NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) RECOMMENDATIONS TO THE U.S. DEPARTMENT OF LABOR FOR CHANGES TO HAZARDOUS ORDERS

May 3, 2002

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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Commonly Used Acronyms and Abbreviations

ANSI	American National Standards Institute
ARDS	Adult Respiratory Distress Syndrome
ATF	Bureau of Alcohol, Tobacco, and Firearms
ATV	All Terrain Vehicle
BLS	Bureau of Labor Statistics
BOC	Bureau of Census
CAIS	Childhood Agricultural Injury Survey
CDC	Centers for Disease Control and Prevention
CFOI	Census of Fatal Occupational Injuries
CFR	Code of Federal Regulations
COPD	Chronic Obstructive Pulmonary Disease
CPS	Current Population Survey
CWP	Coal Workers' Pneumoconiosis
DHHS	Department of Health and Human Services
DOL	Department of Labor
EPA	Environmental Protection Agency
ESA	Employment Standards Administration (Department of Labor)
FACE	Fatality Assessment and Control Evaluation
FLSA	Fair Labor Standards Act of 1938
FTE	Full-time Equivalent Employees
GAO	General Accounting Office
GDL	Graduated Driving Licensure
HO	Hazardous Order
IARC	International Agency for Research on Cancer
MMWR	Morbidity and Mortality Weekly Report
NEISS	National Electronic Injury Surveillance System

NHANES	National Health and Nutrition Examination Survey
NIOSH	National Institute for Occupational Safety and Health
NPRM	Notice of Proposed Rule-Making
NRC	National Research Council
NRC/IOM	National Research Council/Institute of Medicine
NTOF	National Traumatic Occupational Fatality Surveillance System
OIICS	Occupational Injury and Illness Classification Structures
OLPPP	Occupational Lead Poisoning Prevention Program (California)
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PL	Public Law
PMR	Proportionate Mortality Ratio
PTO	Power Take-off
ROPS	Roll-over Protective Structure
SIC	Standard Industrial Classification
SOII	Annual Survey of Occupational Injuries and Illnesses
TISF	Traumatic Injury Surveillance of Farmers
U.S.C.	U.S. Code
WHD	Wage and Hour Division (Department of Labor)

Data Sources, Coding Systems, and Outcome Measures Used Throughout Report

Data Sources

Current Population Survey (CPS): Data on employment and unemployment are collected monthly through a survey of about 50,000 households, scientifically selected to be representative of the civilian, noninstitutionalized population of the United States. Employment data are collected for all household members aged 15 or older. The data are collected by the Bureau of the Census for the Bureau of Labor Statistics (BLS). For this report NIOSH analyzed data files purchased from BLS.

National Traumatic Occupational Fatalities (NTOF) Surveillance System: Data on occupational injury deaths throughout the United States based on death certificates collected from all 50 states and the District of Columbia. Death certificates are included in the system if the decedent was at least 16 years of age, death was caused by an injury, and the death certificate noted that the injury occurred at work. Death certificates alone are estimated to identify approximately 80% of all work-related injury deaths. The NTOF system contains information on deaths dating back to 1980, and is the most comprehensive and accurate data system for work-related injury deaths prior to 1992. The NTOF system was developed and is maintained by NIOSH.

Census of Fatal Occupational Injuries (CFOI): Data on occupational injury deaths throughout the United States based on multiple sources of information, including death certificates, medical examiner reports, workers' compensation claims, and newspaper reports. Worker deaths are verified by at least two sources. The CFOI system contains information on deaths dating back to 1992. Data are collected by the states, New York City and the District of Columbia, and provided to BLS in a cooperative federal/state program. The CFOI system was developed and is maintained by BLS. Through Letters of Agreement, BLS has provided NIOSH with CFOI research files. For the years 1992 through 1997, NIOSH received two different types of files. The first was a standard research file provided to researchers who agree to comply with BLS confidentiality requirements and reporting procedures. This standard research file helps ensure the confidentiality of CFOI data by grouping certain variables, such as age and state. To better meet the analytic needs of NIOSH, BLS provided NIOSH with a more detailed research file that included data by individual year of age. Data from New York City are not included in this more detailed research file because the New York City Department of Health did not agree to NIOSH having New York City data in this more detailed format. Analyses of both research files are included in this report. The standard research file was used for analyses of workers of all ages, and the more detailed file (minus data from New York City) was to used to identify and describe young worker injury deaths.

Survey of Occupational Injuries and Illnesses (SOII): Data on occupational injuries based on an annual survey of a stratified random sample of employers in private industry. Excluded from the sample are self-employed individuals, farms with fewer than 11 employees, private household employees, and government workers. Information is collected on all injuries and illnesses that meet OSHA reporting requirements. Rates of injury are calculated based on hours of work. More information, including demographic information on the victim and nature of the

injury, is collected for those injuries serious enough to require time away from work. The SOII was developed and is maintained by BLS. Current survey methods have been employed since 1992. Estimates in this report are derived from BLS publications.

National Electronic Injury Surveillance System (NEISS): Data on occupational injuries and illnesses collected from a nationally representative sample of 67 hospital emergency departments. The NEISS was developed and maintained by the Consumer Product Safety Commission (CPSC) to identify consumer product-related injuries. Through an interagency agreement between NIOSH and CPSC, the NEISS system was expanded to capture data on work-related injuries and illnesses regardless of product involvement. NEISS data on work-related injuries were collected from 1982 to 1986, then for different age groups beginning in 1992. In 1995, collection of work-related injuries and illnesses was expanded to all ages of workers in a sample of NEISS hospitals. It is estimated that about one-third of occupational injuries and illnesses are treated in hospital emergency departments. NIOSH maintains work-related data collected through the NEISS system.

Traumatic Injury Surveillance of Farmers (TISF): Data on occupational injuries to farmers and farm workers collected from a nationally representative sample of 50,000 farm operators in each of three years: 1993, 1994, and 1995. Information was collected through a mail survey. The sample was drawn from a list of farm operators maintained by the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture. The survey was conducted by NASS for NIOSH through an interagency agreement.

Childhood Agricultural Injury Survey (CAIS): Data on childhood injuries on farms collected from a nationally representative sample of 50,000 farm operators in 1998. Information was collected through a telephone survey. Information was collected to differentiate work-related injuries from non-work injuries, and to differentiate between youth who lived on the farm, worked on the farm, and visited the farm. The survey was conducted by NASS for NIOSH through an interagency agreement.

Fatality Assessment and Control Evaluation (FACE): FACE is a NIOSH research program focused on field evaluations of worker fatalities, including those of youth under 18 years of age. Through assessment of the incident site, employer and witness interviews, and administrative records, NIOSH investigators develop case reports that provide detailed incident descriptions and recommendations to employers and others for prevention of similar incidents. In this report, FACE cases are used to illustrate the circumstances and risk factors associated with young worker fatalities.

Coding Systems

Occupational Injury and Illness Coding Structures (OIICS): BLS data systems that collect data on fatal and nonfatal injuries characterize incidents by primary and secondary source of injury, event, nature of injury, and body part using the Occupational Injury and Illness Coding Structures (OIICS) [National Safety Council 1995]. The source of injury is the object, substance, element, or bodily motion that directly produced or inflicted the injury. The

secondary source is the object, substance, or person that generated the source, or that contributed to the event. For example, in an incident in which a worker was struck by a crate that fell from a forklift, the primary source of injury is the crate and the secondary source is the forklift. For transportation-related events, the primary source is the vehicle occupied by the injured worker, and the secondary source is the vehicle that collided with the worker's vehicle. In the case of a pedestrian injury or fatality, the primary source is the vehicle that struck the pedestrian.

Standard Industrial Classification (SIC): Occupational injury and fatality data systems such as the CFOI and SOII categorize the industry in which a worker is employed using the 1987 Standard Industrial Classification (SIC) [OMB[1] 1987].

Bureau of the Census (BOC) Occupation and Industry Coding Systems: All sources of injury and fatality data cited in this report classify occupation using BOC occupation codes used for the 1990 census [Bureau of the Census 1992]. The CPS employment data used in calculation of fatality rates also code occupation using the BOC system. However, CPS uses BOC industry codes, while most sources of occupational injury and fatality data code industry using the SIC. In most cases, the SIC is more detailed. Generally, SIC codes can be collapsed to the less specific BOC industry codes found in the CPS for calculation of rates.

Outcome Measures

Injuries per 100 fulltime equivalents: Standard measure for reporting rates of nonfatal occupational injuries. Calculated based on hours of work, assuming 2000 hours per fulltime worker per year.

Median days away from work: A measure that provides an assessment of typical injury severity. Fifty percent of injuries require less days away from work than the median, and 50% require more days away from work than the median.

Deaths per 100,000 workers: Standard measure for reporting rates of fatal occupational injuries. Calculated based on average number of workers in a year.

Deaths per 100,000 fulltime equivalents (FTE): A measure for reporting rates of fatal occupational injuries that accounts for hours of work. Assumes 2,000 hours per fulltime worker per year. For most workers and occupations, rates per 100,000 workers are comparable to rates per 100,000 fulltime equivalents. There are differences between these two measures, however, for workers who do not work a standard 40-hour work week, such as youth workers. Accounting for hours of work provides a more accurate assessment of risk for groups that tend to work part-time, and is important when comparing groups that on average work different numbers of hours for the same period of time [Ruser 1998].

Deaths per 1,000 fulltime workers per 45-year work lifetime: A measure for reporting rates of fatal occupational injury that averages fatality risk over a 45-year working life. This measure

[1]*Office of Management and Budget.* See OMB in references.

is labeled "lifetime risk" and facilitates comparisons with standard measures of occupational illness deaths. OSHA considers a lifetime risk of 1 death in 1,000 workers per 45-year work lifetime to be high enough to justify standard development.

EXECUTIVE SUMMARY

An average of 67 workers under 18 years of age die annually from occupational injuries, and an estimated 77,000 are treated in hospital emergency departments for nonfatal injuries. The Fair Labor Standards Act (FLSA), largely unchanged in decades, defines work activities prohibited for young workers through 28 Hazardous Orders (HOs) for nonagricultural and agricultural occupations. The U.S. Department of Labor, NIOSH and others have identified the need to assess the adequacy of existing HOs to protect working youth. Most recently, the following recommendation was made in the National Research Council/Institute of Medicine Report *Protecting Youth at Work*:

> "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/IOM 1998]

The U.S. Department of Labor (DOL) provided funds for NIOSH to develop such a report based on a review of data and the scientific literature. Primary data sources used by NIOSH were the Census of Fatal Occupational Injuries, the Survey of Occupational Injuries and Illnesses, the National Electronic Injury Surveillance System, and the Current Population Survey. Hundreds of scientific articles and reports were reviewed. The report makes recommendations specific to HOs that define prohibited occupations. The report does not address Child Labor Regulation No. 3 which sets hours restrictions and defines permissible work activities for 14- and 15-year-olds, nor statutory issues such as the minimum age for work in HOs and exemptions from the FLSA.

Recommendations in this report are consistent with the DOL commitment to facilitate meaningful employment and training opportunities while protecting youth from the most hazardous work activities. Recommendations are driven by information on high-risk activities for all workers, not just patterns of fatalities and serious injuries among young workers. The general rationale for recommending an HO is that the associated fatality rate be at least 10 per 100,000 workers, or twice the fatality rate for all U.S. workers. The number and severity of nonfatal injuries are also considered, as well as research on health effects of workplace exposures. In addition to making recommendations for revisions and additions to HOs, NIOSH makes recommendations regarding apprentice/student learner exemptions in nonagricultural occupations. Exemptions are recommended in those cases where supervision and training could reasonably be expected to protect young workers from hazards on the job.

NIOSH found justification for all of the existing HOs. Review of available data and scientific evidence found that work currently prohibited by HOs continues to pose risks for death, serious injury and disabling health conditions. NIOSH proposes several types of revisions to HOs: better definition of prohibited activities, incorporation of associated legislative provisions, and in some cases, removal of current exemptions. Additionally, NIOSH makes recommendations to expand several HOs to include similar work with comparable or greater risk. In a couple of cases, NIOSH concluded that revisions of existing HOs may be warranted, to allow use of

currently prohibited equipment which appears to be associated with relatively minor injuries. Tables 1 and 2 summarize recommendations for existing HOs in nonagricultural and agricultural occupations, respectively.

Table 1. Summary of NIOSH Recommendations Pertaining to Existing Nonagricultural Occupation HOs

Existing Nonagricultural HO	**Retain**	**Revise**	**Training exemption**	**Specific recommendations**
HO 1: Manufacturing or Storage Occupations Involving Explosives		X	n/a	Revise the definition to include the current ATF list of explosive materials.
HO 2: Motor Vehicle Occupations		X	n/a	1) Incorporate provisions of the Drive for Teen Employment Act; 2) Provide guidance on "urgent, time-sensitive deliveries" and "incidental and occasional driving"; 3) Delete exemption for school bus driving.
HO 3: Coal Mine Occupations	X		n/a	
HO 4: Logging and Sawmilling Occupations		X	n/a	1) Expand to cover similar work in operation of timber tracts, tree farms and forestry services; 2) Remove the current exemptions for construction work for living or administrative quarters.
HO 5: Power-Driven Woodworking Machines		X	Retain	Expand to include similar power-driven machines used to operate on materials other than wood.
HO 6: Occupations Involving Exposure to Radioactive Substances and to Ionizing Radiation		X	n/a	Revise to reflect current risks to youth for occupational radiation exposures.
HO 7: Power-driven Hoisting Apparatus Operations		X	n/a	1) Expand to cover repairing, servicing, disassembling and assisting in tasks being performed by the machine; 2) Expand to prohibit youth from riding on any part of a forklift as a passenger, and from working from forks, platforms, buckets, or cages attached to a moving or stationary forklift; 3) Expand to prohibit work from truck-mounted bucket or basket hoists, commonly termed "bucket trucks" or "cherry pickers"; 4) Expand to include commonly used manlifts that do not meet the current definition, specifically aerial platforms.
HO 8: Power-driven Metal Forming, Punching, and Shearing Machine Operations		X	Retain	Expand to include several types of metalworking machinery currently excluded from this HO, including milling, turning, grinding, and boring machines.

Existing Nonagricultural HO	Retain	Revise	Training exemption	Specific recommendations
HO 9: Occupations in Connection with Mining, Other than Coal		X	n/a	1) Expand to include all work performed in connection with petroleum and natural gas extraction; 2) Remove exemptions permitting repair and maintenance of roads, and work on track crews.
HO 10: Occupations in the Operation of Power-driven Meat-Processing Machines and Occupations Involving Slaughtering, Meat Packing or Processing, or Rendering		X	Add partial exemption	1) Expand to prohibit work in all meats products manufacturing industries, including poultry slaughtering and processing; 2) Consider a revision* to allow use of meat and food slicers in retail, wholesale and service industries; 3) Allow apprentice/student learner exemptions in retail, wholesale or service industries.
HO 11: Power-driven Bakery Machine Occupations		X	n/a	Consider a revision to allow the use of "counter-top models" of power-driven bakery machines.
HO 12: Power-driven Paper- Products Machine Occupations		X	Retain	1) Incorporate provisions of the Compactor and Baler Act; 2) Expand to include similar power-driven machines used to operate on materials other than paper products.
HO 13: Occupations Involved in the Manufacture of Brick, Tile, and Kindred Products	X		n/a	
HO 14: Occupations in the Operation of Power-Driven Circular Saws, Band Saws, and Guillotine Shears		X	Retain partial exemption	Revise definition to include other machines, such as chainsaws, which perform cutting and sawing functions through direct contact between the cutting surface and the material (the current definition is based on the presence of a continuous series of notches or jagged teeth).
HO 15: Occupations Involved in Wrecking, Demolition, and Shipbreaking Operations	X		n/a	
HO 16: Occupations in Roofing Operations		X	Remove	1) Expand to include all work performed on roofs; 2) Remove the exemption for apprentices/student learners.
HO 17: Occupations in Excavation Operations	X		Remove	Remove the exemption for apprentices/student learners.

* Any revisions of HOs that would allow work that was previously prohibited should be accompanied by a mandatory reporting period in which all serious youth injuries and deaths resulting from previously prohibited activities are promptly reported to the U.S. Department of Labor. This would allow an assessment as to whether the revision should be rescinded or further refined to best protect working youth, while not unnecessarily limiting job opportunities.

Table 2. Summary of NIOSH Recommendations Pertaining to Existing Agricultural Occupation HOs

Existing Agricultural HO	Retain	Revise	Specific Recommendations
HO 1: Operating a Tractor Over 20 PTO Horsepower or Connecting or Disconnecting an Implement or Any of Its Parts To or From Such a Tractor		X	1) Revise to remove the 20 PTO (power take-off) horsepower threshold; 2) Revise exemption for 14- and 15-year olds with tractor certification to require tractors to be equipped with a rollover protective structure (ROPS) and mandate the use of seatbelts.
HO 2: Operating or Assisting to Operate (including starting, stopping, adjusting, feeding or any other activity involving physical contact associated with the operation) any of the following machines: corn picker, cotton picker, grain combine, hay mower, forage harvester, hay baler, potato digger, or mobile pea viner; feed grinder, crop dryer, forage blower, auger conveyor, or the unloading mechanism of a nongravity-type self-unloading wagon or trailer, or power post-hole digger, power post driver, or nonwalking-type rotary tiller		X	Combine HO 2 and HO 3, and expand prohibition from lists of specific machines to machines that perform general functions (e.g. harvesting and threshing machinery; mowing machinery; plowing, planting and fertilizing machinery; other agricultural and garden machinery; excavating machinery; loaders; wood processing machinery, such as wood chippers and debarkers; sawing machinery, including chain saws; powered conveyors; and, mobile equipment, including forklifts).
HO 3: Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any other activity involving physical contact associated with the operation) any of the following machines: trencher or earthmoving equipment; fork lift; potato combine; power-driven circular, band, or chain saw		X	See comments above pertaining to agricultural HO 2.
HO 4: Working on a Farm in a Yard, Pen, or Stall Occupied By a: (i) Bull, boar, or stud horse maintained for breeding purposes; or (ii) Sow with suckling pigs, or cow with newborn calf (with umbilical cord present)	X		
HO 5: Felling, Bucking, Skidding, Loading or Unloading Timber with Butt Diameter of More than 6 Inches.		X	Remove 6 inch diameter threshold.

Existing Agricultural HO	Retain	Revise	Specific Recommendations
HO 6: Working from a Ladder or Scaffold (Painting, Repairing, or Building Structures, Pruning Trees, Picking Fruit, etc) at a Height of Over 20 Feet		X	1) Expand to include work on roofs, on farm structures including silos, grain bins, windmills, and towers; and, on vehicles, machines, and implements; 2) Reduce the maximum height at which youth may work in these settings from 20 feet to 6 feet.
HO 7: Driving a Bus, Truck, or Automobile When Transporting Passengers, or Riding on a Tractor as a Passenger or Helper		X	1) Expand to prohibit driving of all motor vehicles and off-road vehicles (including all-terrain vehicles), with or without passengers, on or off the highway; 2) Expand to prohibit work as an outside helper on a motor vehicle; 3) Retain the provision prohibiting riding on a tractor as a passenger or helper, but move it under Agricultural HO 1.
HO 8: Working Inside: A fruit, forage, or grain storage designed to retain an oxygen deficient or toxic atmosphere; an upright silo within 2 weeks after silage has been added or when a top unloading device is in operating position; a manure pit; a horizontal silo while operating a tractor for packing purposes		X	Expand to prohibit *all* work inside (i) a fruit, forage, or grain storage, such as a silo or bin; (ii) a manure pit.
HO 9: Handling or Applying (including cleaning or decontaminating equipment, disposal or return of empty containers, or serving as a flagman for aircraft applying) Agricultural Chemicals Classified Under the Federal Insecticide, Fungicide, and Rodenticide Act (as amended by Federal Environmental Pesticide Control Act of 1972, 7 U.S.C. 136 et seq.) as Toxicity Category I, Identified by the Word "Danger" and/or "Poison" with Skull and Crossbones; or Toxicity Category II, Identified by the Word "Warning" on the Label		X	Revise to be consistent with EPA Worker Protection Standard for pesticides, encompassing prohibitions against pesticides with chronic health effects as well as pesticides with recognized acute toxicity.
HO10: Handling or Using a Blasting, Including but Not Limited to Dynamite, Black Powder, Sensitized Ammonium Nitrate, Blasting Caps, and Primer Cord	X		

Existing Agricultural HO	**Retain**	**Revise**	**Specific Recommendations**
HO 11: Transporting, Transferring, or Applying Anhydrous Ammonia	X		

NIOSH recommends the development of several new HOs to protect youth from especially hazardous work not adequately addressed in the existing regulations. The recommended HOs encompass work associated with deaths and severe injuries of youth, work with especially high fatality rates, and work associated with disabling health conditions. In several instances, NIOSH recommends extending prohibitions now in place for agricultural occupations to similar tasks in nonagricultural occupations, e.g. pesticide handling, work in confined spaces, and tractor operation. New HOs are recommended for the following types of work:

- Commercial Fishing Occupations
- Construction Occupations
- Work in Refuse Occupations
- Water Transportation Industries
- Work in Scrap and Waste Materials Industry
- Farm Product Raw Materials Wholesale Trade Industry
- Railroad Industry
- Work at Heights
- Tractors (in nonagricultural occupations)
- Heavy Machinery
- Welding
- Confined Spaces (in nonagricultural occupations)
- Work Involving Powered Conveyors (in manufacturing industries)
- Pesticide Handling (in nonagricultural occupations)
- Exposure to Lead
- Exposure to Silica
- Work Requiring the Use of Respiratory Protection

Recommendations in this report are limited to changes to HOs which fall within the regulatory authority of DOL. It is expected that changes recommended in this report would help to reduce the incidence of fatal and serious youth work-related injuries and illnesses each year. However, it must be recognized that considerable numbers of youth work-related deaths and serious injuries would not be impacted by these recommended changes. Many deaths and serious injuries occur among youth not covered by the FLSA, or in situations that would be difficult to regulate under the current framework of the FLSA. Additionally, revisions or additions of new HOs alone will not save lives. Efforts are needed to raise awareness and compliance with HOs to ensure youth are not inappropriately employed in recognized hazardous work settings.

In reviewing available data and scientific information, NIOSH identified several areas that merit additional research prior to future rule-making. Research into risk factors for work-related homicide– a leading cause of young worker injury death– is one such research area. Further research is needed to characterize youth worker exposures to health hazards, such as chemical substances, biologic agents, and repetitive motion, and to determine if such exposures result in negative health outcomes in later years. Research is needed on the effectiveness of youth training programs to help ensure exemptions for apprentice and student-learner programs are effective in facilitating a safe training environment. Finally, research on employer best

practices, and knowledge and attitudes about HOs among employers, parents, youth, and other stakeholders could be used to increase the effectiveness of outreach and educational campaigns.

NIOSH recognizes the need to better protect the health and safety of working youth, and provides this report to assist DOL in aligning child labor regulations with current knowledge about occupational safety and health. NIOSH offers its continued support to work closely with DOL to ensure that child labor regulations provide adequate protections for working youth and to initiate research into those areas of risk where insufficient data currently exist to guide rule-making.

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I. INTRODUCTION

The Fair Labor Standards Act of 1938, as amended [29 USC[2] 201 et seq.] authorizes the U.S. Department of Labor (DOL) to establish rules which prohibit "oppressive child labor" in commerce. Regulations implementing the Act permit the Secretary of Labor to prohibit the employment of youth in occupations declared "particularly hazardous for the employment of children... or detrimental to their health or well-being" [29 USC 201 Sec. 3(l)]. These prohibited activities are referred to as Hazardous Orders (HOs). The minimum age, by statute, for HOs in nonagricultural occupations is 18; the minimum age in agricultural occupations is 16.

The HOs in nonagricultural occupations were established between 1939 and 1963. The agricultural HOs were established in 1970. There have been significant changes in the workplace and advancement in knowledge about occupational safety and health hazards that are not reflected in the existing HOs. The need to update the HOs has been recognized by the Department of Labor [59 Fed. Reg.[3] 25164 (1994); 64 Fed. Reg. 67130 (1999)], NIOSH [NIOSH 1994a, 1997a], and numerous researchers and advocates. Most recently, the following recommendation was made in the National Research Council/Institute of Medicine (NRC/IOM) report *Protecting Youth at Work*:

> "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/IOM 1998]

The DOL responded to the above charge by requesting that NIOSH prepare this review and provided funding in support of this effort. This report updates and expands upon previous NIOSH comments provided to the Department of Labor in response to proposed rule-making [NIOSH 1994a, 2000a]. The report makes recommendations specific to HOs that define prohibited occupations for youth under age 18 in nonagricultural occupations and youth under 16 in agricultural occupations. The report does not address Child Labor Regulation No. 3 which sets hour restrictions and defines permissible work activities for 14- and 15-year-olds. The report also does not address statutory issues, such as minimum age for work in HOs and exemptions from the FLSA. Because the report was written specifically for DOL, existing Hazardous Orders are referenced, but not described in detail.

In addition to making recommendations specific to HOs, NIOSH identifies areas requiring further research to guide future DOL prevention efforts– regulatory and nonregulatory. Finally, NIOSH notes issues beyond the scope of DOL regulatory authority that will impede progress on reducing deaths, severe injuries and illnesses of young workers.

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[2] *United States Code.*

[3] *Federal Register.* See Fed. Reg. in references.

The following sections are included in the report:

- **Youth Employment, Injuries and Illnesses** - Summary of data on youth employment, injuries and illnesses.
- **Development of Recommendations** - Precepts used by NIOSH in recommending changes and additions to HOs, with discussion of limitations of available data.
- **Recommendations Pertaining to Current Hazardous Orders** - Includes a summary of data and research findings used in recommending retention and/or suggested amendments to HOs
- **Recommendations for New Hazardous Orders** - Includes a summary of data and research findings used in recommending each new HO
- **Areas Requiring Further Research** - Identifies research that should be undertaken to guide future DOL prevention efforts– regulatory and nonregulatory.
- **Barriers to Preventing Youth Deaths, Serious Injuries and Illnesses through Regulation** - A summary of issues outside the regulatory authority of DOL which have substantial implications for the potential for child labor regulations to adequately protect working youth.
- **Summary** - NIOSH goals in providing these recommendations.
- **References** - A list of all referenced materials.

II. YOUTH EMPLOYMENT, INJURIES, AND ILLNESSES

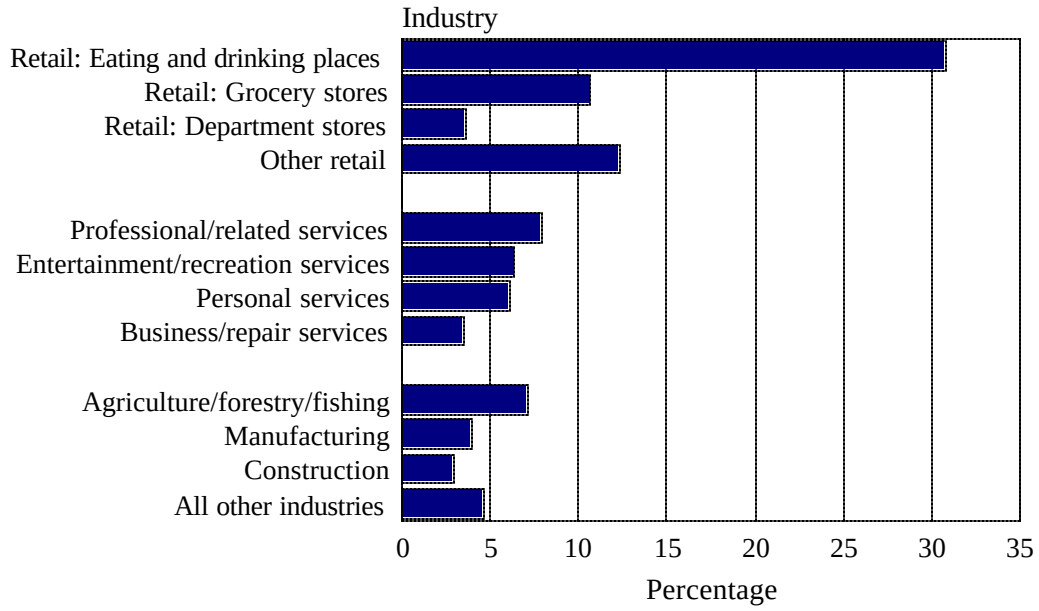
Employment

The Current Population Survey (CPS), a monthly survey of employment conducted by the Bureau of Labor Statistics (BLS), provides data on employment for youth 15 years of age and older (see page vii for more information about this and other data sources). Although BLS collects employment data for 15-year-olds, official published estimates of employment exclude 15-year-olds. Data on youth less than 15 years of age are not routinely collected. Data on the prevalence of youth employment, including those less than 15 years of age, have been reported from periodic surveys, such as the National Longitudinal Survey of Youth [Rothstein and Herz 2000]. Surveys of youth suggest that 80% have worked for pay at some time prior to leaving school [Light 1995; Steinberg and Cauffman 1995].

Young workers typically are employed in part-time, low paying jobs, and they move in and out of the work force. When employed, they spend substantial numbers of hours at work. In a recent nationwide survey, 17.9% of high school students reported working more than 20 hours per week during school [Resnick et al. 1997].

The Bureau of Labor Statistics (BLS) estimated that 2.78 million 16- and 17-year-olds were employed during 2000 [BLS 2001]. Analysis of unpublished data from the Current Population Survey suggests that over 450,000 15-year-olds were employed in 1999 [NIOSH 2001a]. Figure 1 provides data on the distribution of youth employment by industry, based on hours of work, for the 7-year period, 1992 to 1998. Sixty percent of work by 15- to 17-year-olds was in the retail sector – the majority in eating and drinking establishments and grocery stores. Eating and drinking places, or restaurants, accounted for more work by youth than any other industry (35%). Eighteen percent of youth work time was in services industries.

