported in TI publications and made the following statement: “So when we saw these statistics we thought we should step up efforts to get information out to young people as they start their working careers.”[18] MIOSHA program materials make specific references to NIOSH statistics and the Michigan FACE Program, and include references to case studies developed through the TI-supported community-based demonstration projects.[19]

TI-authored peer-reviewed journal articles that identify the incidence and circumstances of young worker injuries have been cited more than 200 times in the scientific literature. (Citation frequency is provided in Appendix I: Supporting Evidence for selected publications.)

What’s Ahead:
The TI Program is currently customizing the pilot-tested curricula to reflect differences in State child labor laws. The TI Program will work with partners (e.g., career clusters programs, American Society for Safety Engineering, and vocational technical education groups) to broadly distribute the curricula. The curricula will also be included on a World Health Organization Website for use by other countries. The TI Program will continue to analyze existing data on young worker injuries and deaths, and report on data trends.

External Factors:
Although there are numerous intermediate outcomes from TI Program efforts to improve young worker safety, surveillance data are not demonstrating convincing reductions in rates of injury and death, with the exception of nonfatal work injuries in the agricultural industry. Although the rates of emergency department-treated injuries decreased between 1998 and 2003, especially for males, these declines were not statistically significant.[20] Fatality rates from 2000 to 2004 appeared generally to be lower than rates in the 1990s, yet recently released data from the BLS show a fatality rate increase. The rate for young worker injury deaths in 2005 was 3.2 per 100,000 full-time equivalents.[21] This rate is only modestly lower than the cumulative rate for 1992 to 2000 of 3.5 deaths per 100,000 full-time equivalents.

Among the external factors impeding progress in reducing young worker injuries are the following:

- Lack of resources for focused and widespread intervention efforts beyond the agriculture sector
- Outdated child labor laws
- Exclusions of family farm youth from child labor laws
- Limited enforcement of child labor laws at the Federal and State level, and
- An absence of specific OSHA standards that address hazards resulting in large numbers of nonfatal youth work injuries (e.g., lacerations, sprains and strains, and burns).

Although results from the TI pilot tests of core curricula are promising, there will be hurdles in trying to get new curricula adopted into schools that already have full slates and increasing pressures to demonstrate improvements in test scores, which do not include testing on occupational safety and health.

References:

1. NRC (National Research Council/Institute of Medicine) [1998]. Protecting youth at work: health, safety, and development of working children and adolescents in the United States. Washington, DC: National Academy Press.

2. NIOSH [1998]. NIOSH Update: Safety, health precautions for young workers highlighted in NIOSH poster to schools. NIOSH Un-numbered publication, June 2, 1998.

3. OSHA [2004a]. Federal agencies launch effort to help teen workers stay safe and healthy on the job this winter. Washington, DC: OSHA News Release 04-2467-NAT, December 6, 2004.

4. OSHA [2004b]. Federal agencies launch effort to help teen workers stay safe and healthy on the job this summer. Washington, DC: OSHA Trade Release, May 18, 2004.

5. OSHA [2004c]. Forklift operations by young workers subject of safety initiative: OSHA, Wage and Hour Division, NIOSH join forces to foster youth safety on the job. Washington, DC: OSHA Trade Release, February 11, 2004.

6. Wegman and Davis [1999]. Protecting youth at work. American Journal of Industrial Medicine 36(5): 579-83.

7. Wegman [1999]. Work should help teens, not hurt them. Pediatrics 103:821-2.

8. Massachusetts Young Worker Initiative Task Force [2003]. Protecting young workers in Massachusetts. Available at: http://www.masscosh.org/documents/ProtectingYoungWorkersinMA1-03.doc

9. BNA, Inc. [2006a]. Youth workers: Greater safety awareness training urged for teens to curb workplace injuries. Occupational Safety & Health Reporter, 36 (35): 796-797, September 7, 2006.

10. The News & Observer [2006]. Editorial: Shielding teen workers. Raleigh, NC: The News & Observer, July 14, 2006. Available at: http://www.newsobserver.com/579/story/460252.html

11. Vollmer S [2006]. Study: Teens in construction jobs at risk. Raleigh, NC: The News & Observer, July 3, 2006. Available at: http://www.newsobserver.com/104/story/457205.html

12. Weier A [2006]. Working 2 jobs': 15 percent of State's teens are injured. Madison, WI: The Capital Times, September 4, 2006.

13. NIOSH [1997b]. NIOSH Update: NIOSH highlights young worker injury prevention as summer employment season nears. NIOSH Un-numbered publication, June 1997.

14. Wage and Hour Division [2005]. Personal communication from Arthur Kerschner Jr, to Dawn Castillo and Elise Handleman, September 21, 2005.

15. California Department of Industrial Relations [2006]. DIR Young Workers Website, http://www.dir.ca.gov/youngworker/youngworkernetwork.html. Accessed October 18, 2006.

16. Connecticut Department of Public Health [2006]. Connecticut Occupational Health e-News: Special Issue for Young Workers, Volume 3(3): 6.

17. APHA (American Public Health Association) [2002]. 2001-9 Protection of child and adolescent workers. American Journal of Public Health 92(3): 461-462.

18. BNA, Inc. [2006b]. MIOSHA announces multi-year campaign focusing on youth worker safety, health. Occupational Safety & Health Reporter 36(40): 902-903, October 12, 2006.

19. Michigan Department of Labor & Economic Growth [2006]. Young worker initiative. Available at: http://www.michigan.gov/cis/0,1607,7-154-11407-149772--,00.html

20. Marsh SM, Derk SJ, Jackson LL [2006]. Nonfatal occupational injuries and illnesses among workers treated in hospital emergency departments--United States, 2003. MMWR 55(16):449-52.

21. BLS [2006c}. Unpublished data from the national census of fatal occupational injuries. Provided by personal communication from Janice Windau to Dawn Castillo on August 21, 2006.