Figure 1. Distribution of Working Youth Ages 15-17 by Industry, Based on Hours Worked, 1992-1998

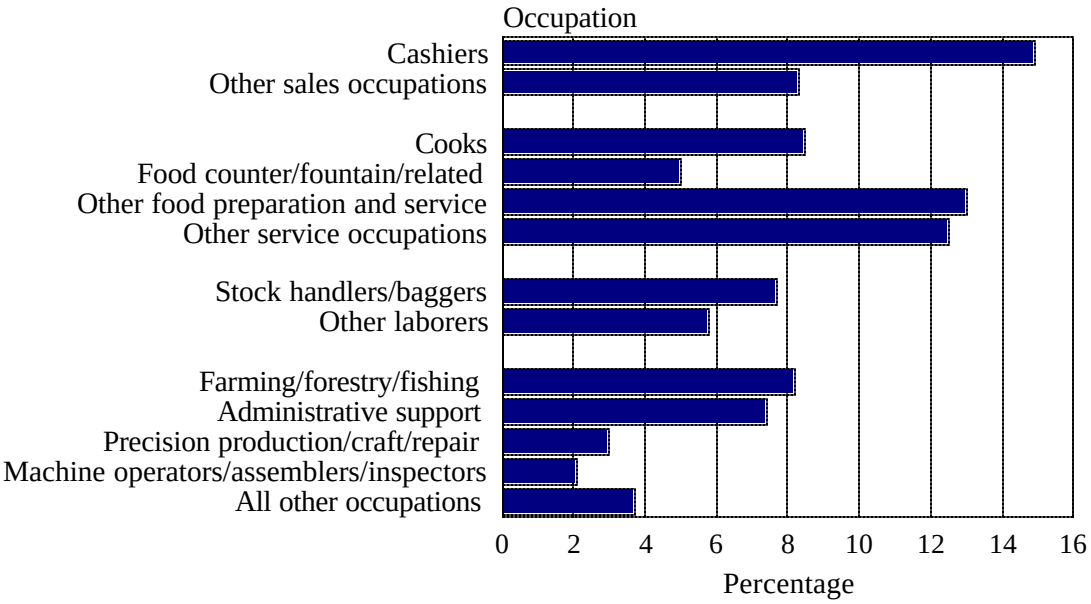


Source: Current Population Survey [NIOSH 2001a]

This includes work in schools, theaters, and nursing homes. Agriculture, forestry and fishing industries accounted for 8% of work by 15- to 17-year-olds. These patterns vary somewhat by age. A previous analysis of CPS data demonstrated that the percentage of 15-year-olds working in agriculture was more than twice that of 16- and 17-year-olds [NRC/IOM 1998].

The types of jobs that adolescents hold are varied. Figure 2 provides data on the distribution of youth employment by occupation, based on hours of work, for the seven-year period, 1992 to 1998. The most common jobs held by 15- to 17-year-olds were cashier and cook. Occupation groups that accounted for substantial amounts of work by 15- to 17-year-olds were: food preparation and service jobs; handlers, equipment cleaners, helpers, and laborers; farming, forestry and fishing occupations, and administrative support occupations. However, job titles may not reflect the actual nature of tasks performed by youth [Bowling et al. 1998; Dunn et al. 1998; Massachusetts Department of Public Health 1998a]. For example, a youth hired as a cashier may also clean and perform other tasks not associated with operating a cash register. This makes it difficult to estimate the kinds of hazardous exposures adolescents may experience on the job. In addition, inaccurate job titles can obscure the fact that adolescents are performing tasks prohibited by child labor laws [NRC/IOM 1998].

Figure 2. Distribution of Working Youth Ages 15-17 by Occupation, Based on Hours Worked, 1992-1998



Source: Current Population Survey [NIOSH 2001a]

Although nationally representative data are not available, there have been a number of surveys that provide information on tasks, exposures, training, and supervision of working youth. In a North Carolina survey, 36% of youth 14-17 years of age reported working on ladders or scaffolding, 31% reported using forklifts, tractors, or riding mowers, and 31% reported working around very loud noises [Dunn et al. 1998]. In surveys conducted at a Massachusetts high school, about half of the students who had worked used cleaning chemicals, over one-third used ladders, 19% used food slicers, and 13% used box crushers [Massachusetts Department of Public Health 1998a]. Only 50% of the Massachusetts youth reported receiving any safety and health training. Pooled survey results from high schools in 4 geographic areas (Philadelphia, Pennsylvania; Brockton, Massachusetts; Oakland and South Central Los Angeles, California) found that 15-20% of youth worked often or always without supervisors present at the worksite [Bowling et al. 1998].

Adolescents' type of employment appears to vary by family income. Youth from low income families, while less likely to be employed [Johnson and Lino 2000; GAO 1991a], are more likely to be engaged in high risk occupations. An analysis by the U.S. General Accounting Office (GAO) found that 20% of employed 15- to 17-year-olds from low income families worked in

hazardous industries, such as agriculture, construction, and manufacturing [GAO 1991a]. Analysis of adolescent employment and contributions to family expenditures has suggested that most youth do not work out of economic necessity [Johnson and Lino 2000]. Though youth from low income families appear to make more contributions to family expenditures than their peers from wealthier families, these contributions appear to be modest– approximately 9% of family income.

Unique Characteristics of Youth Workers

Several youth characteristics raise special concern about the health and safety of adolescents in the workplace. Youth are at increased risk of injury from lack of experience. Inexperienced workers are unfamiliar with the requirements of work, are less likely to be trained to recognize hazards, and are commonly unaware of their legal rights on the job [Castillo et al. 1999a; NRC/IOM 1998].

Developmental factors – physical, cognitive, and psychological – may also place them at increased risk [NIOSH 1997a; NRC/IOM 1998]. There is great variability in the size of adolescents during this period of rapid growth. Smaller youth may be at greater risk because of mismatches between their size and strength and the dimension and design of equipment or machinery designed for adults. Some organ systems, such as the musculoskeletal, reproductive, and endocrine systems, undergo periods of rapid growth and development during adolescence [NRC/IOM 1998, Bearer 1995]. Initiation of reproductive function depends on the development of a complex system of hormones and feedback mechanisms. In addition to adverse effects of occupational exposures of concern for all workers of childbearing age, this period of development in adolescence may introduce added risk of future fertility problems and gonadotoxic and mutagenic effects. Hypothetically, the period of rapid cell growth that occurs during adolescence could increase susceptibility to carcinogens, but little data exist to support or refute this [NRC/IOM 1998]. In a large case-control study of German workers, authors found evidence to support the contribution of occupational risk factors and early age at first exposure to early age of onset of lung cancer [Kruezer et al. 1999].

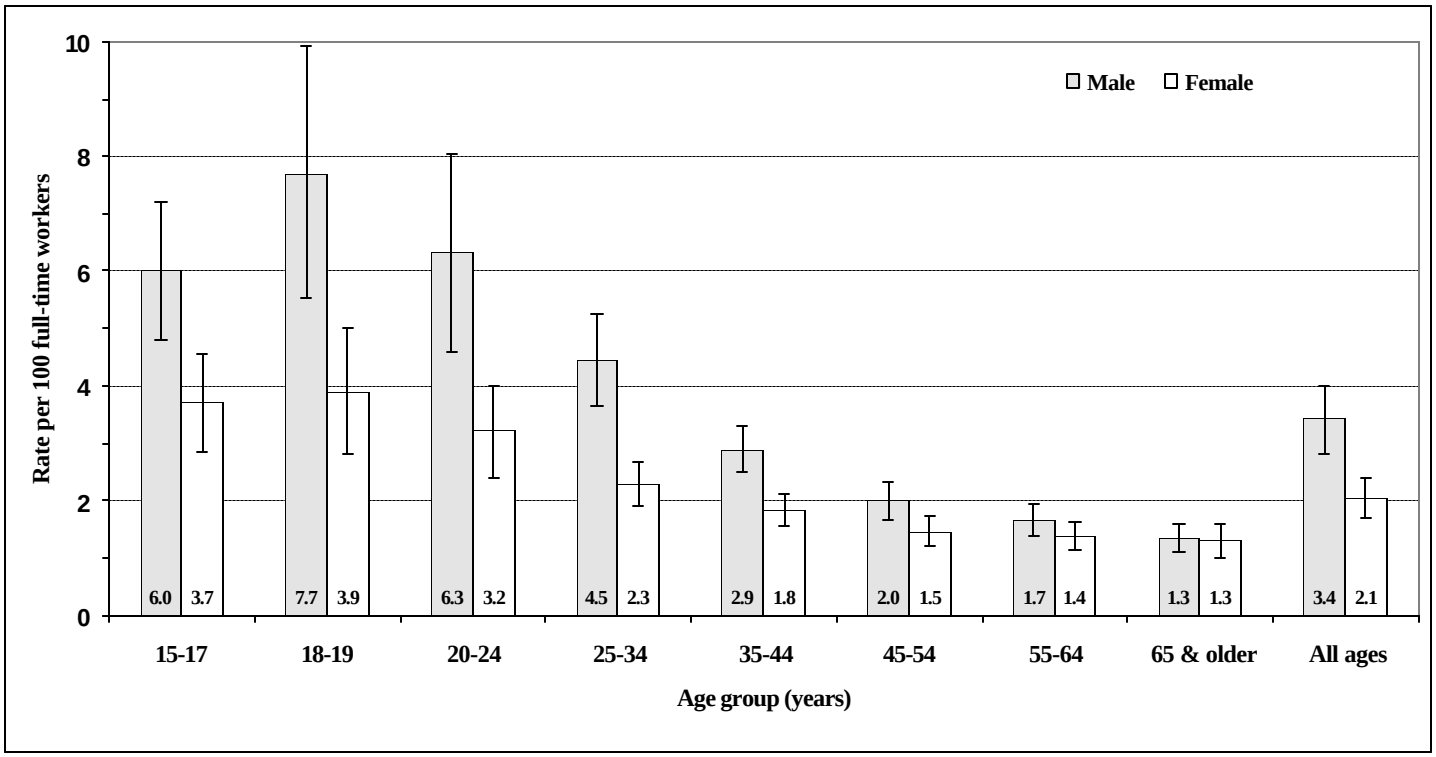
Nonfatal Occupational Injuries and Illnesses

Data on nonfatal occupational injuries and illnesses of workers are available at the national level from the National Electronic Injury Surveillance System (NEISS) and the BLS Survey of Occupational Injuries and Illnesses (SOII). NEISS is based on a sample of emergency departments in the United States, and is presumed to capture injuries among all workers, regardless of the size or type of employer. NEISS tends to capture acute injuries requiring immediate attention, such as lacerations and fractures. The SOII is based on a survey of a sample of employers. Not all types of employers are represented in the survey. For example, government agencies and the self-employed are not included. The SOII provides data specific to youth for those injuries and illnesses serious enough to require *at least one day away from work*. The SOII includes injuries treated in emergency departments as well as other settings,

such as physician offices and clinics. It is recognized that illnesses and injuries, especially those where the association with work may be unclear, are understated in occupational surveillance systems such as the SOII and NEISS [NRC 1987]. NEISS and the SOII are used to describe the incidence and risk for nonfatal occupational injuries and illnesses among youth, with an emphasis on more severe injuries. Cases identified in each of these systems overlap. State-specific data from analyses of worker's compensation claims are also cited.

An estimated 77,000 youth less than 18 years of age were treated in hospital emergency departments for work injuries and illnesses in 1998 [NIOSH 2001b]. It has been estimated that about 34% of occupational injuries are treated in hospital emergency departments; therefore, the total number of youth work injuries may exceed 200,000 each year. Employment data for the calculation of rates were derived from the CPS [NIOSH 2001a]. Youth 15-17 years of age were among the groups at greatest risk for injuries and illnesses treated in emergency departments (Figure 3) [CDC 2001a]. An analysis of workers' compensation data in Washington state found similar patterns of injury rates by age [Miller and Kaufman 1998]. Analyses of emergency department data and workers' compensation data have suggested that youth work injuries incurred in agriculture tend to be more severe than injuries in other sectors [Hard and Layne 1995; Heyer et al. 1992]

Figure 3. Estimated Rates Per 100 Full-Time Worker Equivalents of Occupational Injuries and Illnesses Treated in Hospital Emergency Departments, by Sex and Age Group of Worker – United States, 1998



Note: Error bars indicate 95% confidence interval.
Source: National Electronic Injury Surveillance System (NEISS) [CDC 2001a]

The SOII estimated 15,000 injuries and illnesses resulting in days away from work among youth in 1996 [Windau et al. 1999]. These included nonagricultural wage and salary workers only. The distribution of injuries by industry was about the same as employment; that is, about 80% occurred in retail trades and services [Windau et al. 1999; Barkume et al. 2000]. The SOII data indicated that the group including sprains, strains and tears was the most frequent type of injury resulting in lost work time among youth, accounting for 33% of all injuries (Table 1). Common causes of these injuries were overexertion in lifting heavy or bulky objects, and attempts to break falls on slippery or uneven surfaces.

Occupational injuries and illnesses of youth are costly— on a personal and societal level. In 1993, the cost of injuries and illnesses to young workers less than 18 years of age was estimated to exceed 800 million dollars. This includes direct costs (medical and emergency services, legal and administrative costs arising from workers' compensation, sick leaves, insurance programs, and the cost of workplace disruption caused by occupational injury) and indirect costs (loss of earning and fringe benefits as a result of wage work loss associated with injuries). [Miller and Waehrer 1998].

Table 1. Work Injuries Resulting in Days Away from Work Among Youth Less than 18 Years of Age, United States, 1996

Nature of Injury or Illness	**Percent**
Sprains and Strains	33
Bruises, contusions	14
Cuts, lacerations	13
Heat burns	9
Fractures	8
Fractures and other injuries	4
Other	19

Source: Survey of Occupational Injuries and Illnesses (SOII), Bureau of Labor Statistics [Windau et al. 1999]

The median number of days away from work for youth was 4, compared to a median of 5 for all workers. It is important to note, however, that because youth tend to work part-time, recovery from injuries and illnesses may frequently include unscheduled work days which would not be reflected in "days away from work." There were two types of events in 1996 that resulted in injuries with median days away from work exceeding 10— generally representing two fulltime work weeks [Windau et al. 1999]. Young workers being struck by vehicles resulted in a median of 10 days away from work. An estimated 183 youth less than 18 years of age were struck by a vehicle at work in 1996. Falls to a lower level, of which there were an estimated 630 cases in 1996, had median days away from work of 11. Analysis of pooled data for a 6-year period, 1992-1997, identified two types of injury events that resulted in at least 400 cases and had median lost workdays exceeding 10. For the 6-year period, there were 419 cases of falls from ladders that resulted in bruises and contusions requiring a median of 20 lost workdays. There

were 460 cases of youth sustaining fractures from being caught in or compressed by objects or equipment, with median lost workdays of 14 [Barkume et al. 2000].

Fatal Injuries

Data from the BLS Census of Fatal Occupational Injuries (CFOI) are used to describe injury deaths of youth less than 18 years of age, calculate fatality rates, and make limited comparisons with data for older workers. Results are primarily from two publications authored by BLS staff; the first summarized young worker deaths for the years 1992 to 1997 [Windau et al. 1999], the second data for the years 1992 to 1998 [Barkume et al. 2000]. Rates were calculated based on hours of work rather than number of workers because of data demonstrating that on average, workers less than 18 years of age work fewer hours than adults. Failure to adjust for fewer hours worked by youth overestimates their exposure to workplace hazards and underestimates their risk for injury death [Castillo and Malit 1997; Ruser 1998; Castillo et al. 1994]. Rates for youth are compared to rates for all workers [Windau et al. 1999], and in limited cases to rates for workers 25-44 years of age [Barkume et al. 2000]. Previous research has demonstrated that fatality rates increase dramatically beginning at age 45; it has been hypothesized that decreased tolerance for injuries may account for a part of the rate increase. Limiting the rate comparison to workers 25-44 years of age allows a comparison with workers who more closely resemble youth physically [Castillo and Malit 1997].

CFOI identified 468 youth less than 18 years of age killed while working during 1992-1998, an average of 67 deaths per year [Barkume et al. 2000]. About 30% of the deaths were in family businesses [Windau 1999; Barkume et al. 2000]. The rates for 16- and 17-year-olds for the years 1992-1997 were about three-fourths of the rates for all workers combined (Table 2) [Windau et al. 1999]. The rates for the youngest workers for which rates can be calculated, 15-year-olds, were the same as those for all workers. The lack of employment data precludes the ability to calculate rates for the 109 youth less than 15 years of age who died during this 6-year period. The rate for 15- to 17-year-olds, for the period 1992 to 1998, was about five-sixths of the rate for workers 25-44 years of age [Barkume et al. 2000].

Table 2. Number and Rate of Work Injury Deaths by Age, United States, 1992-1997

Age	**Number of Deaths**	**Rate per 100,000 Fulltime Equivalents**
Total, all ages	37,875	5.0
Under 15 years	109	---
15 years	46	5.1
16 years	91	3.4
17 years	157	3.7

Source: Census of Fatal Occupational Injuries, Bureau of Labor Statistics [Windau et al. 1999]. Dash indicates that a rate could not be calculated because employment data are not available for this age group

Young worker injury deaths were concentrated in agriculture, retail trade, and construction (Table 3) [Windau et al. 1999; Barkume et al. 2000]. These patterns varied somewhat from those seen for workers in general. Proportionately greater numbers of youth were killed in agriculture and retail than was seen in the general population of workers of all ages.

Table 3. Work Injury Deaths by Industry, Youth and All Workers, United States, 1992-1997

Industry Division	**Youth < 18**		**Workers of All Ages**
	(no.)	**(%)**	**(%)**
Agriculture, Forestry, and Fishing	162	40	13
Mining	---	---	3
Construction	53	13	16
Manufacturing	21	5	12
Transportation and Public Utilities	12	3	15
Wholesale Trade	14	3	4
Retail Trade	87	22	12
Finance, Insurance and Real Estate	---	---	2
Services	32	8	12
Government	13	3	11
Other or unspecified industries	7	2	1
Total	403	100	100

Source: Census of Fatal Occupational Injuries (CFOI), Bureau of Labor Statistics [Windau et al. 1999]. Dashes indicate that BLS reporting requirements were not met.

The types of events leading to death of youth workers, for the most part, mirrored those of older workers. The leading types of fatal events for youth were homicide, highway transportation incidents, non-highway transportation incidents, being struck by objects or equipment, being caught in objects or equipment, being struck by vehicles, electrocutions, and falls (Table 4) [Windau et al. 1999; Barkume et al. 2000]. Transportation incidents included incidents involving motor vehicles as well as industrial vehicles, such as tractors and forklifts, in which at least one vehicle was in operation. Highway incidents included events on public roadways, while non-highway incidents included events on industrial premises, farms and parking lots.

Table 4. Work Injury Deaths of Youth Less than 18 Years of Age by Event or Exposure, United States, 1992-1997

Event or exposure	**Number**	**Percent**
Transportation	163	40
Highway Incidents	70	17
Nonhighway incidents	47	12
Worker struck by vehicle	25	6
Water Vehicle	9	2

Event or exposure	Number	Percent
Railway	8	2
Assaults and Violent Acts	82	20
Homicide	72	18
Other	10	3
Contact with Objects and Equipment	82	20
Struck By	36	9
Caught in Objects or Equipment	25	6
Collapsing Materials	17	4
Running Machinery	17	4
Falls	23	6
Exposure to harmful substances and environments	44	11
Electric current	25	6
Exposure to caustic, noxious, allergenic substances	9	2
Oxygen deficiency	10	2
Fires and Explosions	8	2
Total	403	100

Source: Census of Fatal Occupational Injuries, Bureau of Labor Statistics [Windau et al. 1999]

Agriculture – More than half of the 162 deaths in agriculture occurred on family farms [Windau et al. 1999]. Youth killed on farms tended to be younger than youth killed in other industries. Farm workers accounted for about three-fourths of the 109 deaths of youth less than 15 years of age for the 6-year period 1992-1997. Youth 15 to 17 years of age working in agriculture appeared to have over four times the risk for fatal injury of youth workers in other industries, and about the same risk as workers 25-44 years of age working in agriculture [Barkume et al. 2000]. An analysis of CFOI data for the period 1992-1996 demonstrated that fatality rates were highest in the crop production sector (22 deaths/100,000 fulltime equivalent 15- to 17-year-olds), followed by the agricultural services sector (13.5), and the livestock production sector (9.4) [Castillo et al. 1999b]. Of the 162 deaths of youth less than 18 years of age in agriculture for the period 1992-1997, nearly a third (51) were associated with tractors [Windau et al. 1999]. These deaths occurred from tractor rollovers, youth falling from tractors and being struck by attached equipment, nonoperators being run over by tractors, and youth being caught in power take-offs. In 38 of the 51 tractor-related deaths, the fatally injured youth was operating the tractor. Young worker deaths in agriculture also resulted from animal attacks, drowning, lightning, falling trees, and grain engulfments.

Retail trade – Table 5 provides information on types of events among the 87 youth who died in the retail trades industry from 1992-1997 [Windau et al. 1999]. Homicide was the leading cause of death [Windau et al. 1999]. (Suicide and animal attacks were also included in the categories of assaults and violent acts.) Robberies accounted for at least 41 percent of the homicides, and

possibly up to 79% (motive was unknown for 38% of the cases). Highway crashes also accounted for a substantial number of deaths in retail trades.

Table 5. Work Injury Deaths of Youth Less than 18 Years of Age in Retail Trades by Event or Exposure, United States, 1992-1997

Event or exposure	Number	Percent
Assaults or Violent Acts	59	68
Homicides	56	64
Transportation	16	18
Highway crashes	13	15
Other	12	14
Total	87	100

Source: Census of Fatal Occupational Injuries, Bureau of Labor Statistics [Windau et al. 1999]

Construction – The events or exposures leading to youth deaths in the construction industry were diverse (Table 6) [Windau et al. 1999]. Falls and electrocutions were most common. Youth 15- to 17-years of age working in construction appeared to have over seven times the risk for fatal injury of youth workers in other industries, and over 2 times the risk of workers 25-44 years of age working in construction [Barkume et al. 2000].

Table 6. Work Injury Deaths of Youth Less than 18 Years of Age in the Construction Industry by Event or Exposure, United States, 1992-1997

Event or exposure	Number	Percent
Falls	12	23
Electrocution	11	21
Struck by Object	9	17
Excavation and trenching	5	9
Struck by Vehicle	4	8
Other	6	11
Total	53	100

Source: Census of Fatal Occupational Injuries, Bureau of Labor Statistics [Windau et al. 1999]

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III. DEVELOPMENT OF RECOMMENDATIONS

Our society places special value on young people and has adopted various social policies, including protection from hazardous working conditions. Implicit in these policies is the belief that youth should not be exposed to the same risks as adults. "The vulnerable, formative, and malleable nature of childhood and adolescence requires a higher standard of protection for young workers than that accorded to adult workers" [NRC/IOM 1998].

Recommendations made in this report are consistent with the DOL commitment to facilitate meaningful employment and training opportunities while protecting youth from the most hazardous work activities. In addition to making recommendations for revisions and additions to HOs, NIOSH makes recommendations for exemptions for apprentices/student learners. Information from surveillance, published literature and expertise within NIOSH form the basis for the recommendations.

Context for Recommendations

NIOSH recognizes that federal child labor laws are an additional layer of protection afforded to young workers, supplementing OSHA protections and other regulatory programs. The requirements for training and personal protective equipment under specific OSHA standards should mitigate occupational health and safety hazards for young workers. Not all young workers are covered by OSHA standards, however. For example, OSHA standards cannot be enforced on small farms. In addition, compliance with OSHA standards is not universal.

Unlike OSHA standards which prescribe the necessary protections for work (including personal protective equipment and clothing, training, medical surveillance, and exposure limits), HOs prohibit employment in certain jobs and industries deemed as too hazardous. NIOSH recognizes the importance of proposing HOs that are easily understood and enforced by Wage and Hour inspectors (who may have minimal training in control technology and safety and health practices), as well as employers, youth, parents and schools who require this information to make informed decisions about appropriate youth employment.

Recommendations were driven by information on high-risk activities for all workers, not just patterns of fatalities and serious injuries seen among young workers. It is prudent to revise or rescind HOs if current data on occupational injuries and deaths provide compelling evidence that certain work activities no longer pose a danger to young workers. At the same time, it remains critical to limit young workers' exposure to activities which are known to be especially hazardous to workers of all ages. The absence of deaths, injuries and illnesses among youth at the current time does not necessarily mean that those activities do not pose serious risks to youth now or in the future, for a number of reasons:

- By design, current HOs limit youth employment in a number of especially hazardous activities. The absence or small numbers of injuries and illnesses does not mean the HOs are no longer needed, and may in fact testify to their effectiveness.
- There are some especially hazardous activities that are conducted by a small workforce. Although there may be small numbers of deaths and injuries, risks of fatalities and debilitating injuries and illnesses can be quite high. Given relatively low employment of

youth in such activities, expected numbers of fatalities would be quite low despite high risks.

- Current low levels of youth employment in a hazardous activity would minimize youth deaths and injuries. The workforce is constantly changing. Forces that limit youth employment in such work today may not exist in the future.
- Long latency periods for some occupational illnesses mean that resultant diseases may not be detected for years and even decades after exposure as a youth worker, and the association with work exposures may not be recognized.

Hazardous Orders Recommendations

Current HOs include a mix of industry, occupation, and equipment and task prohibitions, with some overlap. That is, certain types of work are encompassed under multiple HOs. In making recommendations for new HOs or expansion of HOs, NIOSH also used a mix of defining characteristics (e.g. industry, occupation, equipment or exposure). An effort was made to propose as parsimonious a list of HOs as possible, recognizing and minimizing overlap between proposed HOs, while at the same time encompassing work and work settings that pose the greatest risks for young workers. This was done for purposes of economy and to make the HOs as simple as possible for employers, parents, and youth. In addition, several recommendations were made to consolidate existing HOs and to modify definitions to better match current classification systems. In examining possible new HOs, NIOSH considered whether the risks for that industry, occupation, or task were already encompassed under existing or proposed HOs sufficiently to address the hazardous activity or setting. For example, if the majority of fatal and severe injuries in a high risk industry sector were associated with work prohibited by existing or proposed HOs, NIOSH would not propose a new HO for that industry sector.

Existing HOs include detailed definitions or descriptions of work encompassed and excluded in each HO. For the most part, this report addresses each of the HOs broadly, not addressing each detailed provision of the HO. Where fatality and injury data and/or the scientific literature provided sufficient detail, specific provisions of HOs were addressed. As well, some changes to exemptions are suggested, where the current exemption may be in conflict with recommendations made elsewhere in the report. Because NIOSH recommendations were dictated by the limits of available data and research, some recommended prohibitions may include work that poses little risk to young workers, e.g., clerical tasks at a construction contractor's office. NIOSH encourages DOL to consider research as a tool for the identification of less risky activities that could be exempted in industry- and occupation-wide HOs.

Industries, occupations, or specific work activities that have a high risk for death or severe injury should clearly be prohibited for young workers. The ability to calculate a risk for death or injury is dependent on the availability of data both on injuries (numerator) as well as employment or exposure (denominator). Fatality data are generally more prevalent than data on severe injuries (although data are available on nonfatal injuries, minor injuries predominate). In considering fatality data, it should be recognized that for every injury death there are numerous nonfatal injuries, many resulting in severe disability— the proverbial tip of the iceberg.

Information on both frequency of fatal injuries and the number of employed workers is generally available for Bureau of the Census occupation and industry categories. Fatality rates for specific occupation or industry sectors provide a more focused assessment of risk than do rates based on data across all industries or occupations. In many cases the industry and occupation codes are compatible with existing HOs, but in some cases they are not.

In considering a specific industry of occupation for a HO, NIOSH used the criterion that the risk of death was more than twice the risk for all workers, measured by a summary rate published by BLS for multiple years. The risk for work-related injury death for all workers for the period of 1992 to 1997 was 5.0 deaths per 100,000 workers [BLS 1999a]. Therefore, industries or occupations with a fatal injury rate more than 10 per 100,000 workers were considered for HOs. A list of all industry groups meeting this criteria and a summary of current or recommended HO coverage is presented in the Appendix of this report (page 145). It is important to note that this threshold rate is per 100,000 workers rather than fulltime equivalents (FTE). Although it is important to account for hours of work when looking at youth rates specifically and contrasting youth rates with those of adults, fatality rates are typically presented by 100,000 workers in the published literature. An analysis by Ruser demonstrated that with the exception of some population groups, such as youth and older workers, rates per 100,000 workers are generally equivalent to those per 100,000 FTE [Ruser 1998]. As noted above, in addition to examining the fatality rate for industries and occupations, the circumstances of fatalities in those sectors were also considered. If the hazardous exposures were diverse and not well addressed in existing or proposed HOs, and industry- or occupation-wide HO was proposed. If the types of hazardous activities were relatively limited and encompassed under existing or proposed HOs, a new HO was not proposed. In general, the evaluation of HOs defined by occupation and industry were straightforward given the ability to evaluate fatality rates.

Less straightforward were evaluations of HOs defined by specific machines or tasks. While assessment of risk is typically feasible for industries and occupations, in general, data are seldom available for specific machines or tasks. Data are available on the number of deaths and injuries associated with specific types of machines or events, however, the level of detail varies. In some cases, information is available for a specific machine (such as a forklift), while in other cases, specific machinery are grouped in ill-defined categories such as "paper production machinery, unspecified" or paper production machinery, not elsewhere classified." More problematic, however, is the virtual absence of data and the numbers of specific machines in use. Thus the data that would be needed to assess level of risk for use of machines or specific tasks are not available. Evaluating the total numbers of fatalities and injuries was often the only available means of assessing the need for these types of HOs. It is not valid to compare the number of deaths involving a machine found in numerous work settings with the number of deaths involving a machine used in a small number of specialized manufacturing operations. For this reason, no frequency threshold was used as a basis for recommending HOs related to machinery use. There are substantial numbers of fatalities associated with some machines addressed by certain HOs, and in those cases NIOSH is confident in recommending that the HOs be continued. In a few select cases, the data are less compelling and a cautious removal of the HO may be considered. For example, a small number of deaths or injuries associated with a specialized machine presumed to be used in a small number of workplaces would indicate a

higher rate, which would be considered more compelling that a small number of deaths and injuries associated with machinery presumed to be prevalent in many workplaces. There are clearly less data available on machinery and task, and the degree of confidence in this data is lower than that for industries and occupations. NIOSH used professional judgement and available data to make reasonable judgements as to level of risk.

In addition to fatality data, data on severe or potentially disabling nonfatal injuries and illnesses were also considered. Injuries were generally considered severe if they resulted in 15 or more days away from work (three times the average median days away from work for all workers) [BLS 1999b]. Amputations were considered to be an especially disabling type of injury. Data on severe or disabling injuries alone were not considered sufficient to recommend an HO. Information on severe or potentially disabling injuries were considered in addition to other data on fatal injuries and/or serious health risks.

In addition to activities with a high risk for fatal and severe nonfatal injuries, the HOs should protect youth from exposures that lead to chronic and debilitating illnesses, seriously impacting the quality and potential of their adult lives. Youth should be protected from exposures where there is evidence that young workers are more susceptible to harm than adults. However, the greatest gaps in knowledge to guide regulation of youth employment are in the area of occupational illness. Little is known about the extent to which work exposures at a young age lead to acute of chronic illness. Additionally, there are little data on the extent of disability and impact on quality of life for specific illnesses. Models used to estimate risk for adult workers, which rely on an 8 hour workday and 40 year working lifetime, cannot be used to estimate risks for youth who frequently work less than 8 hours a day and move in and out of jobs with different exposures. Data demonstrating strong associations between workplace exposures and serious illnesses are cited as justification for HOs to limit or prohibit youth exposures to workplace health hazards. Data on unique youth susceptibility are cited when available. In some cases, theoretical risks suggesting a possible unique susceptibility of adolescents are cited for especially serious hazards, such as exposure to radioactivity in a period of increased cell growth and a developing reproductive system. Finally, a number of health areas requiring further research are included in the section "Areas Requiring Further Research" (page 139).

Recommendations for Apprentice/Student Learner Exemptions

NIOSH has made recommendations for apprentice/student learner exemptions (29 CFR[4] 570) within the current and recommended new HOs. These recommendations are specific to the nonagricultural HOs because of their stringent requirements for training and ongoing close supervision of a qualified and experienced person. The agricultural HOs do not mandate such standards, and thus would not provide adequate assurance of protection. Exemptions are recommended in those cases where supervision and training could reasonably be expected to protect young workers from hazards on the job. However, where there are external factors that are not under the control of a supervisor, where lines of authority are unclear, or where there are

[4]*Code of Federal Regulations*. See CFR in references.

multiple hazards not confined to a specific task, an exemption is not recommended. When available, data on the effectiveness of training in specific industries, occupations, or tasks were taken into consideration in recommending apprentice/student learner exemptions.

Format for Recommendations

The discussion of each HO begins with a recommendation to retain or revise, followed by a brief rationale in support of the recommendation. The remainder of the discussion is dependent upon the nature and amount of data available. In most instances, a table showing data on fatal and nonfatal injuries among workers of all ages is provided. Where available, data on fatal and nonfatal injuries among workers under age 18 (for nonagricultural occupations) or under age 16 (for agricultural occupations) are displayed. Case reports of fatalities and serious injuries to young workers, appearing in text boxes, are used to illustrate circumstances in which these injuries occur. Recommendations are further supported by references to relevant scientific literature.

For each HO recommendation, the summaries include all data NIOSH considered in making the recommendation, and are not limited to data supporting the NIOSH recommendation. This was done recognizing that judgements about justification for HOs are value-laden. Recommendations in this report are based on judgement and expertise of NIOSH staff. Summaries of data are provided to allow DOL to make their own judgements and interpretations. Suggestions for further evaluation are provided for a few select machine-based HOs given limitations in the available data as described earlier in this section.

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IV. RECOMMENDATIONS PERTAINING TO CURRENT HAZARDOUS ORDERS
Non-Agricultural Occupations

HO 1: Manufacturing or Storage Occupations Involving Explosives

Recommendation — Revise the definition of "explosives and articles containing explosives" to delete the reference to the Interstate Commerce Commission, which is now obsolete, and to include the current "List of Explosive Materials," published by the Bureau of Alcohol, Tobacco and Firearms (ATF). NIOSH encourages DOL to retain more general terminology (e.g., ammunition, fireworks, primers, and smokeless powders) within the text of HO 1, since these terms are not contained in the "List of Explosive Materials," yet have meaning for employers, parents, and youth. These recommendations are consistent with the 1999 Notice of Proposed Rule-Making (NPRM) published by DOL and with previous NIOSH comments in support of the proposed rule [64 Fed. Reg. 67130 (1999); NIOSH 2000a].

Rationale — NIOSH review of occupational fatal and nonfatal injury data supports the continued need to restrict minors from working in establishments that manufacture and store explosives and explosive components. The most current "List of Explosive Materials" that ATF maintains on its website appears to be appropriate for DOL use in specifying which materials are relevant to HO 1. This list has two distinct advantages: the list is periodically updated, and establishments that manufacture explosives are licensed by ATF and are likely to know about the list [National Fire Protection Association 1997].

Hazards of Working in Establishments that Manufacture or Store Explosive Materials

The primary hazard that is unique to establishments that manufacture or store explosive materials is the potential for catastrophic fires and explosions resulting from the mishandling of the explosive materials. Data from CFOI for the years 1992 through 1997 demonstrated that fires and explosions killed an average of 194 workers per year [NIOSH 2001c]. Over the same 6-year period, 8 workers under the age of 18 died as a result of fires and explosions [Windau et al. 1999]. It is estimated, based on data from the SOII, that 4,146 workers sustained lost workday injuries and illnesses as a result of fires and explosions in 1996, with 19 of the injuries occurring among workers less than 18 years of age [Windau et al. 1999]. In 1997, explosives and blasting agents (OIICS code 075) caused 205 occupational injuries and illnesses resulting in lost workdays, with a median of 20 lost workdays per injury [BLS 1999b].

> Two youth were killed in 1999 when the trailer they were in exploded when hit by a malfunctioning firework. Though it is not known if the youth were working, fireworks were being stored and assembled in the trailer for an ongoing fireworks show approximately 1/4 mile away. An adult working in the trailer was also killed. [Associated Press 1999].

Assessment of the risk of fatal injury for workers in establishments which manufacture or store explosives is greatly hampered by the classification of these establishments in categories that include related establishments that do not manufacture or store explosive materials. Risks specific to industries that manufacture or store explosives may be diluted by the inclusion of

fatality and employment numbers for lower risk establishments. For this reason, and because of the risk for catastrophic fires and explosions in establishments which manufacture and store explosives, available fatality rates were considered sufficient to justify prohibitions for youth workers. Fatality data were examined for two industries: 1) Industrial and Miscellaneous Chemicals (Bureau of the Census Industry Code 192) and 2) Ordnance and Accessories (Bureau of the Census Industry Code 292). These two industries include establishments that manufacture explosive materials, but they also include establishments that manufacture a variety of other chemical products (e.g., adhesives). From 1992 through 1997, Industrial and Miscellaneous Chemicals had 96 occupational fatalities, representing a work-related fatal injury rate of 3.1 per 100,000 workers [NIOSH 2001c, NIOSH 2001a]. The annual number of deaths was fairly stable, averaging 16 deaths per year. During the same time frame, six workers died in the Ordnance and Accessories industry.

Of the 96 deaths in the Industrial and Miscellaneous Chemicals industry, 30 resulted from fires or explosions and 12 from inhalation or contact with the skin [NIOSH 2001c]. Forty deaths occurred in the sub-industry of Miscellaneous Chemical Products (this group includes the "explosives industry"). Thirty-eight deaths occurred in the sub-industry of Industrial Inorganic Chemicals and another 18 deaths occurred in the sub-industry of Industrial Organic Chemicals.

NIOSH reviewed narrative injury descriptions of the 96 deaths occurring in the Industrial and Miscellaneous Chemicals Industry [NIOSH 2001c] and determined that these establishments have the potential for multiple-death incidents resulting from fires and explosions, especially the Explosives (Standard Industrial Classification [SIC] Code 2892) and Chemical and Chemical Preparations (SIC Code 2899) industries. Of the 30 deaths resulting from fires and explosions, five involved fireworks.

HO 2: Motor Vehicle Occupations

Recommendation— 1) Revise the HO to incorporate the provisions of the Drive for Teen Employment Act, enacted in 1998 as a subsection of the Fair Labor Standards Act, into the HO 2 regulation. 2) Provide guidance on what constitutes "urgent, time-sensitive deliveries" and "incidental and occasional driving." 3) Delete from the regulation the now expired exemption for school bus driving. These recommendations are consistent with the 1999 NPRM published by DOL and with previous NIOSH comments in support of the proposed rule [64 Fed. Reg. 67130 (1999); NIOSH 2000a].

Rationale— Motor vehicle statistics show that teenagers have extremely high rates of motor vehicle crashes, deaths, and injuries. Furthermore, occupational injury fatality data demonstrate that motor vehicle driving is associated with high numbers of occupational deaths among workers of all ages, and adolescents specifically. The revisions to HO2 are proposed for the following reasons:

- By continuing to prohibit 16-year-olds from driving on the job and limiting the amount and

nature of driving permitted for 17-year-olds, the Drive for Teen Employment Act appears consistent with the approach and intent of Graduated Driving Licensure (GDL) systems which are heavily supported by the traffic safety community. The Act provides broad protection for 16-year-olds, the group with the highest crash risk. Extending limited driving privileges increases employment opportunities for 17-year-olds, yet places restrictions to allow gradual development of driving skills among these young workers.

- Formal inclusion of clearer definitions for terms such as "incidental and occasional driving" and "urgent, time-sensitive deliveries" will help employers comply with the Act as they assign driving tasks to young workers. Clarification of such terms will aid Wage and Hour compliance staff as they enforce the Act.

- Given the low seat belt use among adolescents, it is critical to protection of young workers that mandatory seat belt use be an employer policy. Since law enforcement policies and commitment to enforcement vary by state, mandatory seat belt laws alone should not be relied upon for protection of young workers.

Teenagers Have Extremely High Rates of Motor Vehicle Crashes, Deaths, and Injuries

Traffic crashes have long been the leading cause of death among persons ages 16 through 20 years. Persons in this age group have the highest fatality and injury rates due to traffic crashes of any age group. For these adolescents, the 1997 fatality rate was approximately twice that of the total population (30.4 per 100,000 population vs. 15.7), and the injury rate nearly 2.5 times higher (3,116 per 100,000 population vs. 1,270) [NHTSA 1998a]. The total crash involvement rate for 16-year-olds was nearly ten times that of drivers ages 35 to 64 (43 crashes per million miles driven vs. 4). For 17-year-olds, the rate was 7.5 times higher (30 vs. 4) [Transportation Research Board 1996]. Numerous risk factors have been implicated in the elevated traffic injury and fatality rates among youth: lower seat belt use, night driving, risk-taking, inexperience, distractions from teen passengers, immaturity, speeding, driver inattention, driver error, failure to adjust to road and weather conditions, incorrect interpretation of traffic signs and signals, and alcohol use [Ford and Picha 2000; NHTSA 1998b; Phebo and Dellinger 1998].

Motor Vehicle Driving Is Associated with High Numbers of Occupational Deaths among Workers of All Ages, and Adolescents Specifically

Highway crashes continue to be the leading cause of fatalities among workers of all ages, accounting for 7,822 (20.7%) of all occupational fatalities between 1992 and 1997. Further, while the total number of occupational fatalities remained fairly consistent over the 6-year period, occupational fatalities on the highway increased 19.8%, from 1,158 in 1992 to 1,387 in 1997 [NIOSH 2001c]. Given the crash experience of young drivers in the general population and the additional pressures associated with on-the-job driving, maintaining restrictions on motor vehicle operation is essential to the protection of young workers. Despite the protections afforded by HO 2, motor vehicle-related incidents are a leading cause of death among young workers. Between 1990 and 1992, the National Traumatic Occupational Fatalities (NTOF)

surveillance system, based on death certificates from all states, identified 32 motor vehicle deaths of workers ages 16 and 17, comprising 28.8% of work-related fatalities in this age group. The motor vehicle fatality rate of 1.01 per 100,000 full-time equivalent (FTE) workers was higher than the rates for workers ages 18 through 44 [Castillo and Malit 1997]. On average, death certificates in NTOF have been found to identify about 80% of occupational deaths [CDC 2001b]. NTOF differs from CFOI in that the minimum age covered is 16. Table 7 displays occupational motor vehicle fatality rates and frequencies by age group.

Table 7. Frequency and Rates (Deaths Per 100,000 FTE) of Occupational Motor Vehicle Fatality by Age Group, United States, 1990-1992

Age Group (Years)	Deaths	Rate
16-17	32	1.01
18-19	71	0.85
20-24	309	0.86
25-34	870	0.86
35-44	789	0.82
45-54	710	1.16
55-64	470	1.50
65+	234	3.33

Source: National Traumatic Occupational Fatality Surveillance System, National Institute for Occupational Safety and Health [Castillo and Malit 1997]

Analysis of a special CFOI research file provided to NIOSH which includes detailed data such as actual age, but does not include data from New York City, identified 18 highway fatalities among workers age 16, and 29 fatalities among workers age 17 for the years 1992-1997 [NIOSH 2001d]. Ten of the 47 decedents (21.3%) were employed in the agricultural production industry, and thus would not have been covered by HO 2. The occupation specified for 13 of the decedents was “truck driver” or some other transportation occupation. Table 8 displays additional characteristics of occupational highway fatalities among workers ages 16 and 17.

Table 8. Characteristics of Occupational Highway Fatalities Among 16- and 17-Year-Olds, United States, 1992-1997

	Age 16	Age 17
Primary Source of Injury		
Truck	5 (27.8%)	12 (41.4%)
Car	7 (38.9%)	12 (41.4%)
All other	6 (33.4%)	5 (17.2%)
Total	18 (100.0%)	29 (100.0%)
Event Type		
Highway collision	6 (33.3%)	13 (44.8%)
Highway noncollision	7 (38.9%)	9 (31.0%)
All other	5 (27.8%)	7 (24.1%)
Total	18 (100.0%)	29 (100.0%)
Position in Vehicle		
Driver	13 (72.2%)	22 (75.9%)
Passenger	5 (27.8%)	7 (24.1%)
Total	18 (100.0%)	29 (100.0%)
Industry		
Agriculture/forestry/fishing	5 (27.8%)	6 (20.7%)
Construction	—	6 (20.7%)
Transportation, communications, public utilities	—	—
Wholesale/retail trade	—	10 (34.5%)
Services	—	—
All other	7 (38.9%)	—
Total	18 (100.0%)	29 (100.0%)
Occupation		
Transportation and material moving	—	9 (31.0%)
Farming/forestry/fishing	5 (27.8%)	7 (24.1%)
Laborer	—	5 (17.2%)
Service	—	—
All other	9 (50.0%)	—
Total	18 (100.0%)	29 (100.0%)
Time of Incident (Nearest Hour)		
6 a.m. to 11 a.m.	7 (38.9%)	7 (24.1%)
12 noon to 5 p.m.	9 (50.0%)	13 (44.8%)
6 p.m. to 9 p.m.	—	6 (20.7%)
10 p.m. to 5 a.m.	—	—
Total	18 (100.0%)	29 (100.0%)

Source: Census of Fatal Occupational Injuries (CFOI), Bureau of Labor Statistics [NIOSH 2001d]. Dashes indicate that BLS reporting requirements were not met.

Graduated Driver Licensure (GDL) Systems

In recent years, traffic safety researchers have advocated the adoption of GDL systems for youth less than 18 years of age. The rationale for GDL is that while basic driving skills are quickly acquired, young drivers' abilities to make decisions in complex traffic situations develop only through accumulation of real-world driving experience [McLaurin 1999]. The most comprehensive GDL systems begin with a learner's permit period which stipulates basic driver training, adult driver supervision at all times, limited night driving, and restrictions on carrying teen passengers. An intermediate period follows during which fewer driving restrictions are imposed. Full licensure is typically achieved at age 18, provided the young driver remains free of at-fault crashes, moving violations, and driving under the influence convictions [NHTSA 1998b]. Although not all GDL systems have been in place long enough for evaluations to be completed, results thus far are encouraging (e.g., crash decreases of 34% and 31% in Kentucky and Ontario, respectively) [Mayhew 2000; Foss and Evenson 1998].

HO 3: Coal Mine Occupations

Recommendation— Retain current HO.

Rationale— The coal mining industry is associated with high injury death rates and severe nonfatal injuries. Further, work in coal mines is associated with serious lung diseases. Exposure to respirable coal dust at a young age would mean a longer latency period in which to develop, suffer, and die from lung diseases.

The Coal Mining is Associated With High Injury Death Rates and Severe Non-Fatal Injuries and Illnesses

The coal mining industry had the 4th highest lifetime risk of fatal occupational injuries based on NTOF data for the years 1990 and 1991, with 19 deaths per 1,000 fulltime workers– assuming a 45-year work life [Fosbroke et al. 1997]. Lifetime fatal injury risk is an average lifetime risk for workers in a particular industry or occupation, assuming a 45 year working life. It was calculated in a manner comparable to lifetime risk for fatal occupational illness [Fosbroke et al. 1997]. OSHA considers a lifetime risk of 1 death in 1,000 workers to be high enough to justify the development of a standard for an industry [Stayner 1992; Adkins 1993]. There were 255 deaths in the coal mining industry between 1992 and 1997; the fatality rate was 41.9 per 100,000 workers [NIOSH 2001c, NIOSH 2001a]. In 1997, injuries and illnesses where coal was stated as the source resulted in a median of 30 days away from work [BLS 1999b]. Injuries and illnesses in the coal mining industry resulted in a median of 25 days away from work [BLS 1999b].

Work in Coal Mines Is Associated with Serious Lung Disease

Coal Workers' Pneumoconiosis (CWP), more commonly known as "Black Lung Disease," is a chronic, irreversible illness arising from inhalation and deposition of coal dust in the lungs, and

lung tissue reaction to the dust. Clinical and radiographic signs of the disease usually appear after at least ten years of respirable dust exposure. Workers exposed to coal mine dust more commonly develop chronic bronchitis, emphysema, and airway obstruction (types of chronic obstructive pulmonary disease [COPD]) than others with similar tobacco use [Wagner 1994]. A prospective study of 8,878 working male coal miners, medically examined from 1969 to 1971, and followed through 1979, demonstrated increased exposure-related mortality from pneumoconiosis and from chronic bronchitis or emphysema, controlling for age and smoking [Kuempel et al. 1995]. Analysis of death certificates for the years 1987 to 1996 demonstrated that decedents whose typical employment was the coal mine industry died more frequently than would have been expected from CWP (proportionate mortality ratio [PMR] = 111) and chronic obstructive pulmonary disease (PMR = 2.4). PMRs greater than 1 indicate more deaths from a specific cause of death than expected based on patterns in the general population [NIOSH 1999a]. Several epidemiologic studies have demonstrated an elevated risk of certain types of cancer in coal miners [Swaen et al. 1985, 1995; Meijers et al. 1988, 1991; Golka et al. 1998], however, the International Agency for Research on Cancer (IARC) concluded in a comprehensive review [IARC 1997] that there was inadequate evidence in humans and in experimental animals to classify coal dust as carcinogenic. Despite improvements in respiratory protection for coal mine workers, exposures to respirable coal dust continue to occur, as well as illness in workers exposed to less than the permissible level. For the period 1995-1996, 6% of samples collected by the Mine Safety and Health Administration exceeded permissible levels [NIOSH 1999a].

HO 4: Logging and Sawmilling Occupations

Recommendation— 1) Expand the HO to cover work in operation of timber tracts and tree farms (SIC 081) and in forestry services (SIC 085). 2) Remove the current exemptions for construction work for living or administrative quarters.

Rationale— 1) Fatality data show that work in logging and in sawmills and planing mills continues to be associated with substantial numbers of fatalities and nonfatal injuries, and high fatality rates. The logging industry has among the highest average annual fatality rates, and the highest lifetime risk of fatal injury. The forestry industry also has a high fatality rate, and workers face injury risks similar to those of logging workers. Forestry includes forest firefighting, which poses substantial risk to workers of all ages. However, work in Forest Nurseries and Gathering of Forest Products (SIC 083) is associated with very small numbers of fatalities, and should not be prohibited for youth.

2) Construction work has high risks for fatal and nonfatal injuries, and should not be exempted in the construction of living or administrative quarters at logging sites or mills (see recommendation for construction HO on page 101).

<u>The Manufacture of Lumber and Wood Products Is Associated with High Numbers and Rates of Fatal Injury</u>

The logging industry (Bureau of Census Industry Code 230) had the highest lifetime risk of fatal injury of any industry, at 47 deaths per 1,000 workers, based on an analysis of NTOF data for 1990 and 1991. Sawmills, planing mills, and millwork (Bureau of the Census Industry Code 231, which is equivalent to SIC codes 242 and 243) had the 14th highest lifetime risk of 5.8 deaths per 1,000 workers [Fosbroke et al. 1997].

CFOI data demonstrated that there were 1,218 fatalities between 1992-1997 in lumber and wood products manufacturing industries (SIC 24, Table 9) [NIOSH 2001c]. These establishments included logging companies (SIC 241); sawmills and planing mills (SIC 242); and companies that manufacture millwork, veneer, plywood, and structural wood members (SIC 243); wood containers (SIC 244); wood buildings and mobile homes (SIC 245); and miscellaneous wood products (SIC 249). Ninety-three percent of the fatalities occurred in SICs 241, 242, and 243. The fatality rate for the 6-year period for all industries within SIC 24 was 27.7 deaths per 100,000 workers [NIOSH 2001c; NIOSH 2001a]. The fatality rate for the logging industry alone was 103.6 deaths per 100,000 workers, more than 20 times the rate for workers in all industries. It was not possible to calculate fatality rates separately for sawmills and planing mills (SIC 242) and millwork, veneer, plywood, and structural members (SIC 243) because employment data were not available for each of these industry sectors individually. The rate for these two industry sectors combined was 11.5 deaths per 100,000 workers.

Employment in logging was also associated with 3,883 nonfatal injuries and illnesses in 1997 requiring days away from work, with a median of 12 lost work days [BLS 1999b]. Large numbers of injuries and illnesses were also seen in the other five SICs, but these required considerably fewer median days away from work than did logging-related injuries.

Table 9. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work in Lumber and Wood Products Manufacturing Industries, United States

Industry [SIC code]	**Deaths, 1992-1997**	**Deaths per 100,000 Workers, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median Days Away from Work, 1997**
Logging [SIC 241]	874	103.6	3,883	12
Sawmills and planing mills [SIC 242]	187	11.5*	8,482	5
Millwork, veneer, plywood, and structural members [SIC 243]	69	11.5*	9,015	4
Wood containers [SIC 244]	19	7.0**	3,368	4
Wood buildings and mobile homes [SIC 245]	21	4.8	4,013	4
Miscellaneous wood products [SIC 249]	43	7.0**	2,293	4
Total [SIC 24]	1,218	27.7	31,054	---

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries) [BLS 1999b], Bureau of Labor Statistics. Dashes indicate that data were not available.
*Rate for SICs 242 and 243 combined.
**Rate for SICs 244 and 249 combined.

NIOSH analysis of a special CFOI research file for the years 1992 through 1997 (which includes more detail than on the standard research file, but excludes New York City) identified 5 deaths of workers younger than age 18 in SIC 24. All of the fatalities occurred in logging (SIC 241) and in sawmills and planing mills (SIC 242). The fatality rate for all of SIC 24, taking into account hours worked, was 17.6 deaths per 100,000 FTE workers ages 15-17, nearly two-thirds the rate of 27.7 per 100,000 workers of all ages [NIOSH 2001d]. Youth fatalities in these settings involved being struck by falling trees and vehicles [Windau et al. 1999].

In 2000, a 16-year-old male youth was electrocuted while working at a sawmill. The youth was employed to do odd jobs and clean-up work. Working alone while other workers were taking a break, the youth was using a compressed air hose and nozzle to blow sawdust off and away from a 440-volt electric re-saw machine. The youth apparently knelt down under the machine on wet ground and contacted the machine's metal framework which was energized. The re-saw machine had been powered down, but not de-energized. The re-saw machine was located outside and was not protected from weather elements. Additionally, the machine had exposed wiring and was not appropriately grounded. [Missouri Department of Health 2001].

The Forestry Industry Also Has a High Fatality Rate

CFOI identified 82 fatalities of workers employed in the forestry industry (SIC 08) between 1992 and 1997, with a fatality rate of 16.6 deaths per 100,000 workers (Table 10) [NIOSH 2001c]. Fatalities were largely confined to two sectors within the forestry industry: Timber Tracts (SIC 081), which consists of establishments that operate timber tracts or tree farms for the purpose of selling standing timber (35 deaths); and Forestry Services (SIC 085), which contains establishments that perform services related to timber production, wood technology, timber cruising and estimation, and forest firefighting and fire prevention (39 deaths). Although government agencies engaged in forest firefighting and fire prevention are placed by SIC rules in SIC 085, examination of CFOI data showed that 16 additional fatalities that were clearly attributable to forest firefighting were misclassified in the public administration industry division. Therefore, the fatality rate of 16.6 for the forestry industry underestimates the true risk to workers in the industry.

Transportation incidents were the most common fatal event among forestry workers, accounting for 43 deaths (52.4%). However, forestry workers also experienced fatal injuries such as those typically associated with the logging industry: in 26 of the 82 fatalities (31.7%), the worker was struck by a falling object (a tree in all but one instance).

The SOII identified 438 nonfatal injuries and illnesses to forestry workers in 1997 [BLS 1999b]. This small number may be attributed to the lack of coverage of government employees by the SOII. High median days away from work, 25, were associated with nonfatal injuries and illnesses to workers in Forestry Services.

Table 10. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work in Forestry Industries, United States

Industry [SIC code]	**Deaths, 1992-1997**	**Deaths per 100,000 Workers, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median Days Away from Work, 1997**
Timber tracts [SIC 081]	35	---	148	5
Forestry services [SIC 085]	39	---	246	25
Other forestry (includes Forest Nurseries and Gathering of Forest Products [SIC 083] and Forestry, unspecified [SIC 080])	8	---	---	---
Total [SIC 08]	82	16.6*	438	7

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries) [BLS 1999b], Bureau of Labor Statistics. Dashes indicate that data were not available.
*Employment data for calculation of fatality rates below the 2-digit SIC were not available.

HO 5: Power-Driven Woodworking Machine Operations

Recommendation— 1) Expand the HO to include similar power-driven machines used to operate on materials other than wood. *Alternatively, NIOSH encourages DOL to consider rewriting HOs 5, 8, and 12, which respectively address machines that work with wood, metal, and paper, by merging into a single or multiple HOs which address the function of machines rather than the material processed.* 2) Retain the existing exemption for apprentices/student learners.

Rationale— 1) Metal, woodworking, and special material machinery are associated with substantial numbers of worker deaths and injuries. Although it is possible to identify some deaths and injuries attributed to woodworking machines, and tools specifically, in other cases it is not possible to identify if the machine was designed for or used on wood or some other material. Furthermore, many of the hazards inherent in woodworking machines are found in machines that process other materials. *An advantage to rewriting the HOs to address function rather than material processed would be the increased ability to monitor the incidence and patterns of deaths and injuries associated with specific types of machinery using routinely collected fatality and injury data. This would allow an assessment as to which machines continue to be a safety concern for youth, and which machines are no longer a concern because of advances in safety features or because of diminished use in workplaces.*

2) An apprentice/student learner exemption is appropriate since the hazards of specific machinery are typically known, controllable, and limited to the machinery.

Substantial Numbers of Deaths and Nonfatal Injuries and Illnesses Associated with Power-Driven Woodworking Machines and Similar Machinery

> In April 1999, a 17-year-old youth severed his right arm at the elbow while working on a power-driven pallet-notching machine. [Associated Press 2000].

The ability to identify deaths and injuries associated with equipment specifically prohibited by HO 5 is hampered because of an incompatibility with the classification scheme used in occupational injury statistics, the Occupational Injury and Illness Classification Structures (OIICS) [National Safety Council 1995]. The OIICS classify machines by function rather than the material processed by the machine. Although it is possible to identify specific types of machines that principally work on wood, such as saws, in other instances, the machines may work on wood as well as other materials, for example, boring, drilling, planing and milling machinery.

Table 10 provides data on fatal and nonfatal injuries associated with a variety of power-driven machines that operate on wood, metal, and other materials. For the 6-year period 1992-97, there were a total of 287 deaths among workers of all ages in which this type of machinery was found to be a primary or secondary contributor to the death [NIOSH 2001c]. It is assumed that stationary saws are primarily used on wood. Stationary sawing machinery contributed to 46 deaths. In 1997, there were 26,051 injuries and illnesses serious enough to require time away from work associated with metal, woodworking and special material machinery [BLS 1999b]. Stationary saws accounted for 7,415 injuries and illnesses. The median days away from work for injuries and illnesses associated with metal, woodworking and special material machinery was slightly higher than the median for all injuries, 6 compared to 5. Injuries and illnesses associated with stationary saws had a median of 8 days away from work.

> In 2000, a 14-year old male youth was pulled into an operating wood chipper and fatally injured. The youth, who had accompanied his father to work, had been assigned the task of dragging limbs and branches to the wood chipper, and was specifically instructed not to feed the chipper. He picked up a 4- to 5-inch diameter limb and began feeding it into the chipper when a branch struck him in the back and pulled him into the rotating chipper knives [NIOSH 2001e].

Another type of machine that processes wood and is not reflected in Table 10 because it is classified under logging machinery, is a wood chipper (OIICS code 3231). Wood chippers typically consist of a feed mechanism, knives mounted on a rotating chipper disc or drum, and a power plant [NIOSH 1999b]. In order to be able to feed large limbs into the machine, there is minimal or no machine guarding. A NIOSH analysis of CFOI data for the period 1992 to 1997 identified 32 deaths among workers of all ages associated with this machinery [NIOSH 2001c]. Of these deaths, 56% were in industries or occupations not currently covered by HOs, such as landscaping

services, tree removal, and electrical services. Deaths involved being caught by the feed mechanism and being pulled through the chipper knives (41%), and being struck by parts that separated from the machine (34%).

Table 10. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away From Work Associated with Metal, Woodworking, and Special Material Machinery, United States.

Type of Machinery [OIICS code]	**1^N or 2^N Source of Death, 1992-97**	**Nonfatal Injuries and Illnesses (1^o source), 1997**	**Median Days Away from Work, 1997**
Metal, woodworking, and special material machinery, unspecified [350]	12	1,565	8
Bending, rolling, shaping machinery [351]	31	1,733	7
Boring, drilling, planing, milling machinery [352]	23	2,340	5
Extruding, injecting, forming, molding machinery [353]	77	2,172	6
Grinding, polishing machinery [354]	12	2,322	4
Lathes [355]	25	1,109	6
Presses, except printing [356]	32	4,183	7
Sawing machinery, stationary [357]	46	7,415	8
Other metal, woodworking, and special material machinery [359], and threading and tapping machines [358]	29	3,211	3 [OIICS 359] 7 [OIICS 358]
Total	287	26,051	6

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b].

Table 11 provides data on fatal and nonfatal injuries associated with powered handtools. As with the machinery identified above, it is difficult to identify in injury statistics powered tools specific to woodworking. For the 6-year period, 1992-1997, there were 304 deaths associated

with powered tools, 136 of which were associated with cutting tools, such as chain saws [NIOSH 2001c]. In 1997 alone, there were 22,648 non-fatal injuries and illnesses associated with power tools [BLS 1999b]. The median days away from work in 1997 was lower for powered tools than for all injuries, 4 versus 5 days, respectively. It is important to note that there were 8 deaths during the period 1992-97 and 5,812 injuries and illnesses in 1997 for which it was not determined if the handtool was powered. These deaths and injuries are not included in Table 10, but may have in fact involved powered handtools.

Table 11. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Powered Handtools, United States

Type of Powered Handtool [OIICS code]	**1^N or 2^N Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses, (1^N source) 1997**	**Median Days Away from Work, 1997**
Unspecified [720]	---	353	7
Boring (incl. augers, drills) [721]	22	3,093	4
Cutting (incl. chainsaws) [722]	136	5,539	10
Striking and nailing (incl. riveters) [723]	9	2,739	5
Surfacing (incl. sanders) [724]	13	2,604	3
Turning (incl. screwdrivers) [725]	7	1,038	6
Welding and heating [726]	97	5,513	2
Other (incl. nail guns, stapling tools) [729]	20	1,770	5
Total	304	22,648	4

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b]. The dash indicates that BLS reporting requirements were not met.

HO 6: Occupations Involving Exposure to Radioactive Substances and to Ionizing Radiation

Recommendation— Revise HO to reflect current risks to youth for occupational radiation exposures. The following wording is suggested: *Working with any machine that generates ionizing radiation, including assisting in diagnostic or therapeutic radiology procedures*

involving ionizing radiation.

Rationale— Youth are increasingly working in settings such as medical or veterinary offices where they may be exposed to ionizing radiation while assisting in diagnostic radiologic procedures. Evidence for increased susceptibility of youth to ionizing radiation has prompted OSHA and the U.S. Nuclear Regulatory Commission (NRC) to set the maximum permissible exposure for youth at 10% of the permissible level for adults. The increased risk for youth and research showing that radiographic equipment and procedures frequently do not meet national standards make an apprentice/student learner exemption inappropriate.

Occupational Risk to Youth for Exposure to Radiation

According to the Current Population Survey, 46,159 youth under the age of 18 worked in veterinary services, or offices and clinics of physicians, dentists, chiropractors, or other health practitioners during 1999. This number has been increasing since 1988 when 18,068 youth worked in these settings [NIOSH 2001a]. A 1987 survey of 29 randomly selected veterinary practices with radiographic equipment in Ohio indicated that the majority did not meet standards for x-ray equipment and procedures. Protective equipment such as lead shields and radiation exposure monitors were used in fewer than half of the practices [Fritschi 2000].

Concerns about Youth Occupational Exposure to Radioactive Substances and Ionizing Radiation

Risks of occupational exposures to ionizing radiation in youth stem from concerns about increased susceptibility for cell damage associated with adolescent growth and development, as well as concern about increased likelihood for disease development with exposures at an earlier age. There is some evidence of age-specific effects of ionizing radiation from studies of atomic bomb survivors and Marshall Islanders exposed to fallout from nuclear weapons testing [Merke and Miller 1992]. A number of entities have recommended or mandated no exposure or reduced limits for youth occupational exposures to radiation [Emery and Cooper 1998]. The National Council on Radiation Protection and Measurements recommended in 1964 and 1966 that youth not be occupationally exposed to radiation, but that there be a provision for educational activities with exposures not exceeding 0.1 rem (1 mSv) per year. The Nuclear Regulatory Commission [10 CFR 20.1207] and OSHA [29 CFR 1910.2] both limit youth exposures to 10% of the permissible exposure for adults, or 5 mSv (0.5 rem) per year and 3 mSv (0.3 rem) per quarter year. It is noteworthy that this is the only OSHA standard that specifies a standard for youth different than for adults.

HO 7: Power-Driven Hoisting Apparatus Operations

Recommendation — 1) Expand the HO to cover repairing, servicing, disassembling, and assisting in tasks being performed by the machine. This recommendation applies to all

machinery covered under this HO. 2) Expand the HO to prohibit youth from riding on any part of a forklift as a passenger (including the forks), and from working from forks, platforms, buckets, or cages attached to a moving or stationary forklift. 3) Expand the HO to prohibit work from truck-mounted bucket or basket hoists commonly termed "bucket trucks" or "cherry pickers." 4) Expand the HO to cover commonly used manlifts that do not meet the current definition, specifically aerial platforms. 5) Remove the exception that currently permits youth to operate an electric or air-operated hoist of less than one ton capacity.

Rationale — 1) Substantial numbers of deaths and injuries are associated with operating and assisting in tasks performed by power-driven hoisting apparatus, including deaths of youth. Although HO 7 prohibits youth from assisting in operation of cranes and derricks, similar prohibitions do not exist for other machines covered under this HO. Additionally, a considerable number of deaths were associated with activities not directly related to operation of the hoisting apparatus, notably servicing, repairing, and disassembling. 2) Substantial numbers of fatalities occur among workers who are passengers on forklifts, riding on the forks, or working from raised forklifts and attachments. None of these activities is currently prohibited for youth. 3) Worker fatalities are associated with work from truck-mounted basket and bucket hoists. The associated risk of falls and electrocution support expansion of HO 7 to prohibit work from truck-mounted hoists. 4) The current definition of manlifts in HO 7 specifies that youth are prohibited from riding on manlifts driven through pulleys, sheaves, and sprockets. Many other types of manlifts now in use, particularly aerial platforms now excluded from HO 7, appear to pose more significant injury risk. 5) Surveillance systems for fatal and nonfatal injuries do not provide sufficient detail to justify the current exception that allows youth to operate hoists of less than one ton capacity. A hoisted load weighing less than one ton has the potential to cause injury or death as a result of falling, or being improperly rigged or handled. Hoist-related fatalities of young workers have been reported, including a recent case in which a youth was killed while operating a half-ton capacity hoist.

<u>Power-Driven Hoisting Apparatus Are Associated with High Numbers of Deaths and Serious Injuries and Illnesses Among Workers of All Ages, and Youth Specifically</u>

Workers of all ages are killed and seriously injured in incidents associated with the machinery covered by this HO: cranes, forklifts, hoists, manlifts and derricks. Table 12 includes data on fatal and nonfatal injuries associated with selected types of hoisting machines that are clearly identifiable from occupational injury statistics. With the exception of truck-mounted bucket and basket hoists, all are at least partially addressed by HO 7. These selected types of machines contributed to over 1,300 deaths of workers during the 6-year period, 1992-97 [NIOSH 2001c], and over 22,000 serious injuries and illnesses in 1997 [BLS 1999b]. Injuries and illnesses associated with this type of apparatus, with the exception of derricks, had more median days away from work than injuries in general.

Table 12. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Hoisting Apparatus, United States.

Type of Hoisting Apparatus [OIICS Code]	**1^N or 2^N Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses (1^N Source), 1997**	**Median Days Away from Work, 1997**
Cranes [343]	479	1,355	10
Overhead hoists [344]	64	961	7
Derricks [345]	31	140	2
Bucket or basket hoist – truck mounted [3461]	99	189	5
Manlifts [3466]	69	1,227	10
Forklifts [851]	613	18,754	8
Total	1,355	22,437	---

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b]. The dashes indicate that BLS reporting requirements were not met.

CFOI data for 1992-1997 showed that 290 of the 613 forklift-related fatalities (47.3%) were associated with work activities other than operating the forklift. Many of the non-operator fatalities were related to working around the machine: being run over, struck by, or pinned by a forklift (97 fatalities); or being struck by a load that fell from a forklift (74 fatalities). In other instances, workers died when they fell from a work surface elevated by a forklift (65 fatalities), while repairing or servicing a forklift (26 fatalities), or while riding as a passenger on the forklift or forks (21 fatalities) [NIOSH 2001c].

NIOSH analysis of CFOI data for 1992-1997 demonstrated that most crane-related fatalities were among workers other than operators [NIOSH 2001c]. Only 99 of the 479 fatalities (21%) were operating the crane. Thirty-six percent were engaged in construction, repair, and cleaning work; 12% were operating other vehicles or equipment, and 13% were performing material handling tasks. In 58 of the crane-related fatalities, the case narrative stated that the worker was repairing or disassembling the crane.

HO 7 now prohibits youth from operating various types of hoists, including overhead hoists, which were associated with 64 deaths between 1992 and 1997. Over this 6-year period, CFOI also identified 99 fatalities involving truck-mounted bucket or basket hoists commonly referred to as "cherry pickers" or "bucket trucks," machinery not currently prohibited for youth under HO 7 [NIOSH 2001c]. Deaths associated with work from truck-mounted hoists were due primarily to falls (49 fatalities) and electrocution (31 fatalities).

In 2001, a 14-year-old youth working at a rental equipment company was fatally injured by a electric chain hoist. The youth was employed to assist customers with loading and unloading rental equipment from customer vehicles and preparing the rental equipment for use by the next customer. After using a half-ton electric hoist to remove a vibratory plate tamper from a customer's truck, the youth attached himself to the hoist and was seen raising and lowering himself using the hoist. When he had not returned to the office several minutes later, his coworkers found him suspended by the chain around his neck [NIOSH 2001g].

HO 7's definition of "manlift," limited to machines suspended by belts, cables, or chains and driven through pulleys, sheaves, and sprockets, also does not reflect all types of these machines currently in use. CFOI narratives indicate that the majority of the 69 manlift-related deaths between 1992 and 1997 fell outside the definition of "manlift" provided in HO 7 in that the machine was not used as a means of conveyance but as an aerial platform. Aerial platforms may be described as manually-operated, powered, or boom-supported [Equipment Manufacturers Institute 1995].

Analysis of a special CFOI research file that includes detailed data such as age, but excludes data from New York City, identified 11 fatalities of youth less than 18 years of age associated with hoisting equipment for the years 1992 to 1997. Forklifts accounted for 6 fatalities [NIOSH 2001d]. The forklift fatalities involved youth operating the forklift, as well as working in the vicinity of the forklift. Crane fatalities all involved youth assisting in the operations of the crane, such as adjusting outriggers, or hooking or stabilizing a load.

In 1999, a 16-year-old youth and 2 adults fell 1200 feet to their death when the winch operator lost control of the hoist line they were "riding." The three workers, who were standing in loops tied into the hoist line, were being hoisted up to paint a section of a 1500-foot telecommunications tower. The hoist mechanism consisted of a portable capstan hoist at the base of the tower and a pulley at the top. At about the 1200-foot level, the hoist line began to slip off the capstan, and the operator was unable to regain control [NIOSH 2000b].

HO 8: Power-Driven Metal Forming, Punching, and Shearing Machine Operations

Recommendation— Expand the HO to include several types of metalworking machinery specifically excluded from this HO, including milling function machines, turning function machines, grinding function machines, and boring function machines. Retain the apprentice/student learner exemption. *Please also note the recommendation under HO 5, for the Department of Labor to consider rewriting HOs 5,8, and 12 into a single or multiple HOs that address machine function rather than material operated on by a machine.*

Rationale— Data on deaths and injuries associated with metalworking machines include tools currently excluded under this HO. The hazards of these excluded tools are similar to the hazards of woodworking tools which are prohibited by HO 5. There is some evidence to suggest that youth may be at greater risk for amputations from presses than adult workers. Available data suggests that training can be effective in reducing injuries and unsafe behaviors with power presses and handtools, providing support for an apprentice/student learner exemption.

Metalworking Machines Associated with High Numbers of Deaths and Serious Injuries and Illnesses

Please refer to HO 5 (page 31) for a discussion of issues related to the identification of deaths and injuries associated with machines that operate on a specific type of material, such as metal; and, Table 10 (page 33) for data on metal, woodworking and special material machinery. CFOI data demonstrate that fatalities are associated with machines both prohibited and permitted by HO 8 (assuming that some types of machines, such as bending, rolling, and shaping machines work primarily on metal). While CFOI identified 31 fatalities between 1992 and 1997 associated with bending, rolling, or shaping machines, there were also 32 deaths involving presses, 14 involving metalworking lathes, and 12 involving machinery used for grinding and polishing [NIOSH 2001c].

As demonstrated in Table 10 (page 33), injuries requiring at least 1 day away from work have also been associated with these types of machines: 1,733 injuries with 7 median days away from work for bending, rolling, and shaping machines; 2,322 injuries with 4 median days away from work for grinding and polishing machines; and 4,183 injuries with 7 median days away from work for presses. One study suggested that workers less than 19 years of age were more likely than older workers to sustain amputation injuries when operating presses [Jensen and Sinkule 1988].

Evidence for Value of Safety Training

Apprentice/student learner exemptions which are currently permitted under this HO are supported by limited data demonstrating the effectiveness of training. Studies of college students in simulated situations have found training to be effective in decreasing unsafe work practices and injuries associated with operation of power presses and handtools [Rubinsky and Smith 1971; Smith and Rubinsky 1972; Leslie Jr and Adams 1973; Cohen and Colligan 1998].

These studies emphasized the value of hands on experience and simulations.

HO 9: Occupations in Connection with Mining, Other Than Coal

Recommendation — 1) Expand to include all work performed in connection with petroleum and natural gas extraction. 2) Remove the portion of exemption 3 now permitting repair and maintenance of roads, and exemption 4 now permitting work on track crews.

Rationale — 1) Workers throughout the mining industry continue to suffer high numbers and rates of occupational fatalities and injuries, including the oil and gas extraction industry which is currently excluded from HO 9. 2) Removal of these exemptions is consistent with recommendations for new Hazardous Orders addressing construction work and railroad work appearing later in this report (see pages 101 and 113).

<u>High Occupational Fatality Rates and Nonfatal Injuries and Illnesses Throughout the Mining Industry, Including Oil and Gas Extraction</u>

The metal mining (BOC code 040), oil and gas extraction (BOC code 042), and nonmetal mines/quarries industries (BOC code 050) had the 7th, 8th, and 10th highest lifetime risk for fatal injury, 11.2, 10.8, and 7.2 deaths per 1,000 full-time workers, respectively, based on 1990-91 NTOF death certificate data. Coal mining ranked 4th with a lifetime fatal injury risk of 19.1 deaths per 1,000 full-time workers. Lifetime risk for fatal injury, as discussed previously for HO 3 (page 26), is an estimate of average lifetime risk of death for workers in a particular occupation or industry, based on a 45-year working life [Fosbroke et al. 1997].

Workers throughout the mining industry continue to suffer high rates of occupational injury death and large numbers of serious injuries, including in the oil and gas extraction industry which is currently excluded from HO 9. The mining industry had the highest fatality rate of any industry division in 1992-1997, 25.8 deaths per 100,000 workers [NIOSH 2001c; NIOSH 2001a]. The 1992-1997 fatality rate for oil and gas extraction, 25.8 per 100,000 workers, was only slightly lower than the overall industry rate, and was nearly five times the fatality rate among workers in all industries. Table 13 shows that the oil and gas extraction sector accounted for more than half of all mining industry deaths between 1992 and 1997, although substantial numbers of fatalities also occurred in the other three sectors [NIOSH 2001c]. Table 13 also demonstrates the substantial number of injuries and associated disability in the various mining sectors, with the median days away from work far in excess of the median 5 lost workdays reported for all workers [BLS 1999b].

Table 13. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work by Mining Industry Sector, United States.

Industry Sector	Deaths, 1992-1997	Nonfatal Injuries and Illnesses, 1997	Median Days Away from Work, 1997
Metal mining	83	800	33
Coal mining	255	4,987	25
Oil and gas extraction	521	9,550	13
Nonmetallic minerals, except fuels	143	2,732	13
Total	1,002	18,069	18

Source: Census of Fatal Occupational Injuries (Fatalities) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Injuries), Bureau of Labor Statistics [BLS 1999b].

Between 1980 and 1989, NTOF identified 10 fatalities of workers under age 18 in the oil and gas extraction sector [NIOSH 1994a]; however, no additional fatalities of young workers have been identified since 1989 by either NTOF or CFOI. These 10 fatalities involved injury scenarios typical of those experienced by workers of all ages in this industry: electrocution, fall from an oil rig or derrick, being struck by a falling machine part, and explosion of a storage tank.

HO 10: Occupations in the Operation of Power-Driven Meat-Processing Machines and Occupations Involving Slaughtering, Meat-Packing or Processing, or Rendering

Recommendation— 1) Expand to prohibit work in *all meat products manufacturing industries* (SIC 201). Meat products industries include meat packing plants (SIC 2011), sausages and other prepared meat products (SIC 2013), and poultry slaughtering and processing (SIC 2015). 2) Consider a further revision to allow work involving the operation or feeding of meat and food slicers in the retail, wholesale, and service industries. Operation of meat grinders; juice, oil, and fat extractors; and other machines such as bone-cutting saws and meat patty-forming machines should remain prohibited in retail, wholesale, and services industries. 3) Allow student learner/apprenticeship exemptions for the use of meat grinders; juice, oil, and fat extractors; and other machines listed under this HO in retail, wholesale, and service industries, but not for work in meat products manufacturing industries. As defined in the current HO, the operation of these machines would include setting up, adjusting, repairing, oiling, or cleaning [DOL 2001].

Although the suggested revisions would expand the HO to include additional industry sectors which are not encompassed under the existing HO, such as poultry slaughtering and processing, the suggested revisions would also result in some currently prohibited tasks being permitted for youth. Specifically, the proposed revisions would allow youth to operate power-driven meat and food slicers in wholesale, retail, and services industries. If such a revision were to be implemented, it should be accompanied by a mandatory reporting period in which all serious

youth injuries and deaths resulting from previously prohibited activities are promptly reported to the U.S. Department of Labor. This would allow an assessment as to whether the revision should be rescinded or further refined to best protect working youth, while not unnecessarily limiting job opportunities.

Rationale— This is one of the more complex orders. It covers both meat products manufacturing and the operation of meat processing machines in retail, wholesale, and service industries. It applies to butcher shops, grocery stores, restaurants/fast-food establishments, hotels, delicatessens, and meat-locker (freezer-locker) companies, and establishments where any food product is prepared or processed for retail purchase. Sectors and recommendations are described further below.

1) Although injury fatality rates in meat products manufacturing industries are relatively low, rates of disorders due to repeated trauma are extremely high. This is true for poultry processing which is not encompassed in existing HOs, as well as the manufacture of other meat products which for the most part are covered. Repetitive motion disorders, which comprise a portion of repeated trauma disorders, result in substantial days away from work across all industries. In addition to the risk for repeated trauma disorders, there are a number of diverse and serious health hazards associated with the slaughter and manufacture of meat products, including exposure to infectious agents and respiratory hazards. Revising this HO to apply to specific industries instead of occupations or tasks would greatly simplify compliance and enforcement of the HO, and may be a more effective way of protecting youth. The current HO prohibits seven specific types of work associated with meat slaughtering and processing, and may not be all-inclusive of tasks and activities with serious injury and health risks in these industries.

2) Although the title of HO 10 implies that it is limited to meat processing machines, this HO actually includes all occupations involved in the operation, feeding, set-up, adjusting, repairing, oiling, or cleaning of numerous power-driven food processing machines, regardless of the product being processed (including, for example, the slicing in a retail delicatessen of meat, poultry, seafood, bread, vegetables, or cheese). Machines covered include meat and bone cutting saws, meat slicers, and grinders. Available data demonstrate that some types of food processing machines, specifically grinders and juice, oil and fat extractors, are associated with serious injuries, including amputations. Although data show high numbers of injuries associated with power-driven slicers, the injuries appear to be relatively minor. This finding supports the revision of the HO to allow operation of slicers in the retail, wholesale and services industries.

3) A student learner/apprenticeship exemption is not recommended for work in meat products manufacturing industries because of the complexity of measures to prevent repeated trauma disorders, and because these workplaces include diverse hazardous exposures frequently outside the control of individual supervisors or workers. A student learner/apprenticeship exemption is recommended for the use of meat processing machines in non-manufacturing settings. Compared with meat processing machines used in manufacturing, those used in settings such as retail establishments are smaller, less complex machines. Hazards associated with these machines are generally limited to the machines themselves, and may be reduced through worker

training and proper guarding and maintenance. Further, operation of meat processing machines outside manufacturing settings is more likely to be an incidental work task; thus, exposure is likely to be far lower than in a manufacturing facility, where machine operation may be the primary work task.

Occupational Injury and Illness Statistics for the Meat Products Manufacturing Industries

Between 1992 and 1997, CFOI identified 129 occupational fatalities among workers of all ages in the manufacture of meat products (which includes meat packing plants; sausages and other prepared meats; and poultry slaughtering and processing); none of the fatalities were to youth under the age of 18 [NIOSH 2001c]. The fatality rate was 4.8 deaths per 100,000 workers, about the average for all industries [NIOSH 2001c; NIOSH 2001a]. Vehicles were the primary source of fatality (38%), followed by other sources (which include fire, environmental extremes, and bullets)(16%), machinery (13%), and parts and materials (12%).

In 1997, there were an estimated 13,646 occupational injuries and illnesses resulting in days away from work among employees in the meat products manufacturing industry [BLS 1999b]. The greatest number of these injuries and illnesses occurred in meat packing plants (5,526), followed by establishments that produce sausages and other prepared meats (4,147), and poultry slaughtering and processing plants (3,973). For the entire meat products manufacturing industry, the rate of injuries and illnesses resulting in days away from work was 2.8 per 100 FTE, compared with 2.1 for all private industry workers. Within specific meat products manufacturing sectors, workers in sausage and prepared meats plants had the highest rate per 100 FTE, 4.4, compared with 3.6 for meat packing plants and 1.6 for poultry processing plants. The median of 5 days away from work due to injuries or illnesses for all workers in meat products manufacturing was identical to that for workers in all of private industry.

Work in Meat Products Manufacturing Industries is Associated with Significant Risk for Disorders Associated with Repeated Trauma

Repeated trauma, as defined by BLS, includes disorders resulting from repetitive motion (e.g., carpal tunnel syndrome), exposure to noise, and rubbing and abrading as a result of friction or pressure [BLS 1999b]. Workers in meat products manufacturing (SIC 201) have a very high incidence rate of disorders associated with repeated trauma, with a rate of 686 cases per 10,000 full-time workers in 1997 [BLS 1999b]. The rate for meat packing plants specifically was 1,192, while the rate for poultry slaughtering and processing (not currently covered by the HO) was 523. The rate for the manufacture of sausages and other prepared meats was 275, lower than the other types of meat processing industries, but still relatively high. The incidence rates for meat packing plants and poultry processing were well above the threshold of 320 used by NIOSH to define industries where workers face high risk of workplace musculoskeletal disorders [NIOSH 1997b, pages 1-5].

In 1997, an estimated 1,869 workers in the meat products manufacturing industry suffered

repetitive motion disorders requiring days away from work. These disorders accounted for 13.7% of all days-away-from-work occupational injuries and illnesses in the industry, compared with 4.1% in all industries [BLS 2000]. Across all industries, disorders associated with repetitive motion were associated with a median 17 days away from work in 1997 [BLS 1999b]. Information on median days away from work due to repetitive motion disorders was not available for the meat products manufacturing industry specifically.

Although little is known about adverse effects of repeated trauma on adolescent workers specifically, research addressing young athletes suggests that adolescents may be susceptible to growth-related muscle, bone, or tendon injuries [Micheli and Fehlandt 1992]. Premature closure of bone growth plates has been observed in young pianists and gymnasts [Attkiss and Buncke 1998; De Smet et al. 1993]. The relationship between child and adolescent occupational exposure to biomechanical factors and the development of musculoskeletal disorders has been identified in the National Occupational Research Agenda for Musculoskeletal Disorders as a research priority [NIOSH 2001g].

Work in Meat Products Manufacturing Industries is Associated with Other Adverse Health Effects

Work in the manufacture of meat products exposes workers to health hazards such as infectious agents, airborne organic dust, bacterial endotoxins, and hazardous chemicals. Meat handlers, more than most other occupational groups, are at risk for traumatic hand lesions and wound infections [Finkel 1985]. This puts workers at risk for contracting zoonotic infections (infections which occur in both animals and humans) as a result of handling infected animals or their infected secretions or tissues [Cohen 1990; NIOSH 1993a]. Some of these infectious agents such as bovine leukemia virus and bovine papilloma viruses, are carcinogenic in cows, and avian leukosis sarcoma viruses, reticuloendotheliosis viruses, and Marek's virus, are carcinogenic in poultry. It is not known if exposure to these viruses is also associated with carcinogenesis in humans, but increased rates of cancer have been described in meat processing/slaughtering industries [Boffetta et al. 2000; Campbell 1999; Johnson and Griswold 1996; Johnson et al. 1995]. Bacterial endotoxins, which are found in organic dusts, are compounds present on the cell wall of certain bacteria. Ongoing exposure to endotoxins is associated with respiratory diseases and syndromes, including hypersensitivity pneumonitis, organic dust toxic syndrome, chronic bronchitis, mucous membrane inflammation syndrome, and asthma-like syndrome [Kirkhorn and Garry 2000; NIOSH 1992a]. Hazardous chemicals are also present in meat processing settings [NIOSH 1994b]. Use of chlorine and sanitation chemicals in improperly ventilated areas may cause irritation to mucous membranes of the eye, nose, and respiratory tract. Chronic exposure to chlorine may cause chronic obstructive or restrictive lung disease and anosmia (loss of the sense of smell) [Becker 1990].

Deaths and Injuries Associated with Meat Processing and Packing Machinery

It is difficult to identify the numbers of deaths and injuries specifically associated with meat processing and packing machines because of the way occupational injury and illness data are

classified by the OIICS coding system. Machines and equipment used in the processing and packaging of meat products are classified within the OIICS hierarchical coding scheme as special process machinery (OIICS code 37). This category includes subgroups of food and beverage processing machinery (OIICS code 371) and packaging, bottling, and wrapping machinery (OIICS code 373) used for food as well as other products. Meat grinders are the only machines specific to meat processing identified by a separate code (OIICS code 3713). Other codes encompass machines or equipment such as food slicers that could process meat as well as other foods, including fruits and vegetables. Coding guidelines on how bone-cutting saws should be classified – within food and beverage processing machinery (OIICS code 371) or within sawing machinery (OIICS code 357) – are not clear.

Fatal Injuries Due to Food Processing Machinery and Packing Machinery

For the 6 year period 1992 through 1997, there were 46 deaths associated with food processing machinery and packing machinery (OIICS codes 371 and 373), none involving youth less than 18 years of age (Table 14) [NIOSH 2001c; NIOSH 2001d]. Thirty-three of the 46 deaths (72%) occurred within the manufacturing industry division. Of the 33 manufacturing deaths, eight were classified in meat products manufacturing, and 19 in other types of food and beverage manufacturing. Workers in the wholesale, retail, and services industries comprised the 13 remaining deaths, the majority of which did not appear to be associated with machinery used to process or pack foods.

The 46 worker deaths due to food processing machinery and packing machinery were associated with a variety of machines. Workers being caught in meat grinders accounted for five deaths. Deaths associated with other specific types of food processing machinery and packing machinery, including food slicers, were too small in number to meet BLS reporting requirements.

Nonfatal Injuries and Illnesses Due to Food Processing Machinery and Packing Machinery

Nonfatal injuries and illnesses associated with food slicers were frequent (7,280) [BLS 1999b] although rates are not available given the lack of information on the numbers of food slicers in use nationwide. Eighty-six percent of food slicer injuries occurred in retail trades [BLS 1999b]. Injuries from slicers appeared to be relatively minor based on a median of 4 days away from work [BLS 1999b].

Injuries and illnesses associated with meat grinders were less common (315), but appeared to be relatively severe based on days away from work. Median days away from work in 1997 were 18

for meat grinders [BLS 1999b] (Table 14). Sixty-seven percent of meat grinder injuries occurred in retail trades, with 26% occurring in manufacturing industries.

> In 2000, a 15-year-old youth employed by a grocery store had the lower half of his arm severed by a meat grinding machine. The youth's job was to clean up in the meat department, including washing parts of the meat grinder. The youth was instructed to wash and reassemble the meat grinder. The youth reached into the funnel with his right hand to guide the auger screw, and inadvertently activated the "on" switch with another part of his body. The youth's arm was pulled into the grinder, and severed several inches above the elbow. [NIOSH 2000d].

The types of injuries and illnesses associated with meat grinders were further examined using multiple years of SOII data available on CD-ROM [BLS 2000]. From 1994-1999, there were an estimated 1,956 nonfatal injuries requiring days away from work involving meat grinders, requiring an annual average of 11 median days away from work. Amputations accounted for 15% of these injuries (288) [BLS 2000]. NIOSH is recommending that the use of meat grinders continue to be prohibited for youth in the retail, wholesale, and services industries based on the severity and nature of injury, and evidence that these machines result in injury in industries other than manufacturing. An apprentice/student learner exemption is recommended because supervision and training by a qualified and experienced person could reasonably minimize the risks to youth, while providing valuable job skills training. Apprentice/student learner exemptions have stringent requirements for training and ongoing close supervision by a qualified and experienced person.

Juice, oil, and fat extractors were also associated with severe injuries and illnesses, with a median of 22 days away from work (Table 14) [BLS 1999b]. Forty-one percent of injuries from juice, oil, and fat extractors occurred in services industries [BLS 1999b]. It is not possible to separate the number of injuries associated with machines that extract fat from meats from those associated with machines that extract juices or oils from fruits and vegetables. This is not critical for justifying the recommendation to prohibit the use of oil, juice, and fat extractors by youth: other portions of HO 10 prohibit the use of specific powered processing machines regardless of the food being processed.

Table 14. Fatal Injuries and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Food Processing and Packing Machinery, United States

Machinery [OIICS code]	**1[N] or 2[N] Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses, 1[N] Source, 1997**	**Median Days Away from Work, 1997**
Food and beverage processing machinery– specialized, unspecified [3710]	5	308	5
Food slicers [3711]	---	7,280	4
Juice, oil, fat extractors [3712]	---	130	22
Meat grinders [3713]	5	315	18
Mixers, blenders, whippers– food and beverage [3714]	8	712	11
Food and beverage processing machinery– specialized and n.e.c. [3719]	9	771	6
Packaging, bottling, wrapping machinery, unspecified [3730]	---	292	5
Bottling, canning, filling machinery [3731]	---	199	5
Packaging, wrapping, bundling machinery [3732]	10	728	5
Product labeling machinery [3733]	---	133	3
Sealing, stapling machinery [3734]	---	397	14
Packaging, bottling, wrapping machinery, n.e.c. [3739]	5	472	3
Total	46	11,737	---

Source: Census of Fatal Occupational Injuries (Fatalities) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Injuries), Bureau of Labor Statistics [BLS 1999b]. Dashes indicate that BLS reporting requirements were not met.

In summary, the recommendation to prohibit all work by youth in the meat products manufacturing industry sector under HO 10 is strongly supported by the available information. Evaluation of the risks associated with specific machines covered by HO 10 is limited by a lack of injury and fatality data on certain machines, including bone cutting saws and meat patty forming machines. Evaluation of HO 10 is further limited by the inability to calculate injury and fatality rates for any of the machines addressed by this HO.

The information available does indicate that grinders and extractors can cause severe injuries, which supports the case for continued restrictions. The data for operation of meat and food slicers do not indicate risks for fatalities or severe injuries, and thus a case can be made that operation of these types of machines in retail, wholesale, and service industries could be allowed. However, there are a number of reasons to be cautious in proposing this change: data sources do not clearly identify specific food processing and packing machinery involved in fatalities and injuries; injuries from slicers are common; and large numbers of youth are employed in the sectors where these types of machines are used. NIOSH recommends that further evaluation be directed to HO 10 to provide additional consideration of these issues. The implementation of any revision should be accompanied by a mandatory reporting period in which all serious youth injuries and deaths resulting from previously prohibited activities are promptly reported to the U.S. Department of Labor. This would allow additional assessment as to whether the prohibitions should be reinstated or further refined to best protect working youth, while not unnecessarily limiting job opportunities.

HO 11: Power-Driven Bakery Machine Occupations

Recommendation – Consider revising to allow for the operation of "counter-top models" of power-driven bakery machines, comparable to those intended for household use. *If such a revision were to be implemented, it should be followed by a mandatory reporting period in which all serious youth injuries and deaths resulting from previously prohibited activities are promptly reported to the U.S. Department of Labor. This would allow an assessment as to whether the revision should be rescinded or further refined to best protect working youth, while not unnecessarily limiting job opportunities*.

Rationale– Available data suggest that fatal events involving power-driven machines are infrequent, and nonfatal injuries requiring time away from work are of moderate severity. Fatality data identified a small number of fatalities among workers of all ages due to commercial grade bakery machines. None involved counter top models such as those commonly used in the home.

Occupational Injury and Illness Statistics for Food Processing and Packing Machinery

This HO prohibits use of several types of bakery machines, including: horizontal or vertical dough mixers; batter mixers; bread dividing, rounding, and molding machines; dough brakes; dough sheeters; combination bread slicing and wrapping machines; cake cutting band saws; and cookie or cracker machines. There are a number of power-driven bakery machines which are exempted from the HO, including machinery involved in ingredient preparation and mixing, product forming and shaping, finishing and icing, slicing and wrapping, and pan washing. Most of the machines discussed in HO 11, both permitted and prohibited, would be classified as food processing and packing machinery in the OIICS coding system, source codes 371 (food and beverage processing machinery) and 373 (packaging, bottling, and wrapping machinery),

respectively. However, OIICS codes 371 and 373 also encompass many machines not addressed by HO 11 (e.g., meat grinders).

> In 2001, a 16-year-old worker died while cleaning a dough mixer in a pizzeria. The youth was cleaning the machine when he became entangled in the beaters and was pulled into the machine. The youth was working alone at the time, and it is unclear how he became entangled in the machine [Associated Press 2001].

A review of CFOI data for 1992 through 1997 provided information on 10 fatalities to workers of all ages involving power-driven bakery machines prohibited by HO 11. The majority of the cases (80%) involved large commercial mixers. No fatalities were reported that involved counter top bakery machines. Work with mixers, blenders, and whippers (OIICS source code 3714) was associated with 712 non-fatal injuries and illnesses in 1997, with a median of 11 days away from work [BLS 1999b].

As with HO 10, it may be prudent to perform some additional evaluation given the lack of specificity in the available data. Implementation of any revision should be accompanied by a mandatory reporting period in which all serious youth injuries and deaths resulting from operation of powered bakery machines are promptly reported to the U.S. Department of Labor. This would allow additional assessment as to whether the prohibitions should be reinstated or further refined to best protect working youth.

HO 12: Power-Driven Paper-Products Machine Occupations

Recommendation — 1) Retain the current HO and incorporate the requirements of the Compactor and Baler Act (Public Law 104-174, August 6, 1996). 2) Expand the HO to include machines such as balers and compactors used to process other materials such as aluminum cans, plastic, foam, and rubber. 3) Continue to emphasize enforcement of portions of the Compactor and Baler Act requiring balers to conform to construction and operational standards that greatly reduce exposure to hazardous energy. 4) Retain the apprenticeship/student learner exemption currently allowed under this HO. These recommendations are consistent with the 1999 NPRM published by DOL and with previous NIOSH comments in support of the proposed rule [64 Fed. Reg. 67130 (1999); NIOSH 2000a].

Rationale — 1) Power-driven paper products machines are associated with a substantial number of worker deaths and injuries. 2) Balers and compactors used to process other scrap materials such as plastic and aluminum cans pose similar risk of injury from crushing or amputation, and are identified in injury and fatality data. 3) Investigations of baler-related incidents show that failure to maintain machinery in safe operating condition contributes to fatalities and serious injuries, and that neither adult supervisors nor young workers may fully appreciate the risks posed by uncontrolled hazardous energy. 4) An apprentice/student learner exemption is still appropriate as long as training of young workers to recognize injury hazards is accompanied by careful monitoring by adult supervisors and regular inspection and maintenance of balers.

Substantial Numbers of Deaths and Injuries Are Associated with Paper Balers and Compactors

The OIICS system does not include a source code that can be used to identify deaths and injuries associated with balers and compactors. Cases were identified in the CFOI system by searching narrative fields for mention of balers and compactors, then manually reviewing identified cases. The number of cases identified by CFOI using this method should be considered a minimum number of cases. Narrative fields in CFOI frequently do not specify the kind of machine involved. Thus, an unknown number of fatalities associated with balers and compactors are not identified.

A review of cases from CFOI for 1992-1997 provided information on 29 fatalities involving balers or compactors [NIOSH 2001c]. The majority of the cases (59%) involved crushing injuries. Nine deaths (31%) were in the scrap and waste

> In 2000, a 16-year-old worker in a produce market died from crushing injuries when he was caught in the vertical downstroke baler he was operating. The youth, working alone in the basement of the produce market, was using the baler to crush cardboard boxes when he was caught by the machine's hydraulic ram. After the incident, it was determined that the machine's safety interlock had been bypassed, allowing the machine to operate with the loading door in the open position. The youth may have reached into the baling chamber while the machine was operating, and was caught by the ram as it cycled [NIOSH 2001i].

materials industry (SIC 5093), which includes recycling facilities. Eight other fatalities (28%) occurred in a wide range of manufacturing settings. Paper or cardboard balers were specified in 11 of the 29 cases (38%). Other fatalities involved machinery for baling or compacting scrap metal, trash, cans, plastic wrap, and cotton.

In eight of the CFOI cases, the decedent was trying to clear a jam in the machine when the fatality occurred [NIOSH 2001c]. Other fatalities occurred when a co-worker, not knowing someone was in the machine, turned it on, or were due to the machine automatically activating once the jam was cleared. Overall, in almost half of the cases (48%), the machine was either already on, or a co-worker unknowingly activated the machine to cause the fatality. In 17% of the cases the fatality occurred when the decedent fell into the machine.

Substantial numbers of non-fatal baler-related injuries have also been reported. More than three years (Oct. 1, 1996 - Dec. 31, 1999) of data from the National Electronic Injury Surveillance System (NEISS), which provides surveillance of non-fatal occupational injuries presenting to hospital emergency departments, were examined. Again, text searches of narrative fields were used to identify cases. Thus, these estimates of emergency department treated injuries should be considered a minimum number of cases. Paper balers and box compactors accounted for an estimated 2,625 injury reports nationwide. Of these injuries 32% resulted in a crush/contusion, 29% lacerations, 25% sprain/strains, and 14% other injuries including fractures and dislocations. Almost half of the injuries occurred in either a retail or grocery store, with 24% occurring in manufacturing [NIOSH 2001b].

Investigations of Baler-Related Fatalities Identify Injury Risk Factors

Between 1993 and 2000, NIOSH investigated 11 baler-related incidents that resulted in 10 fatalities and one case of a double amputation [California Department of Health Services 1995; Colorado Department of Health 1994a; Massachusetts Department of Health 1996; New Jersey Department of Health and Senior Services 1993, 1995, 1996; NIOSH 1996a; NIOSH 1997c; NIOSH 1997d; Texas Workers' Compensation Commission 1998]. The materials being processed were paper, cardboard, newspaper, trash, and plastic milk jugs. These investigations identified the presence of risk factors influencing the likelihood of injury for workers operating, loading, servicing, and maintaining balers and compactors. In 10 of the cases, uncontrolled hazardous energy and absence of an effective training program contributed to the risk of injury or death. In five cases, machine safeguards were absent and in three cases, there was insufficient supervision/observation of the employee.

The investigations also found that the balers and compactors were routinely used to process other scrap materials, such as plastic and aluminum cans. The machines involved in seven of the cases were known to be prone to material jams. In five of the incidents, the victim was injured after entering or falling into the operating machine during attempts to clear jammed material. Three of the incidents were unwitnessed, but evidence strongly suggests that a jam had occurred prior to the victim entering the machine. The victim was located in an unsafe loading position in

one of the incidents. In another incident, the victim was injured while attempting to retrieve material which had been mistakenly loaded into the compactor. Investigators were unable to determine the manner and reason for the victim's entry into the baler during the remaining incident.

In 1996, a 17-year-old youth employed at a recycling center suffered amputation of both legs after he fell inside a horizontal hydraulic baler. The victim and three co-workers had been loading cardboard into the baler via an inclined conveyor belt when the cardboard jammed in the baler's feed chute. The victim shut down the conveyor and climbed the belt to the feed chute opening, clearing the jam by holding onto the top cover of the baler feed chute and pushing with his feet. When the jam cleared, he fell through the feed chute into the baling chamber. Before he could climb out, the ram automatically activated, cycled into the baling chamber, and amputated his legs near the knees [NIOSH 1997c].

Machines Used to Bale and Compact Paper Products Are Also Used to Compact Other Materials

Fatality data from surveillance systems and from field investigations show that baler and compactor-related deaths are not limited to those in which paper or cardboard is being processed. Many machines are adaptable for baling and compacting a wide variety of materials – paper, aluminum cans, plastic milk jugs, and general household refuse. Others are intended specifically for processing a single product, usually metals. These specialized metal balers and compactors, which handle items such as cars, radiators, and siding, often feature shear blades that may not be present on lighter-duty balers. While these and other large stationary balers are generally found in facilities that specialize in processing scrap and waste materials, smaller general-purpose portable machines are marketed for use in businesses such as grocery stores, hotels, restaurants, and hospitals. Smaller balers found in these and other retail and services establishments operate in essentially the same way as larger balers, and present similar risks of injury.

Other Power-Driven Paper Products Machines Are Also Linked to Deaths and Injuries

Employees who work on or around paper production machinery risk being caught in running machinery, being struck by falling paper rolls, falling from machinery, and being electrocuted. Paper production machinery (OIICS code 374) was involved in 26 fatalities between 1992 and 1997 among workers of all ages [NIOSH 2001c], and 867 nonfatal injuries and illnesses in 1997 [BLS 1999b] (Table 15). OIICS code 374 includes subcategories for some of the machines either explicitly included or excluded under HO 12 (calenders, coaters, dryers, formers, slitters, winders, washers, bleachers, and refiners) but does not allow for identification of other machines also specified in HO 12. Further, case narratives often do not specify machinery involved to the same level of detail found on the lists of inclusions and exclusions under this Hazardous Order. However, there are several types that can be identified. Most prominent are paper winders and rewinders, which are now specifically excluded from HO 12, with eight fatalities. The other paper production machines associated with fatalities were coating machines (now excluded from

the HO); pulpers, repulpers, and paper dryers (neither included nor excluded); and corrugators (included and therefore now prohibited for youth).

Table 15. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Paper Production Machinery, United States

Machinery [OIICS code]	**1^N or 2^N Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses (1^o source), 1997**	**Median Days Away from Work, 1997**
Paper production machinery, unspecified [3740]	8	229	5
Slitters, winders – paper production [3745]	8	332	7
Paper production machinery, n.e.c. [3749]	—	257	6
Other specified paper production machinery [3741, 3742, 3743, 3744, 3746]	6	49	—
Total	26	867	6

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b]. Dash indicates that no data were available.

Current Injury Data Preclude Assessment of Risk Associated with All Machines Covered Under This HO

As discussed above, it is difficult to identify deaths and injuries associated with paper balers and compactors as the OIICS provides no source code that allows identification of these machines. Balers and compactors are now subsumed under the "Other machinery" category which includes all machines not covered by other OIICS codes, and can only be identified through text word searches of case narratives, which frequently do not specify the kind of machine involved. NIOSH will recommend to the Bureau of Labor Statistics that separate codes that distinguish between horizontal balers and vertical upstroke or downstroke balers be established. Horizontal balers with conveyors are most often used in large recycling centers or manufacturing facilities, while vertical balers are used in retail establishments at which youth are frequently employed.

A similar problem exists for other types of machines covered under this HO. Although there is a

separate OIICS source code for paper production machinery, there is not sufficient detail in the existing coding structure to determine if all current prohibitions under this HO are justified, or if specific machines now excluded from the HO ought to be prohibited. Paper rewinders, excluded from this HO but for which there is a separate OIICS code, were associated with nine fatalities between 1992 and 1997 [NIOSH 2001c]. There is no mechanism for tracking fatalities due to other machines now excluded from the HO, such as creping, parchmentizing, and bundling machines. NIOSH will recommend to the Bureau of Labor Statistics that OIICS codes for paper production machinery be modified to cover additional machines specified in HO 12.

Additional Training is Needed for Effective Injury Prevention

The Compactor and Baler Act (PL 104-174; August 6, 1996) specifies conditions under which youth can load certain types of balers. These conditions include compliance with the voluntary American National Standards Institute (ANSI) standard for compactors and balers, which includes training provisions [ANSI 1997a; ANSI 1997b]. While the ANSI standards stipulate training requirements for workers assigned to operate, maintain, and service balers and compactors, NIOSH investigations indicate that additional training is needed for effective injury prevention. For those workers assigned to load only, but not operate, service, or maintain the machines, the training should address safe loading procedures, the recognition of operational hazards and the hazards associated with entering energized machines. NIOSH investigations further indicate that the employer's supervisory and lead personnel should be trained to recognize the need for increased observation of youthful workers, and to understand the prohibitions against minors operating and servicing balers and compactors.

HO 13: Occupations Involved in the Manufacture of Brick, Tile, and Kindred Products

Recommendation— Retain the current HO

Rationale— Work in occupations involved in the production of clay construction products, including brick, tile, and other clay products, and silica brick or other silica refractories continues to be hazardous to workers of all ages. Although injury fatality rates are comparatively low, occupational exposure to respirable crystalline silica in this industry is strongly associated with chronic, debilitating, and sometimes fatal lung disease. Further, inhaled crystalline silica from occupational sources has been classified as carcinogenic to humans by the International Agency for Research on Cancer [IARC 1997].

Fatal Injuries and Nonfatal Injuries and Illnesses Associated with the Manufacturing of Brick, Tile, and Kindred Products

During the 6-year period 1992-1997, CFOI identified 15 deaths associated with the manufacturing of structural clay products (SIC code 325), and a rate of 6.8 deaths per 100,000 workers [NIOSH 2001c; NIOSH 2001a]. During 1997, there were 1,340 injuries and illnesses resulting in days away from work, with a median of 6 days away per injury [BLS 1999b].

Workers May Be Exposed to Silica Dust which Is Associated with Decreased Lung Function and Silicosis

Workers in the brick- and tile-manufacturing industries are exposed to varying amounts of free silica dust. Exposure to respirable crystalline silica dust in these industries is associated with the development of silicosis, lung cancer, pulmonary tuberculosis, and airway diseases such as chronic obstructive pulmonary disease and bronchitis [NIOSH 2001j; Zuskin et al. 1998; Liou et al. 1996; Burge et al. 1995; Myers and Cornell 1989]. Silicosis is a irreversible, sometimes fatal interstitial lung disease caused by the pulmonary response to inhaled crystalline silica [Wagner 1997]. Severity of disease is related to exposure level, duration of exposure, and cigarette smoking [Zuskin et al. 1998; Liou et al. 1996; Myers 1989]. Acute silicosis occurs following exposure to very high concentrations of silica dust, within 2 weeks or up to 5 years. Accelerated silicosis occurs after 5 to 10 years of continued exposure, and chronic silicosis, the most common form of the disease, occurs with insidious onset after at least 10 years of overexposure. Chronic silicosis increases the risk of mycobacterial (tuberculous or non-tuberculous) infections [Elmes 1994]. An analysis of national mortality data from the U.S. National Center for Health Statistics [Althouse et al. 1995] demonstrated that tuberculosis is about 20 times more likely to be listed as a cause of death in decedents with silicosis compared to decedents without silicosis. Evidence has also associated exposure to high levels of crystalline silica with increased rates of autoimmune diseases, including scleroderma, rheumatoid arthritis, and systemic lupus erythematosus [Parks et al. 1999].

In a cluster of 4 cases of acute silicosis in sandblasters in a single tombstone factory, a 23-year-old black male smoker, with exposure to crystalline silica for a period of 2.5 years, died with silicosis confirmed by lung biopsy, and complications of tuberculosis and renal failure [Suratt et al. 1977]. This case demonstrates that although silicosis usually occurs in older workers after many years of exposure, young workers are also at risk after relatively brief periods of exposure to respirable silica dust.

Inhaled Crystalline Silica Is Carcinogenic to Humans

In 1997, the International Agency for Research on Cancer concluded that there is a causal relationship between exposure to crystalline silica and human cancer and classified crystalline silica as a Class 1 carcinogen [IARC 1997]. The increased risk for lung cancer has been shown primarily in workers who have developed silicosis [Finkelstein 1998; Hnizdo et al. 1997; Amandus et al. 1995].

HO 14: Occupations in the Operation of Power-Driven Circular Saws, Band Saws, and Guillotine Shears

Recommendation – 1) Revise definition of machinery covered by this HO to include other machines, such as chainsaws, which perform cutting and sawing functions through direct contact between the cutting surfaces and the material (the current definition is based on the presence of a continuous series of notches or jagged teeth). *Alternatively, NIOSH encourages DOL to consider developing a new HO that combines the sawing machinery covered under this HO with other specialized machinery that performs cutting and sawing functions through direct contact of the cutting surface and the material.* 2) Retain the exemption for apprentices/student learners, except in the case of chainsaws and other hand-held power saws.

Rationale – 1) Stationary saws and hand-held power saws, including chainsaws, continue to be the source of substantial numbers of fatalities as well as nonfatal injuries, which may be unusually severe. The HO bases the definition of prohibited machines on the presence of a continuous series of notches or jagged teeth. Not all machinery that perform cutting or trimming functions have visible notches or teeth, e.g. chainsaws or abrasive cutting discs which perform the same function. 2) For stationary saws and shearing machines, an apprentice/student learner exemption is warranted given that means of controlling hazardous energy associated with these machines are well-understood, and that the hazards are generally confined to the machine itself. In contrast, hand-held power saws, including chainsaws, are used in less controlled conditions, often in construction and logging operations. Injury risk factors associated with hand-held power saws are more diverse, and more difficult to recognize and eliminate.

<u>Worker Deaths and Injuries Are Associated with Power-Driven Stationary and Hand-Held Saws, and Shearing Machines</u>

The Census of Fatal Occupational Injuries (CFOI) for 1992-1997 identified a total of 151 deaths associated with stationary sawing machinery, chainsaws, powered hand-held saws other than chainsaws, and shearing machines of all types (Table 16) [NIOSH 2001c]. For all these machines combined, the highest numbers of fatalities occurred in the manufacturing industry (which includes logging and sawmills) (84 deaths), followed by the construction industry (31 deaths).

The primary hazards associated with the 46 fatalities related to stationary saws were being caught in running machinery (17 deaths), and being struck by flying objects (12 deaths) [NIOSH 2001c]. In this group, there were also fatalities resulting from electrocution and other types of contact with objects. The 29 fatalities related to use of hand-held power saws were associated with a wide variety of hazards. The single most common event was being struck by a swinging or slipping object (9 deaths), with many of the case reports consistent with kickback or loss of control of the hand-held power saw. However, use of these saws was also associated with electrocution, being struck by falling trees, explosions, and carbon monoxide poisoning. Among the 70 chainsaw-related fatalities, the primary fatal events were being struck by a tree (38

deaths) and being struck by a swinging or slipping object (16 deaths). The majority of the latter events involved kickback of the chainsaw. There were seven fatalities associated with shearing machines, six classified into OIICS code 3152 (shearing machines), and a seventh identified through a keyword search of the CFOI injury narrative. In five of the seven fatalities associated with shearing machines, the worker was caught in running machinery.

In 1997, machines covered under this HO were the source of 10,484 nonfatal injuries and illnesses requiring days away from work. Chainsaws, not currently covered under this HO, contributed to another 1,627 injuries. Injuries and illnesses associated with hand-held power saws appear to be particularly severe, with a median 13 days away from work [BLS 1999b].

Table 16. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Stationary Sawing Machinery, Powered Saws, and Shearing Machines, United States

Machinery [OIICS code]	**1^N or 2^N Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses (1^o Source), 1997**	**Median Days Away from Work, 1997**
Sawing machinery – stationary [357]	46	7,415	8
Chainsaws – powered [7221]	70	1,627	10
Hand-held saws – powered, except chainsaws [7224]	29	2,762	13
Shearing machines [3512]	6	307	3
Total	151	12,111	---

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b]. The dash indicates that no data were available.

HO 14 May Now Exclude Similar Machinery that Poses Significant Injury Risk

The current HO bases the definitions of circular saws and band saws on the presence of continuous series of notches or jagged teeth. Not all machinery that performs cutting or trimming functions has visible notches or teeth, e.g., chainsaws or

> In 1995, a 17-year-old youth in New Mexico was killed when he lost control of the chainsaw he was operating. It was his first day on the job [NIOSH 1995a].

abrasive cutting discs which perform the same functions. Available data demonstrate that chainsaws specifically contributed to 70 worker deaths between 1992 and 1997, and over 1,600 lost workday injuries. It is the potential for contact with the moving disc or band, rather than notches or teeth alone, that creates the greatest injury risk from this group of sawing and cutting machines. CFOI data that show the predominance of caught-in-running-machinery incidents support this argument. Thus, the definition of "saw" under this HO may exclude certain machines similar to circular and band saws that present injury risks from unguarded cutting surfaces, despite the absence of visible notches or teeth.

HO 15: Occupations Involved in Wrecking, Demolition, and Shipbreaking Operations

Recommendation— Retain the current HO.

Rationale— The wrecking, demolition, and shipbreaking industries are associated with large numbers of fatal and severe nonfatal injuries. Wrecking, demolition, and shipbreaking also expose workers to potentially lethal and carcinogenic substances, including asbestos, lead, polychlorinated biphenyls (PCBs), as well as other toxic substances.

Wrecking, Demolition, and Shipbreaking Operations Are Associated with Fatal and Nonfatal Injuries

> In 1996, a 16-year-old laborer was electrocuted while salvaging conductors and electrical equipment from an inactive oil field. The youth, working as a summer hire for an electrical contractor, was coiling de-energized power lines that had been released by the 25-year-old crew leader. When one of the lines was cut, tension on the pole caused the de-energized line that the victim was holding to contact a nearby energized, 7,200-volt power line, energizing the salvage power line [NIOSH 1996b]

During the 6-year period 1992-1997, 129 deaths were identified by CFOI in wrecking and demolition industries. Of these, 109 were identified as occurring in establishments coded as SIC 1795 ("Wrecking and Demolition Work"), and an additional 20 were identified by a keyword search ("wreck" or "demoli") of narrative information. Among the 109 fatalities to employees of demolition contractors (SIC 1795 only), 56% were employed as laborers. The primary work tasks associated with these deaths were construction, repair, or cleaning (58%). The predominant events leading to fatalities were being struck by a falling object (22%), being caught in or crushed by a collapsing structure (20%), and falling from a roof (11%) [NIOSH

> In 1998, a 17-year-old male laborer, who was working on the dismantling of a section of railroad tracks, died when a bulldozer on which he had been riding overturned and fell on top of him. The bulldozer, also driven by a 17-year-old, was being driven across a trestle, partially on a catwalk that was not designed to carry such a load [Minnesota Department of Health 1998].

2001c]. Fatal injury rates could not be calculated because employment data were not available.

Shipbreaking, meaning any kind of breaking down of a ship for the purpose of salvaging and selling its scrap-metal and other components, is classified within SIC 4499, "Water Transportation Services, Not Elsewhere Classified." This group also includes industries such as boat rental, boat chartering, and piloting. Narratives for all fatalities in this group were examined, and no fatalities involving shipbreaking were identified.

Englund and Cohn [1997], investigative reporters with the Baltimore Sun Newspaper, documented fatal and severe non-fatal injuries in shipbreaking operations in the U.S., in a Pulitzer Prize-winning series of articles about the industry. Extremely hazardous working conditions were described in shipbreaking operations in Texas, Maryland, North Carolina, California, and Rhode Island. Three workers died within 12 months of each other at two shipbreaking operations, in Texas and North Carolina. A 43-year-old worker who was working in total darkness without safety equipment, fell 30 feet into a tank and died 2 days later due to his injuries. In the same yard, a 58-year-old laborer was killed while walking across a scrapyard when he was struck by a large piece of bulkhead being cut by another worker. An OSHA investigation in a North Carolina scrapyard revealed that the death of a worker, killed when he was struck by a piece of metal thrown from a pipe-splitting alligator shear, could have been prevented if the alligator shear had the required safety guards. The same North Carolina scrapyard was cited by OSHA for safety violations after a 28-year-old worker, who was cutting steel pipes in the engine room of a destroyer, suffered severe burns, a fractured leg, and temporary blindness in an explosion. A torch had ignited vapors which had accumulated in the room. Other instances of safety violations were also described.

> In 1989, a 15-year-old laborer was working alone in the basement of an abandoned 3-story building and was trapped for 2 hours when the structure collapsed. He had been salvaging bricks from a column that was supporting the building. He was rescued by emergency personnel and suffered minor injuries [NIOSH 1995b].

<u>Workers in These Industries May Be Exposed to Asbestos, Lead, Polychlorinated Biphenyls (PCBs), and Other Toxic Substances which Cause Severe Illness and Cancer.</u>

Many older structures and ships which are demolished contain asbestos in insulation, lead in paint, and polychlorinated biphenyls, which were used extensively in the past for electrical insulation, air system gaskets, and fluorescent light fixtures. Other toxic substances may also be present [Klitzman et al. 1994; Balco and McKenna 1994; Jaques 1994; Pigg 1994; Oliver 1994; IARC 1977, pp. 29-32]. Englund and Cohn [1997] described cases of improper handling of toxic substances in ship-scrapping yards. They found OSHA records revealing that in a yard in California, workers were told to lie to investigators about the mishandling of asbestos. A yard in North Carolina was cited for not training workers to properly remove asbestos, not providing

protective suits, and not providing medical screening. In Rhode Island, a state agency discovered unsafe practices in a scrapyard which had no fire watches, did not monitor for lead and asbestos, and did not have an approved plan for PCB removal. A worker in Texas described "burning cables," the illegal practice of burning the PCB insulation off copper cables [Englund and Cohn 1997].

Exposure to asbestos is associated with chronic, fibrotic, interstitial lung disease, as well as malignant mesothelioma, lung cancer, and cancers of the larynx and gastrointestinal tract [Wagner 1997; IARC 1987, p. 108]. The risk of lung cancer after exposure to asbestos rises multiplicatively in the presence of smoking [IARC 1977, p. 69].

Lead poisoning in demolition workers can result from inhalation or ingestion of inorganic lead during abrasive blasting, welding, cutting, and torch burning of surfaces coated with lead-based paint, lead pipes and solder, and other lead building material. Acute, high-dose exposure may cause anemia, abdominal colic, peripheral neuropathy, central neuropathy, nephropathy, and sterility. Tremors, stupor, seizures, and coma may occur in severe poisoning in which blood levels rapidly rise to over 100 mcg/dL. Lower-level, chronic, or recurrent exposure may lead to non-specific symptoms and more subtle organ damage [Levin and Goldberg 2000].

PCBs were commonly used in a variety of industrial applications from the 1930's until the 1970's. Demolition workers and shipbreakers may be exposed to PCBs if they are working on structures built during that time. PCBs were primarily used for their insulating, fire resistance, and dielectric properties in electrical transformers and capacitors, but can also be found in lubricants, sealants, paint, plastics, newspaper print, and dyes, many of which laborers may come into contact with in demolition operations. The Environmental Protection Agency (EPA) banned their production in 1978 when the adverse health effects of PCBs were recognized (Public Law 94-469). A review of mortality studies of exposed workers reported higher than expected rates of several types of cancer, including melanoma, and cancers of the liver, rectum, gastrointestinal tract, brain, and hematopoietic system [Kimbrough et al. 1999]. PCBs are considered potentially carcinogenic to humans by NIOSH [NIOSH 1986a], the EPA [EPA 1980], and IARC [IARC 1987].

HO 16: Occupations in Roofing Operations

Recommendation — 1) Expand current HO to include all work performed on roofs. The HO should not be limited solely to roofing operations that involve construction, maintenance, and repair of roofs. 2) Remove the exemption for apprentices/student learners. These recommendations are consistent with the 1999 NPRM published by DOL and with previous NIOSH comments in support of the proposed rule [64 Fed. Reg. 67130 (1999); NIOSH 2000a].

Rationale — 1) All work on roofs, including work unrelated to the construction, maintenance, and repair of roofs, is associated with high numbers of work-related injury deaths and serious injuries among adults and youth. Work on roofs presents fall hazards and frequently places

workers in close proximity to overhead power lines. 2) The diverse hazards of working on roofs make an exemption for apprentices or student learners inappropriate. Close supervision and training will not sufficiently reduce the risk of fatal injury. The high risk of fatal injury in the roofing occupation among all workers also supports the removal of an exemption.

Hazards of Working on Roofs

Work on roofs is associated with falls from heights and contact with electrical energy. Workers are exposed to serious injury and death from falls that arise from:

- stepping or falling into roof openings created for skylights
- stepping, falling, or sliding off the roof edges after tripping or losing balance
- stepping on unsupportive roofing materials, such as insulation or rotten roofing
- placing weight on poorly secured structural members (e.g., rafters), or nonstructural roof attachments (e.g., gutters)
- being knocked off balance by loads on cranes and material hoists
- falling through a skylight
- being blown over when handling sheets of plywood
- falling when a ladder slips or collapses
- falling due to failure or collapse of scaffolding
- stepping onto or off of a roof from either a ladder or a scaffold

> In 2000, a 16-year-old male construction framing crew-member died after a 27-foot fall from the roof of a building under construction. The youth had been moving a roof truss into place for installation, supporting himself on an 8-inch-wide structural beam. The youth fell into the interior of the building and was fatally struck on the head by one of the trusses that also fell [NIOSH 2000d].

Workers may sustain serious burn injuries and electrocution from inadvertent contact with electrical wiring or with electrical power transmission lines. Contact may either be direct, where the employee actually touches an uninsulated power line, or indirect, where the employee is holding a conductive object (e.g., an aluminum gutter, ladder, or antenna) and the object contacts the power line.

The Roofing Occupation Has One of the Highest Lifetime Risks of Work-Related Injury

The hazards associated with work on roofs is reflected in the risk of occupational fatal injury among roofers. The roofer occupation is among the occupations at highest lifetime risk of fatal work-related injury among workers of all ages [Fosbroke et al. 1997] and one of the riskiest occupations in the construction industry [Chen and Fosbroke 1998]. Roofers had a lifetime risk of 9.4 deaths per 1,000 working lifetimes in 1990 and 1991, ranking 16th among all occupations [Fosbroke et al. 1997]. Fatality data from CFOI indicate that between 1992 and 1997, the annual rate of work-related fatality was 28.8 deaths per 100,000 roofers [NIOSH 2001c; NIOSH 2001a]. Falls accounted for 71% (233) of the 326 fatalities identified during that period.

Work on Roofs is Associated with Fatal Falls

During the period 1992 to 1997, 803 work-related fatal falls from roofs occurred [NIOSH 2001c]. The majority of fatal falls from roofs occurred in the construction industry, followed by services, manufacturing, agriculture, and wholesale or retail trades (Table 17). From 1982 to 1997, the NIOSH Fatality Assessment and Control Evaluation Program investigated 26 fatalities in which a worker fell from or through a roof [NIOSH 2000e]. Investigators identified the following factors associated with roof-related falls: unguarded roof openings; unsecured or unstable materials; and loss of balance. Four of the fatalities were associated with falls through skylights. Failure to provide standard skylight covers or fixed standard railings on all exposed sides as required by OSHA General Industry Standards [29 CFR 1910.23(a)(4)] contributed to the skylight-related fatalities.

> In 1998, a 15-year-old youth died while working as a window washer's helper. The youth had been standing on the roof assisting the window washer with the set up of the rooftop carriage supporting the boatswain's chair. As the window washer bounced in his chair to check the stability of the apparatus, the carriage, which had not been tied back to an anchor and had no counter weights attached, slipped over the edge of the roof. The two workers' fall protection harnesses were tied to the carriage, causing them both to fall. The window washer was severely injured and the youth was killed. [Washington Department of Labor and Industries 2001].

Table 17. Number and Percent of Fatal Falls from Roofs By Industry Division, United States

Industry Division	**Deaths, 1992-1997**	**Percent**
Construction	651	81.1
Services	39	4.9
Manufacturing	30	3.7
Agriculture	25	3.1
Wholesale or retail trades	21	2.6
Other	37	4.6
Total	803	100

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Among young construction workers less than18 years of age during the period 1992 through 1997, 12 fatal falls occurred, three-fourths of which involved falls from or through roofs and

skylights. In comparison, these types of falls accounted for only one third of fatal falls in construction workers of all ages [Windau et al. 1999].

Non-Fatal Falls from Roofs Are Severe and Result in Many Days Away from Work

In 1997, falls from roofs accounted for 3,341 total non-fatal work-related injuries and illnesses. The median of 30 days away from work for these types of injuries indicates that they are commonly severe. Approximately 45% of these injuries and illnesses resulted in 31 or more days away from work. Less than 25% of the injuries and illnesses resulted in fewer than 6 days away from work [BLS 1999b].

Work on Roofs Increases Proximity to Overhead Power Lines and Risk of Electrocution

From 1992 through 1997, there were a total of 1924 deaths due to electrocution. This includes injuries resulting from contact with any energized source of power, including lightning. Direct or indirect contact with overhead power lines accounted for 778 of these deaths. A keyword search (keyword=roof) of the narrative descriptions of these 1924 electrocution cases revealed that the victim was working or preparing to work on a roof in at least 66 cases. Based on manual review of these 66 cases, 41 victims were electrocuted when they or long metal items they were holding came into contact with a power line. Seventeen of the victims came into direct contact with electrical currents such as ungrounded wiring, air conditioning or refrigeration units. Seven workers were struck by lightning while working on a roof. Sixteen of the 66 were employed as roofers, 17 were construction laborers, and 11 were carpenters. Other occupations included heating and air conditioning mechanic, electrician, plumber or pipe fitter, stock handler, and structural metal worker [NIOSH 2001c].

> In 1986, a 17-year-old part-time laborer was electrocuted and another 17-year-old severely injured while cleaning soot from a smoke stack on the flat roof of a two-story building. The victim and his coworker could not reach the smoke stack with the metal scraper they had been given. Without a supervisor present, they decided to improvise an extender with a 9-foot piece of metal pole. As the victim was carrying the pole, it contacted a 7200 volt power line which was 13 feet, 3 inches above the surface of the roof and electrocuted him. His co-worker was severely injured when he attempted to help [NIOSH 1986b].

HO 17: Occupations in Excavation Operations

Recommendation – 1) Retain the current HO. 2) Remove the exemption for apprentices/student learners.

Rationale – 1) Excavation and trenching operations are associated with large numbers of worker deaths, including deaths among young workers. 2) This work environment presents injury risks due to collapsing earth, machinery, falling objects, fires, explosions, drowning, and

electrocution. Nearly three-fourths of the fatalities involved collapsing earth in trenches and excavations. This hazard can be reduced or eliminated only by sloping, shoring, or installation of trench shields: interventions which require action by a supervisor or other responsible party. Therefore, individual workers have little or no control over their exposure to this hazard, and neither training in safe work practices nor use of personal protective equipment will reduce the risk sufficiently. These factors, along with the diversity of injury hazards present in this work environment, support removal of the exemption for apprentices/student learners.

Substantial Numbers of Worker Deaths and Injuries Are Associated with Excavation Operations

Like HO 15, HO 17 addresses a range of work settings rather than work within a specific industry or involving a specific machine. For this reason, identification of fatalities and injuries associated with work in trenches, excavations, tunnels, and shafts is difficult, and involves a degree of subjectivity. CFOI for 1992-1997 contained 355 cases whose case narrative was consistent with this work setting, and which met one or more of the following criteria: "trench,", "excav," "shaft," or "tunnel" appeared in the narrative; the deceased was employed in SIC 1794 (Excavation Contractors); or the fatal event was coded as an excavation or trenching cave-in (OIICS event code 041) [NIOSH 2001c].

In 1997, a 17-year-old construction laborer died of injuries sustained in a trench cave-in at an oil tank removal site. The youth was in a 12-foot-deep trench, using a gas-powered saw to cut the rods which held the tank in the ground. The trench was neither shored nor sloped. The youth had finished cutting three rods when the side wall of the trench collapsed. He was pushed up against the tank by the force of the soil, striking his head on the tank. After being removed from the trench by emergency personnel, the youth was transported to a nearby hospital, where he was pronounced dead on arrival [Massachusetts Department of Public Health 1998b].

As Table 18 shows, the primary injury hazard during excavation operations was collapsing earth, in most instances due to trench collapses. However, nearly one-fourth of the fatalities were associated with other types of hazards, notably machinery. In the majority of these events, a worker in a trench or excavation was struck by a machine part, usually a bucket. The 13% of fatalities not associated directly with collapsing earth or machinery were due to a wide variety of events: electrocution, fires and explosions, drowning, and being struck by falling objects. Workers employed in the construction industry accounted for 80% of the fatalities, but deaths also occurred among workers in a range of other industries [NIOSH 2001c].

Table 18. Characteristics of Deaths Associated with Work in Trenches, Excavation Operations, Tunnels, and Shafts, United States

	Deaths 1992-1997
Injury hazard	n (%)
Collapsing earth	265 (74.6%)
Machinery	44 (12.4%)
Other	46 (13.0%)
Total	355 (100.0%)
Industry	
Construction	284 (80.0%)
Transportation, communications, public utilities	14 (3.9%)
Public administration	13 (3.7%)
Mining	11 (3.1%)
Services	11 (3.1%)
Agriculture, forestry, and fishing	10 (2.8%)
Other	12 (3.4%)
Total	355 (100.0%)

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

The number of nonfatal injuries and illnesses associated with excavation operations is also difficult to ascertain, given that there is no single OIICS code to identify these events, and that the hazards addressed by this HO are not limited to a single industry. Injury data specific to SIC 1794 are not reported. In SIC 179, the broad group of miscellaneous special trades construction contractors which includes excavation contractors, there were 18,854 days-away-from-work injuries and illnesses in 1997 requiring a median 8 days away from work [BLS 1999b]. For OIICS event code 041 (excavation or trenching cave-in), there were 143 nonfatal injuries and illnesses reported in 1997 resulting in a median 10 days away from work. Neither of these measures is satisfactory for assessing the number of nonfatal injuries associated with excavation operations: the industry grouping is too broad, and the event code is too narrow.

Deaths of Young Workers Have Occurred During Excavation Operations

Of the 355 excavation-related fatalities identified by CFOI between 1992-1997, five involved the deaths of young workers younger than age 18 [NIOSH 2001d]. All of these involved trench collapses in which the youth was struck or buried by falling earth. All five youth were employed in the construction industry.

In 1999, a 17-year-old laborer died and a co-worker was injured when an unprotected wall of a trench they were working in collapsed. The excavator operator responsible for digging the trench and setting sewer system components had removed the trench shield to aid in removal of broken pipes, but did not replace the shield when work began the following day. The youth and a co-worker entered the unprotected trench to set pipe and check the grade of the sewer line. A section of the trench wall 30 feet long and 11 feet high caved in, burying the youth up to his mid-chest and his co-worker up to his knees. It took some time for the two workers to be removed from the trench, as the trench shield had to be re-installed to ensure rescue workers' safety. The youth was transported to a local hospital, but died 5 hours after the incident following emergency surgery. [NIOSH 2000f].

Agricultural Occupations

HO 1: Operating a Tractor Over 20 PTO Horsepower or Connecting or Disconnecting an Implement or Any of Its Parts To or from Such a Tractor.

Recommendation — 1) Retain the HO with the removal of the 20 PTO (power take-off) horsepower threshold. 2) Revise exemption for 14- and 15-year-olds with tractor certification to require tractors to be equipped with a rollover protective structure (ROPS) and mandate the use of seatbelts.

Rationale — 1) Tractor-related fatalities have been the leading source of work-related farming deaths in the U.S. for many years. Available data sources frequently do not include enough detail to determine the horsepower of tractors or PTOs involved in fatal and non-fatal injuries. Additionally, PTO horsepower differs from tractor engine horsepower and may be difficult to identify by Wage and Hour inspectors, employers, supervisors and youth workers. Furthermore, available data do not support the notion that a tractor's horsepower (engine or PTO) is related to risk of injury. Therefore, the current 20 horsepower PTO requirement should be eliminated. 2) A ROPS, when used in conjunction with a seatbelt, is the most important safety feature on a tractor in reducing the number of deaths from overturns. This engineering safety measure, in addition to tractor safety training and mandated seatbelt use, should be an effective means of preventing a substantial number of tractor-related injuries and fatalities among young workers.

Tractors Are a Leading Cause of Fatal and Non-Fatal Injuries in Agriculture

Tractor-related incidents are the most common type of agricultural fatality in the U.S. [Myers et al. 1998a; Etherton et al. 1991; Purschwitz and Field 1990]. Tractor overturns are the most common event among tractor fatalities, followed by run-overs [Myers et al. 1998a; Etherton et al. 1991].

CFOI for 1992-1997 identified 1845 tractor (OIICS source codes 8530 and 3123) fatalities in all industries; over 75% (1421) occurred in agricultural production [NIOSH 2001c]. Of the agricultural fatalities, approximately half (707) resulted from tractor overturns [OIICS event codes 4233 and 4141], with 265 deaths resulting from tractor run-overs [OIICS event codes 4232

In 1995, a 12-year-old male working part-time for a farmer was killed when he lost control and overturned a tractor in a 12-foot deep roadside ditch. The youth, who was driving a tractor equipped with a front end loader and pulling an empty feed wagon, was driving downhill on a slightly sloping gravel road. As the youth came to the bottom of the hill, the road had a culvert and deep ditches dropping off sharply at the edge of the road. The youth drove too close to the edge, causing the tractor to roll completely, crushing him under the left rear wheel and fender of the tractor. The tractor had no ROPS or seatbelt, and the seat was adjusted in the back position, making the distance from the seat to the brakes too long for this driver. Additionally, the loader frame may have obstructed the view of the front wheels making it difficult to see the exact position of the front wheel and the edge of the road. [University of Iowa 1995a]

and 4330] (Table 19). The tractor-related fatality rate for agricultural production workers of all ages was 11.1 deaths per 100,000 workers [NIOSH 2001c; NIOSH 2001a].

A review of agricultural fatality investigations in 10 states between 1990-1996 revealed that in 27 of the 31 fatalities attributed to tractor overturns, a ROPS was not in place. In two of the remaining overturns, a ROPS was present, but the operator was not wearing a seatbelt [Pratt and Hard 1998].

Table 19. Fatal Events for Tractor-Related Fatalities in the Agricultural Production Industry [SIC 01,02] for All Ages, United States

Event [OIICS event code]	**Deaths 1992-1997**
Overturns [4233]	625
Fell from and struck by vehicle [4232]	188
Jack-knifed, overturned [4141]	82
Pedestrian struck by vehicle in non-roadway area [4330]	77
Struck by rolling, sliding objects on floor or ground level [0240]	68
Highway accident, moving in same direction [4112]	48
Caught in running equipment or machinery [0310]	38
Struck by falling object [0210]	33
Fall from moving vehicle [4231]	25
Noncollision accident, unspecified [4230]	24
Compressed or pinched by rolling, sliding, or shifting object [0320]	23
Vehicle struck stationary object [4220]	20
Caught in or compressed by equipment or objects, nec [0390]	16
Other	154
Total	1421

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

A review of non-fatal farm injury data for all ages identified an estimated 5,745 tractor-related lost-time work injuries on U.S. farms from 1993-1995 resulting in a median 5.5 days of restricted activity for the injured person [NIOSH 2001k].

Fatal and Nonfatal Tractor-Related Injuries to Youth in Agriculture

Just as with adult farm workers, tractors are also the leading source of fatalities for young agricultural workers, with overturns being the most frequent injury event [Hard et al. 1999; Castillo et al. 1999b]. Tractors pose added risk to youth for many reasons. Youth may lack work experience and the cognitive abilities to recognize and control potential hazards. Additionally, there may at times be a physical mismatch between the youth and the size of the machinery [CDC 1999a]. As illustrated in the case in the text box on page 67, the youth was operating a tractor in which the seat was set at the farthest distance from the brake pedals, making it difficult for the youth to operate the brakes safely.

A review of CFOI data (1992-1997) identified 27 tractor-related fatalities for youth under the age of 16 [NIOSH 2001d]. Fourteen of the fatalities occurred while the youth were operating the tractor. Nineteen of the deaths resulted from the tractor overturning. Other circumstances included run overs, PTO entanglements, and fatalities while disconnecting implements from the tractor. Table 20 shows the age distribution for youth fatalities and the associated injury event.

In 1994, a 10-year-old male suffered acute lacerations of the brain and multiple skull fractures when the tractor he had been driving overturned. The youth was driving the tractor on a public highway, pulling a hay baler and a hayrack loaded with bales of hay. When the youth attempted to make a turn onto a gravel road, the rear wheels of the tractor began to slide and the momentum of the baler, hayrack, and load of hay caused the tractor to slide to the edge of the road and overturn, pinning the youth beneath the tractor. Although emergency personnel arrived moments after the incident, the youth was pronounced dead at the scene. The tractor was not equipped with a ROPS [Minnesota Department of Health 1994].

A review of non-fatal farm injury data identified an estimated 3069 injuries from tractors for 1998 for youth under the age of 16 [NIOSH 2001l]. These data were from the Childhood Agricultural Injury Survey (CAIS). CAIS was a nationwide telephone survey of farm operators which collected youth injury information for the calendar year of 1998. CAIS was conducted for NIOSH by the U.S. Department of Agriculture. Of these injuries, 2185 youth were operating the tractor at the time of the injury. Sixty-three percent of the tractors were equipped with ROPS and 56% of the tractors had seatbelts. Of those tractors with seatbelts, 82% of the operators reported to be wearing them at the time of the injury. Injury severity was measured on a 5-point scale (1=minor 5=life threatening). Injuries that occurred on a tractor equipped with a ROPS had a mean severity of 1.4. Injuries on tractors not equipped with a ROPS had a mean severity of 3.0. In 44% of the injuries, the youth was using the tractor for tilling purposes at the time of the injury.

Table 20. Agricultural Tractor-Related Deaths to Youth by Age Group and Injury Event, United States

Age Group	Deaths 1992-1997	Events [OIICS event code]
Less than 12	9 (34%)	Caught in running equipment or machinery [0310], Compressed or pinched by rolling, sliding, or shifting objects [0329], jack-knifed/overturned no collision [4141], overturn [4233], pedestrian struck by vehicle [4330]
12-13	9 (33%)	Jack-knifed/overturned no collision [4141], fell from and struck by vehicle [4232], overturn [4233], pedestrian struck by vehicle [4330]
14-15	9 (33%)	Jack-knifed/overturned no collision [4141], overturn [4233], collision between railway vehicle and other vehicle [4420]

Source: Census of Fatal Occupational Injuries [NIOSH 2001d]

Data Are Deficient in PTO Horsepower Information

Agricultural HO 1 deals specifically with youth under the age of 16 operating a tractor over 20 PTO horsepower. There are two compelling reasons for removing the horsepower requirement from HO 1. First, although tractors used for farming tasks generally exceed the 20 PTO horsepower requirement, the available data sources do not specify horsepower when providing details on tractor-related incidents. Additionally, since PTO horsepower differs from tractor engine horsepower (PTO horsepower being slightly less than engine horsepower),Wage and Hour inspectors, employers, supervisors and youth workers may not be able to determine PTO horsepower without contacting the manufacturer or consulting an operator's manual. The difficulties in determining a tractor's PTO horsepower, both in research and enforcement, make compliance with the HO difficult. Therefore, the PTO horsepower requirement should be eliminated.

Training As a Means of Instilling Safe Tractor Operating Practices

Youth ages 14 and 15 who have completed approved tractor or machinery certification programs are exempt from requirements of the agricultural hazardous orders covering these work activities [DOL 1990]. The effectiveness of these tractor safety training programs has not been adequately evaluated nationwide. However, two studies have attempted to evaluate these tractor certification programs in two states, Indiana and Wisconsin [Carrabba et al. 2000; Wilkinson et al. 1993]. Carrabba et al. [2000] recently conducted a study in Indiana to determine the impact of 4-H tractor safety programs on the behavior and attitudes of youth tractor operators [Carrabba et al. 2000]. The results of this study indicate that participants in tractor safety programs demonstrate a greater level of confidence in operating tractors, and that the programs appear to have a positive influence on the safe operating procedures of participants in the training. A study by Wilkinson et al. [1993], which evaluated the training certification programs in

Wisconsin, found that youth who had completed a training program reported an increase in usage of tractors equipped with ROPS and were less likely to ride on a tractor as a passenger.

Effectiveness of Rollover Protective Structures for the Prevention of Tractor-Related Injuries

ROPS are structural components attached to vehicles and are designed to protect the operator if the vehicle overturns during operation; they can either be enclosed in a tractor cab or unenclosed. A ROPS limits the degree to which the tractor rolls and the seatbelt keeps the operator within the protective space of the ROPS. A seat belt should always be used in conjunction with ROPS.

Rollover protective structures have been identified as the best means of preventing deaths from overturns. However, only 35% of all farm tractors in the U.S. were equipped with ROPS in 1993 [Myers et al. 1998a]. A study of tractor rollover incidents in Nebraska found that of approximately 250 persons involved in unprotected tractor rollover incidents, 40% died. Only one person operating a ROPS-equipped tractor that rolled over was fatally injured, and this person was not using a safety belt at the time of the incident and was ejected from the ROPS protective zone [CDC 1993a]. Additional studies of ROPS effectiveness in the U.S. have shown that for tractors equipped with ROPS, fatalities occurred only when farmers did not use a seatbelt to prevent ejection from the protective environment of the ROPS during a rollover [Reynolds and Groves 2000]. A study in Sweden, which has implemented regulations requiring ROPS on all tractors, has shown a 92% reduction in tractor rollover fatalities following the intervention [Springfeldt et al. 1998]. The United States has a tractor rollover lost-life rate 24 times higher than Sweden [Thelin 1998]

Other studies provide further evidence of a reduction in agricultural tractor fatalities associated with increased use of ROPS [Cameron et al. 1992; Cotten 1997]. Additionally NIOSH has estimated that a 71% reduction from the current number of rollover fatalities would be expected by increasing the use of ROPS to cover all tractors that do not currently have any form of ROPS. NIOSH further estimated that the efficacy of ROPS would approach 100% if accompanied by universal use of safety belts on all unenclosed ROPS equipped tractors [CDC 1993a]. Cotten [1997] reported that ROPS have proven to be effective, and that the powerful impact of this engineering design is illustrated by the fact that tractors equipped with ROPS constitute less than 1% of fatalities when used in conjunction with safety belts.

HO 2: Operating or assisting to operate (including starting, stopping, adjusting, feeding or any other activity involving physical contact associated with the operation) any of the following machines:

- **i) Corn picker, cotton picker, grain combine, hay mower, forage harvester, hay baler, potato digger, or mobile pea viner;**
- **ii) Feed grinder, crop dryer, forage blower, auger conveyor, or the unloading mechanism of a nongravity-type self-unloading wagon or trailer, or**
- **iii) Power post-hole digger, power post driver, or nonwalking-type rotary tiller.**

HO 3: Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any other activity involving physical contact associated with the operation) any of the following machines:

- **i) Trencher or earthmoving equipment;**
- **ii) Fork lift;**
- **iii) Potato combine; or**
- **iv) Power-driven circular, band, or chain saw.**

Recommendation – Combine HO 2 and HO 3, and expand prohibition from lists of specific machines to machines that perform general functions (e.g. harvesting and threshing machinery; mowing machinery; plowing, planting and fertilizing machinery; other agricultural and garden machinery; excavating machinery; loaders; wood processing machinery, such as wood chippers and debarkers; sawing machinery, including chain saws; powered conveyors; and, mobile equipment, including forklifts) following the terminology used in current coding systems.

Rationale – Work with machinery in agriculture is associated with high numbers of work-related deaths among adults and youth. Work with machinery exposes workers to many hazards such as entanglements, run-overs, roll-overs, being struck by materials and objects, and falls. The current HOs list specific types of machinery which are prohibited; this is problematic due to the continuing introduction of new types of machinery in agricultural production. Combining the two HOs into one inclusive machinery HO based on the function performed by the machine would allow more effective tracking of injuries and comprehensive coverage of new types of machinery that may come onto the market.

It is recognized that HO2 and HO3 were originally separated based on opportunities for machinery certification. Although the issue of machinery certification is beyond the scope of this report, DOL should consider evaluating which machines may be safely operated by 14- and 15-year-old youth with appropriate safety training. It is important to note that those machines which 14- and 15-year-olds may be certified to operate under the current HO 2 result in more deaths annually than those listed in HO 3 for which certification is unavailable. Machinery certificates should make it clear which machinery are permitted, so that employers and compliance personnel can easily determine if a youth has received the required training. Changing administrative procedures to clarify which machines a youth may operate would eliminate the need to separate HO 2 and HO 3.

Farm Machinery is Associated with Substantial Numbers of Deaths and Injuries among Workers

During the 1980's, machinery-related incidents were the second leading cause of occupational fatalities in the United States. Thirty percent of these were in the agriculture/forestry/fishing industries [Pratt et al. 1996]. A 1991 study found that agricultural machines were involved in an annual average of 369 deaths per year [Etherton et al. 1991]. Other studies have shown that farm machinery is a leading source of traumatic injuries on U.S. farms [CDC 1995; Etherton et al. 1991].

During the period 1992-1997, 472 farm machine-related deaths were identified by CFOI in agricultural production (OIICS source codes: 3100-3190, 3240, 3427, 4830) [NIOSH 2001c]. Harvesting machinery, including balers, were the most common source of machinery-related fatalities (Table 21). Plowing and cultivating machinery, and spreaders, are examples of machines that contributed to a substantial number of deaths yet do not appear to be encompassed under the existing agricultural HOs. Because of the lack of detail in the OIICS coding structure and information in narrative fields of the CFOI system, it was not possible to identify whether the fatalities identified in categories such as balers (OIICS source 3111) and combines (OIICS source 3112) were covered by the existing agricultural HOs. For example, grain combines are prohibited by HO2 and potato combines are prohibited for youth by HO3. It is not possible to determine if other types of combines are reflected in the fatality statistics.

Almost a quarter of the farm machine-related fatalities resulted from being caught in running equipment or machinery (Table 21) [NIOSH 2001c]. Other common fatality events were falling from and being struck by machinery (16%), overturns (14%), and being struck by falling objects (9%).

Other Types of Machinery Are Associated with Substantial Numbers of Deaths and Injuries among Agricultural Workers

An additional 125 fatalities were identified which resulted from nonagricultural equipment (i.e., earthmoving equipment, loaders and forklifts) (Table 22) [NIOSH 2001c]. Front-end loaders, not covered by agricultural HO2 or HO3, were associated with the highest number of deaths (36), followed by forklifts (24), and bulldozers (18). Similar to the farm machinery fatalities, many of these fatalities resulted from overturns (18%), being stuck by a falling object (15%), and pedestrians being struck (11%). Most of the fatalities from falling objects resulted from being struck by falling buckets. When examining the data for fatalities related to power-driven saws, there were no fatalities associated with band or circular saws in agricultural production and less than 5 fatalities attributable to chain saws.

Table 21. Fatal Injuries to Agricultural Production Workers Associated with Agricultural and Garden Machinery, United States

Machinery [OIICS source code]	**1° or 2° Source of Death, 1992-1997**
Agricultural/garden machinery [310]	**30**
Harvesting, threshing machinery [311]	**165**
Harvesting and threshing machinery, unspecified [3110]	–
Balers [3111]	60
Combines [3112]	47
Harvesters, reapers [3113]	17
Threshers [3114]	–
Harvesting, threshing machinery, n.e.c. [3119]	34
Mowing Machinery [312]	**145**
Mowing machinery, unspecified [3120]	12
Lawn mowers – riding [3122]	8
Mowers – tractor [3123]	115
Mowing machinery, n.e.c. [3129]	10
Plowing, planting, and fertilizing machinery [313]	**73**
Plowing, planting, and fertilizing machinery, unspecified [3130]	8
Plowing and cultivating machinery [3131]	22
Seed planting machinery [3132]	7
Spreading machinery – agricultural [3133]	22
Plowing, planting, and fertilizing machinery, n.e.c. [3139]	14
Other agricultural/garden machinery [319]	**10**
Conveyors – screw, auger [3427]	**27**
Trailers [4830]	**22**
Total	472

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]. Dashes indicate that BLS reporting requirements were not met.

Table 22. Fatal Injuries to Agricultural Production Workers Associated with Nonagricultural Machinery, United States

Machinery [OIICS source code]	**1° or 2° Source of Death, 1992-1997**
Excavating machinery [321]	32
Loaders [322]	69
Forklifts [851]	24
Total	125

Source: Census of Fatal Occupational Injuries [NIOSH 2001c].

Fatal and Non-Fatal Machine-Related Injuries to Youth Working in Agricultural Production and Services Sectors

A review of fatal work-related injuries to youth in the agricultural production and service sectors has shown that machinery is the second leading source of fatal injuries to youth in the United States. The machinery-related fatalities in this study were associated with several different types of machinery including: plowing, planting and fertilizing machinery; harvesting and threshing machinery; and loaders [Castillo et al. 1999b].

CFOI data (1992-1997) identified 23 farm machinery-related fatalities to youth less than 16 employed in agricultural production. The machinery most commonly associated with youth fatalities were spreading machinery, not currently prohibited by HO2 or 3, and augers. Ten of these fatalities resulted from the youth being caught in running equipment or machinery, and 5 deaths resulted from youth riding on and falling from the machinery. An additional 6 cases were identified which involved machinery currently prohibited in HO3. Two-thirds of these injuries resulted from work with loaders, which is not explicitly covered by either HO 2 or HO 3. There were no identifiable youth fatalities associated with power-driven circular, band, or chain saws [NIOSH 2001d].

In 1997, a 13-year-old male died of injuries sustained when he was run over by a grass seeder. As an adult coworker drove a tractor pulling the seeder, the youth rode in an area between the seeder and the tractor on the hitch of the seeder. The youth was using his hand to reach into the open seed compartments and keep the seed evenly distributed inside the compartments. While he was doing this, he apparently lost his balance and fell from the frame of the seeder and was run over by it [Minnesota Department of Health 1997].

An examination of CAIS data identified an estimated 3035 machinery-related injuries in 1998.

Tilling and planting machinery (47%) and harvesting machinery (9%) were the most common types of machinery involved in the injuries. Approximately half of the machinery was reported to have protective equipment in place at the time of the injury. Additionally, 51% of the injured youth were wearing some type of protective clothing. Safety goggles (88%) were the most common type of protective clothing being used, followed by gloves (11%). An estimated 166 injuries occurred to youth operating chain saws. [NIOSH 2001l].

HO 4: Working on a Farm in a Yard, Pen, or Stall Occupied By a:
(i) Bull, boar, or stud horse maintained for breeding purposes; or
(ii) Sow with suckling pigs, or cow with newborn calf (with umbilical cord present).

Recommendations – Retain current HO.

Rationale – Agricultural injury statistics clearly show that animal-related farm injuries remain problematic for all workers, regardless of age. Farm animals may be dangerous to humans in many different situations, such as: territorial protection, maternal instincts, social relationships, or simply an interruption of their normal habits. Youth exposed to these hazardous situations often lack the experience and the knowledge to detect the subtle signs an animal often exhibits in these situations before attacking. Further, the difference in body weight between a child and the average farm animal makes injuries more common and severe [NIOSH 2000a; 64 Fed. Reg. 67130 (1999)].

Work with Farm Animals Accounts for a High Proportion of Fatal and Nonfatal Injuries in Agriculture

Animal-related injuries are an important occupational hazard associated with farming [Boyle et al. 1997; Layde et al. 1996; Cogbill et al. 1985]. A study of injuries in five states has shown that animals are the primary source of injuries to both males (25%) and females (49%) in the farm household [Boyle et al. 1997]. Additionally, in a study of occupational farm injuries in central Wisconsin, cattle were responsible for the majority (87%) of animal-related injuries [Layde et al. 1996].

A review of data for both fatal and non-fatal animal-related injuries was conducted. HO 4 deals specifically with youth under the age of 16 working on a farm in a yard, pen, or stall occupied by a: 1)bull, boar, or stud horse maintained for breeding purposes; or 2) sow with suckling pigs, or cow with newborn calf (with umbilical cord present). However in the majority of instances existing data are not specific enough to provide this level of detail. Additionally, because the farm often serves as both the home and work place for many youth, it is often difficult to distinguish between work and non-work injuries.

The Census of Fatal Occupational Injuries (CFOI) for 1992-1997 identified 167 fatalities involving animals on farms, 133 of which were identified as occurring in a farm yard, pen, or stall as specified by HO 4. Almost half (49%) of the fatalities were due to interactions with a

bull. In 29% of the bull-related fatalities, the incident occurred while the bull was being moved or loaded in or out of the farm yard/pen/stall. Five fatalities were identified which involved a cow with a newborn calf [NIOSH 2001c].

Data from the Traumatic Injury Surveillance of Farmers (TISF), a nationwide mail survey of farm operators which collected injury information from farm operators in agricultural production for the years 1993-1995, suggested that in 1994 an estimated 121,937 lost-time work injuries occurred on U.S. farms [Myers 1998]. Twenty percent of these injuries were attributable to livestock, which was the leading cause of injury. Several studies also have indicated that animal-related injuries account for between 12 and 33% of all farm injuries [Brison and Pickett 1992; Pratt et al. 1992; Nordstrom et al. 1995; Lewis et al. 1998].

Youth Suffer Fatal and Nonfatal Injuries Due to Animal-Related Work in Agriculture

Several studies have shown that animals are one of the most common sources of injury to children on farms [Layde et al. 1996; Cogbill et al. 1985; Hoskin and Miller 1979]. Cogbill et al. [1985] reported that animal-related injuries account for 43% of injuries to children on farms. Additionally, in a survey of farm injuries in 21 states, Hoskin and Miller (1979) found a significant number of injuries occurring as a result of a cow protecting her calf.

A review of CFOI cases for 1992-1997 found that 6% (n=8) of animal-related fatalities clearly identified as occurring in a farm yard, pen, or stall, occurred to youth under the age of 16. As previously stated, the data were not specific enough in some instances to report at the level of detail indicated in the HO [NIOSH 2001d].

An examination of non-fatal farm injury data for youth collected by NIOSH for the calendar year of 1998 estimated that 20% (6438) of all injuries to youth under the age of 20 occurring on farms were animal-related (injury rate: 3.2/1000 youth). In over 70% of the cases the injured youth was under the age of 16. Additionally, 69% of these animal-related injures were determined to have occurred while the youth was completing work/chores on the farm. The animals most commonly involved in the injuries were horses (37%) and cattle (31%) [NIOSH 2001l].

HO 5: Felling, Bucking, Skidding, Loading or Unloading Timber with Butt Diameter of More than 6 Inches.

Recommendation – Retain HO, but remove the 6 inch diameter threshold.

Rationale – Work on farms associated with timbering exposes workers to many of the same risks as in logging occupations (see nonagricultural HO 4, page 27). Tractors can overturn while attempting to remove stumps or while dragging logs that get caught on stumps or trees. Trees can fall on people and chain saws can buck causing severe lacerations and amputations. This type of work continues to be extremely hazardous for all workers, and includes tasks which are prohibited for minors less than 18 under nonagricultural HO 4. Available data sources often do

not report sufficient detail to determine the butt diameter of trees. Further, there is no evidence that working with timber with a butt diameter of 6 inches or less is any safer than work with larger timber. Therefore, the 6 inch diameter threshold should be removed. It is evident from the data that these types of activities present considerable risk to workers of all ages and should remain prohibited for agricultural workers less than 16.

Hazards of Logging Are Present in Agricultural Settings

Logging is one of the most hazardous industries in the United States [Braddee and Myers 1997; Myers and Fosbroke 1994]. Although there is little data on logging-type fatalities in agricultural production, many of the same hazards exist for farmers as for loggers (see nonagricultural HO 4, page 27). According to NTOF data for the years 1980-1992, logging-type practices resulted in 173 work-related "struck by falling object" deaths to farmers, which represented 46% of all deaths in the agricultural production industry [Braddee and Myers 1997]. A study of 16 rear rollovers due to improper hitching to farm tractors in New York found that 63% of overturns occurred when operators were pulling logs or removing stumps [CDC 1996a].

Fatalities Associated with Logging-Type Activities in Agricultural Production

From 1992-1997, CFOI identified 97 fatalities associated with felling, bucking, skidding, loading or unloading timber among workers in agricultural production in the U.S. [NIOSH 2001c]. Over half of these deaths resulted from being struck by an object, most commonly a felled tree or limb. Almost one-third of these deaths occurred while a worker was using a tractor to push or pull trees or stumps causing the tractor to overturn. Other common factors were being struck by a tree while pushing/pulling with tractor or other machinery, and falls from heights (Table 23). Of those fatalities due to being struck by an object, the majority of the cases (12%) involved being struck by a tree.

Table 23. Fatality Events Associated with Logging-Type Activities in Agricultural Production, United States.

Event [OIICS Event Code]	**Deaths 1992-1997**
Struck by Object [02]	51
Fall to lower level [11]	8
Nonhighway, noncollision accident [423]	34
Other	4
Total	97

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Youth Injuries Associated with Logging-Type Activities in Agricultural Production

Data from the CAIS identified 219 injuries in 1998 requiring at least 4-hours of restricted activity or professional medical attention to youth less than 16 who were injured while using chain saws to cut wood on the farm [NIOSH 2001l].

In 1994, a 13-year-old male sustained fatal massive head trauma when the tractor he was using overturned to the rear while pulling a felled 18-inch diameter tree that was still partially attached at the stump. The tow chain had been hooked directly around the rear axle. The tractor was not equipped with a ROPS [CDC 1996a].

HO 6: Working from a Ladder or Scaffold (Painting, Repairing, or Building Structures, Pruning Trees, Picking Fruit, etc.) at a Height of Over 20 Feet.

Recommendation – 1) Expand the HO to cover work on: roofs; farm structures including silos, grain bins, windmills, and towers; and vehicles, machines, and implements (while retaining prohibitions against work from ladders and scaffolds). 2) Reduce the maximum height at which youth under 16 may work in these settings from 20 feet to 6 feet.

Rationale – 1) Fatality and injury data for the agricultural production industry show that large numbers of worker fatalities and injuries result from falls from elevation. Fall hazards in agriculture are much broader than those identified in HO 6. Expansion of the HO to cover work on roofs, on farm structures, and on vehicles, machines, and implements would cover more of the work situations in which fatal falls have been found to occur. 2) Available fatality data for workers of all ages suggest that permitting youth to work at heights of up to 20 feet is not sufficiently protective: the majority of fatal falls among agricultural production workers for which the height of the fall was known occurred from a height of 20 feet or less. Lowering the height threshold for youth in agriculture would make HO 6 more consistent with occupational safety standards for the construction industry that require fall protection at 6 feet.

Fatal Falls Among Agricultural Production Workers Continue

CFOI identified 166 fatal falls among agricultural production workers between 1992-1997, the majority of which were falls from elevation [NIOSH 2001c, Table 24]. Most prominent among fatal falls in agricultural production were falls from vehicles, machinery, or implements, and falls from roofs and farm structures. Work from ladders and scaffolds, the only work situations now restricted for youth by agricultural HO 6, were not associated with large numbers of fatal falls. There were 17 falls from ladders, comprising 10.2% of the total. Data on falls from scaffolds did not meet minimum BLS reporting requirements.

Table 24. Fatal Falls Among Agricultural Production Workers, United States

Event*	**Deaths, 1992-1997**
Fall from vehicle, machine, or implement	33
Fall from farm structure (e.g., silo, grain bin, windmill)	19
Fall from roof	18
Fall from ladder	17
Fall from floor, dock, or ground level	16
Fall from horse	13
Fall from haystack or hay bales	11
Fall from tree	7
Fall or jump to lower level, other and unspecified	12
Fall on same level	14
Fall, unspecified	6
Total	166

Source: Census of Fatal Occupational Injuries, [NIOSH 2001c].
*Event categories in this table do not correspond directly to OIICS categories. Cases were re-grouped to provide more specific information about circumstances of fatal falls in agricultural production.

Clearly, fall hazards in the agricultural production industry are not limited to ladders and scaffolds, which are the only hazards now addressed in HO 6. Work on roofs and work at heights on farm structures could be defined clearly, but other hazards such as working at heights on stationary vehicles and work in trees and on haystacks may be more difficult to address.

Data on the Height of Fatal Falls in Agriculture Are Limited

Of the 152 fatal falls from elevation in the agricultural production industry identified by CFOI, only 38 case narratives (25%) indicated the number of feet fallen by the fatally injured worker. However, it is noteworthy that in 22 of the 38 incidents, the worker fell from 20 feet or less. These data suggest that permitting work at a height of up to 20 feet does not provide adequate protection for agricultural workers of all ages, and is therefore not adequate to protect youth.

Substantial Numbers of Nonfatal Falls Occur Among Agricultural Production Workers

In 1994, there were an estimated 19,008 nonfatal falls from elevation resulting in ½ day or more restricted activity among U.S. farm workers. Falls on the same level resulted in an estimated 12,153 injuries resulting in restricted activity [Myers 1998].

Fall-Related Fatalities and Injuries Among Youth Working in Agricultural Production Have Been Reported

CFOI identified fall-related fatalities among agricultural workers younger than age 16, none of which involved a fall from elevation. In 1998, youth under age 16 on U.S. farms incurred an estimated 11,334 injuries resulting in restricted activity due to falls from elevation [NIOSH 2001l]. Notable among these were falls from equipment or vehicles, many of which were all-terrain vehicles (ATVs) (1,346 injuries); falls from horses (1,198 injuries); falls associated with climbing steps or ladders (659 injuries); and falls associated with climbing other structures, often trees or hay bales (603 injuries).

Other Federal Occupational Health and Safety Standards Do Not Address Falls in Agriculture

Federal occupational safety and health standards applicable to workers of all ages require use of fall protection for construction industry employees who work 6 feet or more above a lower level. 29 CFR 1926, Subpart M, stipulates that these employees must be protected from falling through the use of guardrail systems, safety net systems, or personal fall arrest systems [29 CFR 1926.501]. These standards apply to work situations such as unprotected sides and edges, work on roofs, work at the edge of excavations, and work above dangerous equipment. Construction workers on scaffolds who are working more than 10 feet above a lower level must be protected from falling to that level; 29 CFR 1926.451 (g) specifies types of fall protection to be used for the various types of scaffolds. Standards for general industry found in 29 CFR 1910, Subpart D, address fall hazards by requiring guarding of wall and floor openings, and by defining specifications for ladder and scaffold construction. Additionally, standards for some types of scaffolds require the use of guardrails at work levels of 10 feet or higher [29 CFR 1910.29]. None of the above standards for construction or general industry extend to workers in agricultural production, nor do agricultural health and safety standards contain fall protection provisions of any kind.

> In 1997, a 12-year-old boy died after falling off a hay wagon on which he was riding. The wagon was being pulled by a tractor driven by the boy's uncle. The boy apparently slipped and fell off the wagon, and was then run over by the wagon's wheels. [Associated Press 1997; Evansville Courier 1997].

HO 7: Driving a Bus, Truck, or Automobile When Transporting Passengers, or Riding on a Tractor as a Passenger or Helper.

Recommendation – 1) Expand to prohibit driving of all motor vehicles and off-road vehicles

(including all-terrain vehicles), with or without passengers, on and off the highway. 2) Expand to prohibit work as an outside helper on a motor vehicle. 3) Retain the provision prohibiting riding on a tractor as a passenger or helper, but move it under agricultural HO 1.

Rationale – 1) There are a number of strong arguments for this revision. Limiting this HO to buses, trucks, and automobiles does not reflect the breadth of vehicles now in use in agricultural production. Fatality and injury data support prohibition of driving of all types of motorized vehicles, including all terrain vehicles (ATVs). Most states do not allow youth under age 16 to exercise full driving privileges; in a few states the minimum age to obtain a learner's permit is 16. Yet, HO 7 does not explicitly prohibit driving by agricultural workers under age 16. In contrast, nonagricultural HO 2 places substantial restrictions on motor vehicle operation by 16- and 17-year-olds in other industries. Finally, operating a motor vehicle without passengers, currently allowed under HO 7, does not reduce crash risk among young drivers to acceptable levels.

2) Available data indicate that there are fatalities and injuries among agricultural workers, including youth under 16, associated with working as an outside helper on a vehicle. Revising HO 7 to include prohibition of this activity would offer increased protection to young agricultural workers, and would make this HO consistent with nonagricultural HO 2.

3) Fatalities and injuries associated with riding on a tractor as a passenger have been reported among agricultural workers, including youth under 16. Retention of this provision is warranted, but it should be removed from HO 7 and placed under HO 1 so that all tractor-related hazards are addressed in a single HO.

<u>Agricultural Worker Fatalities and Injuries Are Associated with Driving Motor Vehicles, and with Being an Outside Helper on a Vehicle</u>

During 1992-1997, CFOI identified 1,541 fatalities of agricultural production workers due to collisions and single-vehicle incidents on or off the highway (OIICS event codes 41 and 42). These comprised 45.6% of all occupational fatalities in the agricultural production industry. However, because of overlap with other agricultural HO's, three groups were excluded from the following discussion of HO 7: 1,008 tractor-related incidents classified by the OIICS system as vehicle-related (already covered under Agricultural HO 1); 207 incidents involving mobile machinery, including forklifts (already discussed under Agricultural HO's 2 and 3); and 12 fatalities involving animal-drawn vehicles. The remaining 314 cases were collisions or single-vehicle incidents occurring on or off the highway, in which an agricultural production worker died [NIOSH 2001c].

The majority (74.5%) of these 314 vehicle-related incidents occurred on the highway. Highway incidents were dominated by truck-related incidents, with off-highway incidents most often associated with trucks and ATVs (Table 25). Automobile-related incidents occurred primarily on the highway, while those involving ATVs were more common off the highway.

CFOI data show that the decedent was operating the vehicle in 83.8% of on-highway incidents,

compared with 71.3% of off-highway incidents. CFOI does not record coded information as to whether passengers were being transported, although in some instances the case narrative provides some insight. Notable among the truck-related fatalities were 22 in which the decedent was riding on the vehicle as an outside helper, generally in the truck bed. Fifteen of these occurred off the highway, comprising 40.5% of the off-highway truck fatalities.

Table 25. Fatalities Associated with Highway and Nonhighway Accidents Involving Motor Vehicles (Excluding Tractors, Mobile Machinery, and Animal-Drawn Vehicles), by Primary Source of Injury – Agricultural Production Workers, United States

Primary Source of Injury* [OIICS Source Code]	**Highway Accident [OIICS Event 41], 1992-1997**	**Nonhighway Accident [OIICS Event 42], 1992-1997**
Automobile [821]	33	---
Truck [825]	178	37
All-terrain vehicle [841]	6	30
Other vehicle [800-899, except 821, 825, 841, 851]	17	12
Total	234	80

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]. Dashes indicate that BLS reporting requirements were not met.

* The primary source of injury identifies the object that directly produced or inflicted the fatal injury. For incidents involving vehicles, the vehicle occupied by the decedent is the primary source of injury, while the striking vehicle, if any, is the secondary source.

Fatalities and Injuries of Agricultural Workers Younger Than Age 16 Associated with Driving Motor Vehicles, and with Being an Outside Helper on a Vehicle

CFOI identified a total of ten vehicle-related fatalities of agricultural workers under age 16 between 1992 and 1997, excluding events involving tractors, mobile machinery, and animal-drawn vehicles. Six occurred on the highway, and four off the highway [NIOSH 2001d].

The primary sources of injury most commonly cited was a truck (6 deaths). Youth fatalities involving automobiles and ATVs were also reported, but the frequencies were too small to meet

BLS reporting thresholds for CFOI data. The fatally injured youth was driving the vehicle in the majority of the fatalities, but there were incidents in which the youth was riding on the vehicle as an outside helper.

In 1998, there were an estimated 5,444 vehicle-related injuries to youth under age 16 on U.S. farms, based on data from the CAIS, a nationwide telephone survey of U.S. farm operators conducted for NIOSH by the U.S. Department of Agriculture. Nearly half (47.4%) of the vehicle-related injuries involved ATVs. Other prominent sources of injury were automobiles (27.2%) and trucks (6.3%). The majority of injured youth (73.9%) were operating the vehicle, 8.7% were riding in a passenger seat, and 6.1% were riding elsewhere in or on the vehicle [NIOSH 2001l].

> In 1998, a 9-year-old boy died when he was run over by a cargo truck driven by his father, a contracted seasonal farm laborer. The boy had been picking blueberries with his father and an 11-year-old boy. At the time of the incident, the two boys were assigned to pick up containers filled with blueberries from the side of the field road, and load them into the back of the cargo truck. The boys were riding in the back of the cargo truck with the door open as the father drove the truck in reverse. The 9-year-old either jumped or fell off the rear of the truck, and was run over by the reversing truck [NIOSH 1998].

Hazards of Youth Operating Motor Vehicles Are Not Limited to Transporting Passengers

HO 7 currently prohibits driving by young agricultural workers only while transporting passengers. Studies of highway crash risk in the general population show that transporting teenage passengers increased risk of fatal crash for teenage drivers, although the presence of passengers age 30 or older presented essentially the same level of risk as driving alone [Chen et al. 2000; Preusser et al. 1998]. Although it is clear from CFOI case narratives that riding on the outside of a truck is associated with fatalities among agricultural workers of all ages, available data do not provide enough information to ascertain the overall involvement of passengers, teenage or adult, in fatalities of young agricultural workers. Transporting teen passengers may introduce additional risk for young drivers in the general population, but it is by no means the only issue to be considered.

Fatality and Injury Risk to Youth Operators of ATVs

Another vehicle-related risk not currently addressed under HO 7 is the operation of ATVs by youth. Consumer product safety data show that persons under age 16 were the victims in 35% of all reported ATV-related deaths in the general population between 1985 and 1998 [Consumer Product Safety Commission 2000]. Data on ATV-related deaths and injuries are available from the Consumer Product Safety Commission. These data include injuries associated with work as well as recreational use. ATV use was associated with an estimated 28,700 injuries of youth under 16 treated in hospital emergency departments in 1999 [Consumer Product Safety Commission 2000]. Risk of ATV-related injury for youth under 16 was 2.5 times that for operators aged 16 to 34 years, and 4.5 times that for operators aged 35 to 54 years [Consumer

Product Safety Commission 1998]. A 1997 survey found that use of ATVs for nonrecreational activities such as farming or ranching has increased in recent years, and that 95.9% of ATV operators under the age of 16 were driving ATVs with engines greater than 90 cc. These ATVs are intended for use by adults, and are manufactured with labels warning against their use by children [Consumer Product Safety Commission 1998]. The American Academy of Pediatrics has recommended that states prohibit all use of ATVs by persons less than 16 years of age, noting that the immature judgment and motor skills that hamper the ability of youth under age 16 to safely operate other motor vehicles are also relevant to ATV operation by youth [American Academy of Pediatrics 2000].

HO 7 Is Inconsistent with Many State Motor Vehicle Licensing Laws

HO 7 is inconsistent with many state licensing laws in that it prohibits driving when transporting passengers, but does not otherwise prohibit driving. In 43 states, it is possible to obtain a learner's permit before age 16; however, a driver's license (with and without intermediate restrictions) can be obtained in only five of these states before age 16 [Insurance Institute for Highway Safety 2001]. HO 7 does not explicitly prohibit motor vehicle operation by youth who in many states are not old enough to obtain full driving privileges under their state licensing laws. To be consistent with minimum requirements of state licensing laws, HO 7 should be revised to prohibit agricultural workers under age 16 from operating a motor vehicle on the highway.

Substantial numbers of fatalities were also identified as occurring off the highway among agricultural workers of all ages. While there would be some overlap between HO 7 and state licensing laws if HO 7 were expanded to prohibit all highway driving for agricultural workers under age 16, child labor laws provide the only means of addressing hazards associated with driving and other vehicle-related tasks off the highway. There is no evidence to suggest that off-highway driving or work as an outside helper should be permitted for youth; there were 80 such fatalities among workers of all ages over a 6-year period, four of which were among youth younger than 16. Work as an outside helper on a motor vehicle is of particular concern. This is now prohibited for youth under 18 under nonagricultural HO 2, but no similar protections for youth under 16 exist in agricultural HO 7.

Fatalities and Injuries of Agricultural Workers Who Were Tractor Passengers Have Also Been Reported

Of the 1,421 tractor-related fatalities to agricultural production workers identified by CFOI for 1992-1997, 12 of the victims were clearly riding on a tractor as a passenger [NIOSH 2001c]. There are a number of other cases in which injury

> A 10-year-old boy working with his father to load bales of hay onto a wagon was severely injured when the tractor on which he was a passenger overturned. The boy's father, who was driving the tractor, attempted to stop a runaway hay wagon by positioning the tractor's loader bucket in the path of the wagon. As the wagon struck the loader bucket, the tractor overturned, severely crushing the boy's arm under the tractor seat, and fatally injuring his father [University of Iowa 1995b].

circumstances suggest the worker may have been a passenger on the tractor, but the CFOI narrative does not specifically mention it. CFOI identified a total of 27 tractor-related fatalities of agricultural workers younger than age 16 during 1992-1997 (see discussion under agricultural HO 1, page 51), but did not identify enough cases involving tractor passengers under age 16 to meet BLS reporting thresholds [NIOSH 2001d]. Nonfatal injuries to youth associated with this situation have been reported: in 1998, an estimated 417 injuries were incurred by youth under age 16 while riding as a passenger on a farm tractor [NIOSH 2001l].

Inclusion of Work on Tractors Under Agricultural HO 7

Other agricultural work involving operating tractors and connecting or disconnecting implements is covered under agricultural HO 1. Prohibitions against riding on a tractor as a passenger or outside helper should also be addressed under HO 1. There are three distinct advantages to this change: (1) all work activities associated with tractor operation would be addressed under a single HO; (2) HO 7 would be more clearly focused on hazards of motor vehicle operation, and could more easily be modified to align with nonagricultural HO 2; and (3) Wage and Hour inspectors would find it easier to enforce both agricultural HO 1 and HO 7.

HO 8: Working Inside:

- **i) A fruit, forage, or grain storage designed to retain an oxygen deficient or toxic atmosphere;**
- **ii) An upright silo within 2 weeks after silage has been added or when a top unloading device is in operating position;**
- **iii) A manure pit; or**
- **iv) A horizontal silo while operating a tractor for packing purposes**

Recommendation – Expand the HO to prohibit *all* work inside (i) a fruit, forage, or grain storage, such as a silo or bin; (ii) a manure pit.

Rationale – Work in silos, bins and manure pits presents hazards in many forms: grain engulfment; exposure to silo gas; and oxygen deficiency. The current HO is not comprehensive enough in addressing these hazards. Work in silos and grain bins poses substantial risk of engulfment. Given this hazard, it is recommended that the HO be expanded to prohibit work inside all types of fruit, forage, or grain storage facilities, not just those designed to retain toxic or oxygen-deficient atmospheres. Further, although the HO provides for a 2-week waiting period to protect youth from entering a storage facility soon after new silage has been added, toxic gases may be present at any time in these locations. Therefore, the removal of the 2-week waiting period is also recommended. Manure pits also produce toxic atmospheres which can overcome a worker in a very short period of time, and often result in multiple fatalities. The hazards presented by manure pits justify their being retained in the HO.

Grain Engulfment Associated with High Numbers of Deaths

Suffocation in flowing grain is the most common cause of death associated with grain storage structures in the U.S. [CDC 1996b]. Hazards exist either when the grain is being unloaded or loaded, or when workers fall into an air pocket under a crust of grain. Grain that flows during loading and unloading has characteristics of quicksand and can rapidly induce immersion [CDC 1996b]. A worker can be completely submerged in flowing grain in less than 8 seconds [CDC 1996b; Shutske 1999]. Suffocation can also occur if a worker enters a grain bin containing caked, frozen, or spoiled grain. When such grain is unloaded from below, an overlying crust forms which can collapse under the weight of a person standing or walking on the crust [CDC 1996b].

> In 1995, a 13-year-old male died of injuries sustained after he was engulfed in corn inside a steel grain bin. The youth had been seated on the roof ladder of the bin observing corn being removed from the bin through an opened roof cover. The youth fell into the bin unnoticed. It was not known that he was in the bin until a tennis shoe came out of the discharge opening. Emergency personnel arrived on the scene and used power saws to cut several holes into the bin. The youth was removed and transported to the hospital where he died two days later [Minnesota Department of Health 1995].

Silo Gas Another Hazard Associated with Silos and Grain Bins: Silo Filler's Disease

After a silo is filled with chopped silage, a natural fermentation process takes place which produces several harmful gases. The predominant gases formed are carbon dioxide (CO_2) and oxides of nitrogen, which are heavy gases that will displace oxygen in a closed silo. This, in addition to oxygen depletion by microbial activity in silage, can cause the oxygen concentration in a silo to become low enough to cause suffocation and death [Pavelchak et al. 1999; NIOSH 1994b].

The nitrogen oxides formed include: nitrogen dioxide (NO_2), the most lethal; nitrous oxide (N_2O) which is easily oxidized to NO_2; and nitrogen peroxide (N_2O_4), which has similar toxic effects as NO_2, but is colorless and odorless. Nitrogen dioxide is directly toxic to the lungs by forming nitrous and nitric acids and causing burns to the small airways and alveoli. This causes a syndrome known as "Silo Filler's Disease" which may lead to Adult Respiratory Distress Syndrome (ARDS) and death. The amount of acid formed and the severity of lung injury are directly related to the concentration of NO_2 [Wright 1989; CDC 1982]. Nitrogen dioxide levels begin to increase within four hours after filling. Although nitrogen dioxide levels are generally within a safe range after two weeks, dangerous amounts may remain for months if the silo has not been opened [CDC 1982].

Manure Pits Present High Risk

Manure pits are fermentation tanks in which raw animal waste undergoes anaerobic bacterial decay [CDC 1989]. Manure pits allow for easy cleaning of animal confinement buildings and the efficient underground storage of large amounts of raw manure [NIOSH 1990a]. Four main

gases are produced in manure pits: hydrogen sulfide, methane, ammonia, and carbon dioxide. Hydrogen sulfide is considered the most dangerous because it is highly toxic and is rapidly released during agitation and pumping. Methane is continuously produced and released into the air at a steady rate. Methane gas displaces oxygen in the closed environment of a manure pit creating an oxygen-deficient, flammable, and explosive atmosphere [Doss et al. 1993]. Deaths in manure pits can result either from oxygen deficiency or from the direct toxic effects of these four gases [CDC 1993b]. The warmer, more humid weather that occurs during the summer months accelerates the production and accumulation of hazardous gases [NIOSH 1993b; CDC 1993b]. Farm workers should be particularly aware of the hazards of entering pits during the summer when conditions are optimal for increased gas generation [CDC 1993b]. The increased risk during the summer months is particularly troublesome given the fact that most youth are employed as farm workers during that time.

Multiple Fatalities are Common in Silos, Bins, and Manure Pits

Incidents in silos, bins or manure pits often result in multiple fatalities when co-workers or others die during attempts to rescue initial victims [CDC 1993b; NIOSH 1993b; NIOSH 1990b]. Often after a worker enters an oxygen-deficient or toxic atmosphere and collapses, co-workers notice the collapsed worker and enter the same atmosphere to attempt rescue; if they do not use proper precautions they also collapse. From 1982-1992, NIOSH FACE investigated 68 confined space incidents of all types resulting in 104 fatalities; 38% of the fatalities occurred during a rescue attempt [CDC 1993b].

Many Hazards Exist in Silos, Bins, and Manure Pits

A review of CFOI, 1992-1997, identified 91 fatalities in agricultural production associated with entering a silo, grain bin, or manure pit (Table 26) [NIOSH 2001c]. One hundred and eight cases were identified by OIICS event codes for caught in or crushed in collapsed materials (0400, 0490), other cave-ins (0420), inhalation in enclosed, restricted or confined space (3411), depletion of oxygen from cave-in or collapsed materials (3830), depletion of oxygen in other enclosed, restricted, or confined space (3840), and other oxygen deficiency (3890). A review of the narratives for these cases identified the 91 cases which were associated with entering a silo, grain bin, or manure pit. Over 60% of the fatalities occurred in grain bins, 25% in silos, and 13% in manure pits. Sixty-five percent of the deaths were due to grain engulfment, with the remainder attributable to asphyxiation either due to oxygen deficiency or a toxic atmosphere. Four of the fatal incidents resulted in multiple deaths when a co-worker attempted rescue.

Table 26. Deaths Associated with Work in Silos, Grain Bins, and Manure Pits, United States

Event [OIICS Event Code]	**Deaths, 1992-1997**
Caught in or crushed in collapsing materials, n.e.c. [0490]	59
Inhalation in enclosed, restricted, or confined space [3411]	24
Depletion of oxygen in other enclosed, restricted, or confined space [3840]	6
Other	2
Total	91

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Youth Agricultural Workers Also at Risk

CFOI (1992-1997) identified 8 fatalities in agricultural production to youth less than 16 occurring in either a silo, bin, or manure pit [NIOSH 2001d], the majority of these were from grain engulfments. CAIS data for 1998 estimated 1470 non-fatal injuries to youth less than 16 from silos or grain bins [NIOSH 2001l]. An estimated 1250 of the injuries required admission to a hospital, with an average hospital stay of 6 days.

HO 9: Handling or Applying (including Cleaning or Decontaminating Equipment, Disposal or Return of Empty Containers, or Serving as a Flagman for Aircraft Applying) Agricultural Chemicals Classified Under the Federal Insecticide, Fungicide, and Rodenticide Act (as Amended by Federal Environmental Pesticide Control Act of 1972, 7 U.S.C. 136 et seq.) as Toxicity Category I, Identified by the Word "Danger" and/or "Poison" with Skull and Crossbones; or Toxicity Category II, Identified by the Word "Warning" on the Label

Recommendation—Revise the HO to be consistent with EPA Worker Protection Standard for pesticides. Any future changes to the EPA standards which either enhance protections for all workers or add an additional margin of safety for children should also be reflected in the HO. The following wording is suggested: *Performing any tasks that would fall under the EPA definition of "pesticide handler," in 40 CFR Part 170 - The Worker Protection Standard.* The definition of "pesticide handler" as written in the Worker Protection Standard can be found on page 91 of this report.

Rationale—The current HO only addresses exposures of farm workers under age 16 to Toxicity Category I and II pesticides, which are of concern because of their acute toxicity. There is no protection against other chronic hazards of pesticides, such as their potential neurotoxicity, reproductive toxicity, endocrine disruption, and carcinogenic effects. The EPA's Worker Protection Standard was designed to protect workers from acute and chronic exposures to pesticides. The HO to protect young agricultural workers from the hazardous effects of pesticide exposure should, at a minimum, be consistent with the EPA standard.

40 CFR Part 170 - The Worker Protection Standard

This part of the Code of Federal Regulations (CFR) addresses workers' and pesticide handlers' occupational exposures to pesticides used in the production of agricultural plants on farms or in nurseries, greenhouses, and forests. Workplace practices required by the Standard are designed to reduce the risks of pesticide-related illness or injury by reducing or eliminating exposure to pesticides.

According to this regulation, a "pesticide handler" is defined as any person, including a self-employed person:

(1)Who is:

(i) Mixing, loading, transferring, or applying pesticides.
(ii) Disposing of pesticides or pesticide containers.
(iii) Handling opened containers of pesticides.
(iv) Acting as a flagger.
(v) Cleaning, adjusting, handling, or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues.
(vi) Assisting with the application of pesticides.
(vii) Entering a greenhouse or other enclosed area after the application and before the inhalation exposure level listed in the labeling has been reached or one of the ventilation criteria established by this part (§ 170.110(c)(3)) or in the labeling has been met:
(A) To operate ventilation equipment.
(B) To adjust or remove coverings used in fumigation.
(C) To monitor air levels.
(viii) Entering a treated area outdoors after application of any soil fumigant to adjust or remove soil coverings such as tarpaulins.
(ix) Performing tasks as a crop advisor:
(A) During any pesticide application.
(B) Before the inhalation exposure level listed in the labeling has been reached or one of the ventilation criteria established by this part (§ 170.110(c)(3)) or in the labeling has been met.
(C) During any restricted-entry interval.

(2) The term does not include any person who is only handling pesticide containers that have been emptied or cleaned according to pesticide product labeling instructions or, in the absence of such instructions, have been subjected to triple-rinsing or its equivalent.

Pesticide Use in Agriculture

Pesticides are defined by the Federal Insecticide, Fungicide, and Rodenticide Act (7 USC 136) as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, or weeds or any other forms of life declared to be pests; any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant." Pesticides are extensively used in U.S. agricultural production, amounting to about 4.5% of total farm production costs. In 1997, over 1.2 billion pounds of active ingredient were used and included over 20,700 products and more than 890 active ingredients [Aspelin and Grube 1999].

Tasks Involving Risk of Exposure to Pesticides

The following tasks involving handling or applying pesticides put workers at risk for hazardous exposure:

- Mixing, loading, transferring, or applying pesticides
- Disposing of pesticides or pesticide containers
- Handling opened containers of pesticides
- Acting as a flagger for aerial applications
- Cleaning, adjusting, handling, or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues
- Assisting with the application of pesticides
- Entering a greenhouse or other enclosed area after the application
- Entering a treated area outdoors before expiration of the restricted-entry interval

[40 CFR 170 - The Worker Protection Standard; Wilk 1993]

National Estimates of Pesticide-Related Fatalities

The most recent national estimates of unintentional deaths due to pesticides, where data were extracted from death certificates and validated by physicians or coroners, were in the 1970's. Of the 113 unintentional pesticide-related deaths in the two-year period 1973-1974, 11% of the deaths were classified as occupationally related and 27% of the deaths occurred to children under 5 years of age [Blondell 1997]. Poison Control Center data from 1985 through 1992 revealed 40 deaths (3 occupational) due to pesticide exposure [Blondell 1997]. CFOI data from the period 1992-1997 identified 9 pesticide-related deaths, which included intentional and unintentional inhalation and ingestion of pesticides [NIOSH 2001c].

National Estimates of Pesticide-Related Illnesses

Estimates of the occurrence of pesticide-related illness in the U.S. have been made using a variety of data sources. The U.S. EPA has extrapolated statistics from the state of California to estimate physician-diagnosed pesticide illnesses and injuries among agricultural workers in the

U.S. at 10,000-20,000 annually [Blondell 1997]. California maintains the most reliable reporting system for occupationally related pesticide poisonings [GAO 1995]. Potential occupational cases of pesticide poisoning are investigated by the local county agricultural commissioner and reported to the state [Edmiston and Maddy 1987].

Based on NEISS data from 1990-1992, there were an estimated 20,000 (95% CI, 15,000-25,000) annual emergency department visits resulting from pesticide exposure [Blondell 1997]. Emergency department data will only capture injuries severe enough in the mind of the injured person to require emergency department treatment. It has been estimated that only about 34% of injuries and illnesses occurring in the workplace are initially treated in an emergency department [CDC 2001a].

The American Association of Poison Control Centers Toxic Exposure Surveillance System which collects data from 65 participating poison control centers, representing an estimated 95.3% of human poison exposures in the U.S. in 1998, revealed 86,289 human poison exposure cases due to insecticides, pesticides, or rodenticides during 1998. Of these reported cases, 46,447 were children under 6 years of age and 14,436 were between 6 and 19 years of age [Litovitz et al. 1999].

A recent study examined pesticide poisoning among working children using data from state-based surveillance systems (data were available from 1988-1999) and Poison Control Center data from the Toxic Exposure Surveillance System (data were available from 1993-1998) [Calvert 2001]. A total of 531 children under age 18 years were identified to have acute occupational pesticide-related illness. Between 1993 and 1998, the overall incidence rate was found to be 1.71 times that observed in working adults aged 25-44 years (95%CI=1.53, 1.91). It was estimated that 62% of the cases were children employed in agriculture production and services (BOC codes 010 [agricultural production, crops], 011 [agricultural production, livestock], 012 [veterinary services], 020 [landscape and horticultural services], and 030 [agricultural services, n.e.c.]) and 32% were employed in other industries. Of the 81% of cases where the EPA acute toxicity category was available, 67% of the illnesses were associated with toxicity category III pesticides, which are not covered under the HO as currently written.

The above numbers may greatly underestimate the true incidence of pesticide-related illness. Based on two household surveys conducted in California in 1969 and in 1973, Kahn estimated that the number of officially reported cases of pesticide-related illness is only about 1-2% of the true number [Kahn 1976]. Applying this estimate nationally, Coye [1985] estimated that the "true" prevalence of pesticide-related illness cases was about 313,300 (1% of an estimated 4 million farm workers) during 1982.

Acute Health Effects of Pesticide Exposure

Acute effects of pesticide exposure vary by type of pesticide. The majority of pesticide poisonings are caused by organophosphates. This type of pesticide works in both pests and humans by inhibiting the enzyme acetylcholinesterase, which normally breaks down the neurotransmitter acetylcholine (ACH). ACH is a neurotransmitter present in many organ systems of the body and is required to transmit impulses between nerve cells and to provide vital communication between systems. When acetylcholine is not broken down concentrations increase in the intercellular spaces, leading to symptoms of nervous system hyperactivity, neuromuscular paralysis, and central nervous system dysfunction (cholinergic effects). Examples of these symptoms include:

- blurred vision caused by eye muscle contraction;
- tearing, salivation, nausea, vomiting, pulmonary edema, urination, and perspiration caused by stimulation of secretory endocrine glands;
- cardiac arrhythmias caused by impaired impulse conduction to the heart;
- constriction of the bronchial airways caused by smooth muscle contraction;
- cramps, weakness, and paralysis caused by skeletal muscle contraction;
- headache, dizziness, malaise, hallucinations, convulsion, depression and loss of consciousness, and respiratory drive depression caused by central nervous system excitation followed by depression.

Pesticide poisoning incidents have been documented among California farm workers aged 9-19, and often have required medical treatment and lost work time. One incident involved 23 farm workers, including 2 young farm workers aged 9 and 11, who were exposed to two Toxicity I pesticides mevinphos (Phosdrin) and phosphamidon (Dimecron). Workers experienced severe symptoms of poisoning, and some were hospitalized for observation and treatment. Cholinergic symptoms abated within four weeks, while headaches, weakness, blurred vision, and anorexia were more persistent throughout the 18 weeks workers were studied. The two young workers experienced adverse effects such as nervousness and sleep disorders for considerably longer periods after exposure to these neurotoxic pesticides [Midtling et al. 1985; Coye et al. 1987].

Symptoms of acute exposure to other types of pesticides vary depending on the type of pesticide. Carbamates have similar anticholinergic effects as organophosphates. Acute exposure to organochlorine insecticides causes symptoms of central nervous system excitation, including excitability, dizziness, disorientation, paresthesias, tremors, and convulsions. Fumigants and nematocides cause symptoms of respiratory irritation and central nervous system depression. Substituted phenols interfere with a fundamental cellular energy production process (oxidative phosphorylation) which causes systemic effects such as fever, increased heart and respiratory rate, high blood pressure, anxiety, and seizures. Acute exposure to other types of pesticides cause effects of varying severity [Rosenberg 1990].

Chronic Health Effects of Pesticide Exposure

Evidence suggests that the majority of pesticide-related illnesses are chronic rather than acute [Coye 1985], but little is known about the extent and magnitude of chronic health problems

related to occupational exposures to pesticides [NRC/IOM 1998; NRC 1993]. Serious chronic and delayed effects include chronic dermatitis, sterility, adverse reproductive outcomes, blood disorders, abnormalities in liver and kidney function, and chronic neurotoxicity [Rosenberg 1990]. Low-level exposure to pesticides may produce nonspecific central nervous system symptoms such as headache, fatigue, drowsiness, insomnia, and sleep disturbances, mental confusion, disturbances of concentration and memory, anxiety, and emotional lability. There is also evidence in adults that acute pesticide poisoning leads to chronic effects on neurologic function [Steenland et al. 1994; Rosenstock et al. 1990; Savage et al. 1988]. Carcinogenicity of pesticides to humans has not been proven conclusively. However, experimental studies have shown that some pesticides can cause cancer in animals, and epidemiologic research has shown associations with cancer in humans [Blair 1996]. The International Agency for Research on Cancer [IARC 1987] considers some pesticides to be probable human carcinogens.

Special Risks to Young Workers

Health effects of pesticides have been largely unstudied with respect to young workers [NRC/IOM 1998]. However, based on an extensive review of the literature and studies on immature animals, the National Research Council [1993] concluded that the toxicity of pesticides can potentially be influenced by the immaturity of biochemical and physiological functions and body composition of developing children and adolescents. There is age-related variation in susceptibility to pesticides, based on different metabolic rates and ability to activate, detoxify and excrete xenobiotic compounds, and both qualitative and quantitative differences in toxicity of pesticides between children and adults.

Guillette et al. [1998] studied two groups of 4- to 5-year-old children residing in northwestern Mexico, who had similar genetic backgrounds, diets, water mineral contents, cultural patterns, and social behaviors. One group lived in an agrarian environment (n=33) where pesticides had been used since the 1950's. The other group (n=17), lived in the foothills where traditional methods for controlling pests did not include pesticides. The children exposed to pesticides had significantly less stamina, gross and fine eye-hand coordination, and cognitive ability, as measured by the ability to draw a person. Some studies suggest chronic effects of pesticide exposure in children, including attention deficit disorders, decrease in stamina, gross and fine eye-hand coordination [Weiss 1997; Harmon et al. 1975].

The US EPA recently cancelled many uses of three highly toxic pesticides, methyl parathion, chlorpyrifos, and azinphos methyl because they posed unreasonable risk to children (neurorotoxic and neurodevelopmental). This determination is required under the Food Quality Protection Act of 1998, but has been done for only a few pesticides to which children and adolescents are exposed and never to determine unreasonable risks to farm workers under age 18. The EPA is completing a hazard assessment of all organophosphates to determine the developmental and reproductive toxicity of these pesticides for enhanced susceptibility of infants and children [EPA 1998a]. Many pesticides in current and past use have not been tested for all endpoints of concern, and pesticide studies conducted to date are designed primarily to assess pesticide toxicity in sexually mature animals, not developing children and adolescents [NRC/IOM 1998, NRC 1993].

HO 10: Handling or Using a Blasting Agent, Including but Not Limited to, Dynamite, Black Powder, Sensitized Ammonium Nitrate, Blasting Caps, and Primer Cord

Recommendation – Retain the HO.

Rationale – Explosives are used in agriculture for a variety of purposes, such as stump or rock removal, to facilitate the building of a farm pond, or demolition of a farm structure. The use of explosives opens up the potential for catastrophic events, such as fires and explosions, and has the potential for multiple-victim incidents. Although available data do not identify explosive-related fatal and nonfatal injuries in agricultural production associated with the items listed in HO 10, clearly this type of activity presents a substantial hazard to workers exposed to the use of blasting agents. Retaining this HO would be consistent with the nonagricultural HO prohibiting work in the manufacture and storage of explosives (HO 1, page 21). Therefore, it is recommended that HO 10 remain in place.

Scarcity of Data on Blasting Agent Use in Agricultural Production

A review of CFOI data for the years 1992-1997 identified 63 deaths in agricultural production associated with fires and explosions. However, there were no deaths in agricultural production associated with the use of blasting agents as listed in HO 10. The most common source of explosion resulted from workers welding on tanks or equipment (22%) followed by propane/gasoline explosions (16%), and explosions related to overfilling tires or tanks with air (13%) [NIOSH 2001c].

Hazards Associated with Use of Blasting Agents

The lack of fatal and non-fatal injury data does not imply that the use of such blasting agents should be permitted for youth under the age of 16. The inherent danger associated with the use of explosives, coupled with the potential for catastrophic results when explosives are used improperly, warrant enough concern to retain the current HO. Such hazards are described in the discussion of nonagricultural HO 1 (see page 21).

HO 11: Transporting, Transferring, or Applying Anhydrous Ammonia

Recommendation—Retain the HO.

Rationale—Anhydrous ammonia is a toxic, corrosive chemical [EPA 1998b] which requires strict handling, operating, and maintenance procedures to prevent hazardous exposure [ANSI 1999]. Any exposure to the chemical may cause severe injury or death. No data exist to support any changes to the HO.

Anhydrous Ammonia is a Commonly Used Fertilizer

Anhydrous ammonia (ammonia without water) is an inexpensive chemical used commonly in agriculture as a fertilizer [Helmers et al. 1971]. Above its boiling point of minus 28 degrees Fahrenheit, it is artificially kept in a compressed liquid state at high pressure for ease of transport, storage, and application [Johnson 1975]. Tanks are pulled by tractors and ammonia is sprayed directly onto fields. Exposures can occur during spraying or during connection and disconnection of spraying equipment [Shaver and Tong 1991].

Exposure to Anhydrous Ammonia May Cause Severe Burns and Death Due to Suffocation

Anhydrous ammonia can cause severe burns and death due to its powerful corrosive action on tissue. Inhalation of high concentrations causes death due to bronchoconstriction, edema, and inflammation of the airway walls [EPA 2000; Leduc et al. 1992; Sharp 1965]. Exposure to lower concentrations for longer periods can also be fatal as the gas reaches deeper parts of the lung. Chronic fibrosis of the lung may occur if the victim survives the initial insult. Direct contact with the ammonia in liquid form causes severe burns to skin and mucous membranes. Due to its high water solubility and alkalinity, it causes necrosis of the tissue and can penetrate deeply. Severe corneal burns may result from contact with the eyes. If contact occurs as anhydrous ammonia liquid escapes from a container, vaporization can cause freezing burns of the skin and eyes due to rapid heat loss [Shaver and Tong 1991].

National and State Data on Injuries, Illnesses, and Deaths Due to Anhydrous Ammonia

Eight fatalities were identified in CFOI during the six-year period 1992-1997 related to work with anhydrous ammonia [NIOSH 2001c]. The majority of the cases were due to exposure to anhydrous ammonia gas. Explosions involving anhydrous ammonia were also identified. During 1997, injuries and illnesses where the source was identified as anhydrous ammonia resulted in a median of 20 days away from work; 66% of the 88 cases resulted in more than 10 days away from work [BLS 1999b]. The Iowa State University Extension reported that between 1990 and 1992, 55 Iowans were injured in incidents involving anhydrous ammonia, 19 of which required hospitalization for burns, loss of eyesight, and respiratory problems [Schwab et al. 1993]. During 1985, one-third of all emergency department visits due to agricultural chemicals in a 21-county area in Nebraska were caused by anhydrous ammonia fertilizer [Rettig et al 1987]. Other deaths and severe injuries caused by exposure to anhydrous ammonia have been reported in the literature [EPA 2000; Leduc et al. 1992; Sobonya 1977; Johnson 1975; Kass et al.

1972; Helmers et al. 1971].

Requirements for the Safe Storage and Handling of Anhydrous Ammonia

Because of the dangerous properties of anhydrous ammonia, a national standard exists for safe storage, transportation, and handling of the chemical [ANSI 1999]. According to the standard, only properly trained personnel who are familiar with its physical properties should handle anhydrous ammonia. Because it must be stored at high pressure, any leak will cause the ammonia to spray and quickly vaporize. Anhydrous ammonia quickly reacts with any moisture, including moisture in skin and mucous membranes, causing severe dehydration, cell destruction, and chemical burns. Handlers of anhydrous ammonia must wear appropriate personal protective equipment, including eye protection such as tight-fitting, chemical-proof goggles or an approved full-face respirator. Proper use of specially approved equipment must be followed [ANSI 1999; Shutske 1994]. In the event of an emergency, handlers should be able to act by shutting off the flow of gas and coordinating evacuation. Youth should not be given the heavy responsibility of following these complex procedures which, if not followed, could be fatal or severely debilitating to themselves and any others nearby.

V. RECOMMENDATIONS FOR NEW HAZARDOUS ORDERS

The following recommendations address serious occupational health and safety hazards for young workers under age 18 that are not covered by the current Hazardous Orders. DOL should be able to implement these proposals though the administrative rule-making process without any new statutory authority.

Non-Agricultural Occupations

Commercial Fishing Occupations

Recommendation – Establish a new HO for work in commercial fishing occupations. An apprentice/student learner exemption is not recommended.

Rationale – Workers in commercial fishing occupations have extremely high rates of occupational fatality, with similarly high fatality rates among fishers younger than age 18. Fishers work in a highly unpredictable environment and face numerous risks for fatality or serious injury. Many of the injury risks, particularly those related to weather, are not substantially reduced or eliminated through training or experience, therefore an apprentice/student learner exemption is not justified.

Commercial Fishers Have Extremely High Fatality Rates

The substantial risk of fatality associated with work in commercial fishing occupations worldwide has been reported in the scientific literature for decades [Bell et al. 1990; CDC 1993c; CDC 1994; Driscoll et al. 1994; Lincoln 2000; NIOSH 1997e; NIOSH 1994c; National Transportation Safety Board 1987; Reilly 1985; Schilling 1971]. During 1992-1997, CFOI identified 440 fatalities of U.S. workers in fishing occupations, which include fishers (BOC occupation code 497) and captains and other officers on fishing vessels (BOC occupation code 498) [NIOSH 2001c]. The 6-year fatality rate of 161.1 per 100,000 workers was the highest among all occupations, exceeding the rate of 148.2 among logging occupations (BOC occupation code 496) for the same period. Fishing, hunting, and trapping occupations had the second highest lifetime risk of occupational fatality for 1990-1991, with 47.2 deaths per 1,000 45-year working lifetimes [Fosbroke et al. 1997]. Other research found that male captains of vessels and fishers were at substantial lifetime risk for fatality associated with a vessel sinking (38.2 and 24.3 deaths per 1,000 working lifetimes, respectively) [Myers et al. 1998b].

Of the 440 fatalities of fishers and other fishing vessel crew identified by CFOI between 1992-1997, the predominant fatal events were water vehicle accidents (312 deaths, 70.9%) and drownings (68 deaths, 15.5%) [NIOSH 2001c]. The remainder involved events such as contact with electric current, being caught in running machinery, being struck by objects, and assaults. Fatalities have also occurred during harvesting of sea urchins and sea cucumbers, which is usually done by hand by divers using scuba equipment [CDC 1994; Lincoln 2000].

Work in Commercial Fishing Occupations Occurs in a Complex, Unpredictable Environment

Work in commercial fishing poses substantial risk of fatality from a variety of sources. Fishers

are exposed to hazards of drowning, falling overboard, vessel losses due to capsizing or foundering, vessel collisions, fires and explosions, machinery-related incidents, and hypothermia [Driscoll et al. 1994; NIOSH 1997e; Reilly 1985]. Among the numerous factors that have been linked to fatalities among fishers and other crew are: economic pressures from brief fishing seasons; fatigue; delays in rescue efforts due to the isolated locations of some fishing grounds; lack of safety training requirements for commercial fishers; unpredictable and severe weather conditions; nonuse of personal flotation devices; crew inexperience; lack of seaworthiness of vessels; and slippery and unstable work surfaces [Driscoll et al. 1994; NIOSH 1997e; NIOSH 1994c; National Transportation Safety Board 1987; Reilly 1985; Schilling 1971].

Nonfatal Injuries and Illnesses Among Fishers Have Also Been Reported

There were an estimated 343 nonfatal injuries and illnesses requiring days away from work among fishers in the U.S. in 1997. Although the number was small compared with other occupations, these appear to have been of high severity. The median days away from work was 30, with 93.9% resulting in 21 or more days away from work [BLS 1999b]. Between 1991 and 1995, the Alaska Trauma Registry, which collects data on injuries requiring hospital admission in Alaska, recorded 392 nonfatal injuries in the commercial fishing industry [Husberg 2000].

Fatalities and Nonfatal Injuries of Young Workers in Fishing Occupations

CFOI identified five fatalities of fishers younger than age 18 between 1992 and 1997. The 6-year fatality rate per 100,000 FTE workers for ages 15-17 was 137.0. All five youth drowned when their fishing vessel capsized, or when they fell from the vessel [NIOSH 2001d; NIOSH 2001a].

In 1993, a 16-year-old commercial fisherman became trapped and drowned after the fishing vessel he was on capsized while under tow. The vessel was disabled and at anchor, with only the skipper and the youth on board. After 11 hours, another vessel arrived and began to tow the fishing vessel back to port. Within 2 minutes after towing began, the vessel capsized, trapping the 20-year-old skipper and the youth inside the pilot house. The skipper escaped and swam to safety, but efforts to rescue the youth were unsuccessful [NIOSH 1993c].

The Alaska Trauma Registry identified a total of eight nonfatal injuries among fishers younger than age 18 during 1991-1998 [Alaska Trauma Registry 2001].

Alaska Trauma Registry data for 1991-1998 included the following injuries to fishers ranging in age from 11 to 17 years:

- Leg caught in seining line/ring on a purse-seiner, pinning fisher against side of boat
- Fisherman's finger caught between a boat and a skiff.
- Arm caught in winch of fishing boat
- Multiple abdominal stab wounds during fight with another fisherman
- Foot caught in coil rope attached to seiner, dragging fisher against skiff
- Tip of middle finger pulled off when gloved hand caught in coiled rope, and rope was moved out

Construction Occupations

Recommendation – Establish a new HO prohibiting all work in construction occupations as defined by Bureau of the Census occupation codes 553-599, 866, and 869. An apprentice/student learner exemption is not recommended.

Rationale – Workers in many of the construction trades have extremely high rates of occupational injury fatalities, and sustain large numbers of nonfatal injuries, many of a severe nature. Prohibiting work by youth in construction occupations, rather than in the entire construction industry, has the advantage of protecting youth who may be asked to perform construction tasks for non-construction employers. It also ensures continued opportunity for youth to perform low-risk jobs such as clerical work in the construction industry. Despite a number of existing HOs that address specific types of hazardous construction work (such as roofing and trenching), construction work accounts for a substantial number of young worker deaths. The number of deaths of young workers in construction is exceeded only by the number of deaths in agriculture, forestry, and fishing, and retail trades. Additionally, available data suggest that youth working in the construction industry and occupations have elevated fatality rates, and that rates for youth are more than twice those of young and middle-aged adults.

Several factors support the establishment of a construction-wide HO instead of an approach focusing on individual trades and occupations within construction. Most of the occupations do have elevated fatality rates. Construction work is also associated with adverse health effects from exposure to hazardous substances and from musculoskeletal disorders. Some construction occupations that have relatively low fatal injury rates are associated with exposure to other agents which may have long-term health effects, and thus merit inclusion. Youth employed in

construction are more commonly employed as laborers and helpers and are not likely to have the skills to be technically considered a member of any specific construction trade. In addition, jobs with small construction firms or in residential construction are likely to cut across a multitude of tasks and construction occupations. In summary, NIOSH suggests that any HO cover the entire construction sector.

Because construction sites frequently include hazards outside the control of individual workers or contractors, an apprentice/student learner exemption is not recommended.

Injuries and Fatalities Among Workers in the Construction Trades

Between 1992 and 1997, 5,298 workers in the specialized construction trades and in construction laborer occupations died as a result of work-related injuries. Occupation-specific fatality rates ranged from 1.9 per 100,000 workers for carpet installers to 85.9 for structural metal workers. In 10 of the 32 construction occupations, fatality rates were greater than 20 per 100,000 workers, or more than 4 times the rate among all workers in all occupations [NIOSH 2001c; NIOSH 2001a, Table 27].

Additionally, a number of the occupations listed in Table 27 were among the 50 occupations with the highest lifetime risks of fatal occupational injury in 1990-1991: structural metal workers (4th); electrical power installers and repairers (8th); construction laborers (10th); roofers (16th); construction supervisors, n.e.c. (20th); construction trades, n.e.c. (23rd); electricians (27th); brickmasons and stonemasons (33rd); concrete and terrazzo finishers (34th); and plumbers, pipefitters, and steamfitters (48th) [Fosbroke et al. 1997].

In 1997, workers in construction trades occupations experienced an estimated 179,035 nonfatal injuries and illnesses requiring days away from work, nearly 10% of days-away-from-work injuries in the U.S. that year. Excluding construction laborer occupations, the median days away from work for all lost-time injuries and illnesses of construction trades workers was 8 [BLS 1999b].

Table 27. Fatal Injuries and Nonfatal Injuries and Illnesses to Workers in the Construction Trades, United States

Occupation [BOC Code]	**Deaths, 1992-1997**	**Deaths/100,000 Workers, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median Days Away from Work, 1997**
Supervisors, Construction Occupations				
Supervisors; brickmasons, stonemasons, and tile setters [553]	15	37.4	212	15

Occupation [BOC Code]	**Deaths, 1992-1997**	**Deaths/100,000 Workers, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median Days Away from Work, 1997**
Supervisors, carpenters and related workers [554]	33	26.8	781	13
Supervisors, electricians and power transmission installers [555]	34	14.8	547	6
Supervisors; painters, paperhangers, and plasterers [556]	22	34.5	139	66
Supervisors; plumbers, pipefitters, and steamfitters [557]	20	21.6	366	11
Supervisors, n.e.c. [558]	420	12.2	5,905	7
Construction Trades, Except Supervisors				
Brickmasons and stonemasons [563]	88	8.7	3,237	8
Brickmason and stonemason apprentices [564]	---	---	139	10
Tile setters, hard and soft[565]	7	2.1	544	16
Carpet installers [566]	12	1.9	1,353	8
Carpenters [567]	548	7.6	37,091	8
Carpenter apprentices [569]	5	10.6	770	5
Drywall installers [573]	43	5.1	5,219	15
Electricians [575]	541	13.7	17,748	7
Electrician apprentices [576]	30	17.8	2,423	6
Electrical power installers and repairers [577]	237	35.8	2,799	9
Painters, construction and maintenance [579]	264	8.7	6,665	10
Paperhangers [583]	---	2.3	780	11

Occupation [BOC Code]	**Deaths, 1992-1997**	**Deaths/100,000 Workers, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median Days Away from Work, 1997**
Plasterers [584]	22	10.0	862	6
Plumbers, pipefitters, and steamfitters [585]	205	7.3	12,967	8
Plumber, pipefitter, and steamfitter apprentices [587]	12	15.3	1,913	3
Concrete and terrazzo finishers [588]	52	12.1	1,842	8
Glaziers [589]	14	6.4	1,784	5
Insulation workers [593]	25	7.2	2,276	7
Paving, surfacing, and tamping equipment operators [594]	23	43.3	236	12
Roofers [595]	326	28.9	6,100	9
Sheetmetal duct installers [596]	21	10.6	3,181	5
Structural metal workers [597]	264	85.9	4,214	13
Drillers, earth [598]	35	35.8	972	9
Construction trades, n.e.c. [599]	251	21.7	4,039	10
Construction laborer occupations				
Helpers, construction trades [866]	68	10.8	6,169	5
Construction laborers [869]	1,649	38.1	45,761	7
Total	5,293	---	179,035	---

Source: Census of Fatal Occupational Injuries (Deaths) and Survey of Occupational Injuries and Illnesses (Nonfatal injuries) [NIOSH 2001c], Bureau of Labor Statistics [BLS 1999b]. Employment data used in the calculation of fatality rates were obtained from the Current Population Survey [NIOSH 2001a]. Dashes indicate that no data were available.

Fatalities of Young Workers Employed in the Construction Trades

> In 1998, a 15-year-old roofer helper died after falling 16 ½ feet from a roof to a concrete basement way. At the time of the incident, the youth and a 16-year-old co-worker had been removing shingles from the roof of a house. While working to remove old shingles, the youth either struck a bundle of new shingles with his body or with the handle of a shovel. The bundle began to slide toward the back edge of the roof. In attempting to retrieve the bundle, the youth lost his balance and fell off the back edge of the roof, landing on his back and striking his head on the concrete basement way. The 15-year-old youth died the following day of a closed head injury [NIOSH 1999c].

Between 1992-1997, CFOI identified 55 fatalities of workers under 18 employed in the specialized construction trades or as construction laborers. Thirty-five of the 55 (63.6%) were working as construction laborers. Among all youth ages 15-17 employed in the construction trades and laborer occupations, there were 24.6 deaths per 100,000 FTE employees during 1992-1997. Among youth employed as construction laborers, the fatality rate was 42.3 [NIOSH 2001d; NIOSH 2001a]. A previous analysis of CFOI data suggested that youth 15-17 years of age working in construction had greater than 7 times the risk for fatal injury as youth in other industries, and greater than twice the risk of workers 25-44 years of age working in construction [Barkume et al. 2000].

All but eight of the 55 fatally injured youth less than 18 years of age who died between 1992 and 1997 while working in construction occupations were employed in the construction industry: seven (12.7%) in residential construction, eight (14.5%) in heavy construction, and 32 (58.2%) by special trades contractors. Specific industries with the highest number of young worker fatalities were roofing, siding, and sheet metal work (7); electrical work; and concrete work. The predominant fatal events were: falls (14, 25.5%); contact with electric current (14, 25.5%); transportation incidents (11, 20.0%); and being struck by objects (9, 16.4%).

Health Hazards in Construction

Work in construction may involve exposure to numerous substances with many possible adverse health effects. Workers on construction sites, even those who do not work directly with hazardous substances, may still be exposed as bystanders [Ringen et al. 1995]. Among the substances that have been linked to occupational illness among construction workers are dusts such as asbestos, cement, synthetic vitreous fibers, silica, and wood dust; dusts and fumes from sources such as cadmium, lead, copper, zinc, and asphalt; and solvents and other chemicals such as toluene, polyurethanes, epoxy resins, and methylene chloride. Among the conditions and adverse effects that result from exposure to these substances (and have been linked to work in construction) are: lead poisoning, asbestosis and other lung disorders related to exposure to fibers, cancers, inhalation injury, asthma, chronic obstructive pulmonary disease, bronchitis, contact dermatitis, silicosis, teratogenic effects, neurotoxic effects, and other chronic toxic effects [Osorio and Melius 1995; NIOSH 1991a; NIOSH 1992b; NIOSH 2001m; Ringen et al.1995; Ruhl and Kluger 1995; Sullivan et al. 1995]. Inhaled fibers are more dangerous than other particles because they become trapped and are not cleared by the lungs. If they remain in

the tissue long enough, chronic irritation and inflammation can cause cells to mutate and become cancerous [Elmes 1994].

Population studies have shown that work in construction occupations has been associated with increased mortality due to chronic diseases and cancer. Based on death certificate data from the National Occupational Mortality Surveillance System (1979-1990), significantly elevated proportionate mortality ratios (PMRs) for cancer, mental disorders, pneumoconioses, asbestosis, silicosis, chronic liver disease, and systemic sclerosis have been observed among men usually employed in construction [Robinson et al. 1995]. Twenty of 64 preventable sentinel occupational health conditions resulting from workplace exposures have been linked with employment in a construction trade [Robinson et al. 1995; Mullan and Murthy 1991].

Construction workers are rarely based at the same work site for extended periods, thus the nature and levels of their exposure to hazardous substances and environments may vary over time. Measuring exposure to harmful agents on construction sites is complicated by the mobility of workers on individual construction sites, frequent changes in work sites and employers, logistics, and limitations in measurement technology [Ringen et al. 1995]. Diagnosis of work-related illnesses is complicated by long latency periods [Ringen et al. 1995; Sullivan et al. 1995]. It has been suggested that the extensive movement of construction workers on the job site requires workers to be more responsible for their own protection than in other work settings [Ringen et al. 1995]. If the construction work environment presents these challenges to workers of all ages, it may pose greater dangers for young workers, who are likely to have less of the experience and knowledge needed to recognize and respond to the variety of health and safety hazards present.

Work in the construction trades has also been associated with morbidity and disability due to musculoskeletal disorders. Construction work may involve manual handling of heavy materials, static muscle contractions, exposure to vibration, repetitive motions, and awkward or strenuous work postures or movements [Holmstrom et al. 1995; Ringen et al. 1995]. In 1997, construction industry workers in the U.S. sustained an estimated 44,317 nonfatal injuries and illnesses attributed to overexertion, 25,500 of which involved lifting, and an additional 2,806 injuries and illnesses related to repetitive motion [BLS 1999b].

Work in certain construction trades may be associated with relatively low risk of fatal injury, yet may present risk of adverse health effects or musculoskeletal disorders that is unacceptable for workers under 18. Examples include low back pain and knee disorders among carpet and tile layers [Engholm and Englund, cited in Holmstrom et al. 1995; NIOSH 1990c], asbestosis among insulation workers [Sullivan et al. 1995]; exposure to lead and solvents among painters [Osorio and Melius 1995; Ringen et al. 1995]; and exposure to silica among plasterers, drywall installers, and other occupations [Lofgren 1993].

Work in Refuse Occupations

Recommendation – Establish a new HO prohibiting work in refuse collection. An apprentice/student learner exemption is not recommended.

Rationale – Refuse collection workers have high rates of work-related fatalities, which are due primarily to hazards related to traffic vehicles and refuse collection vehicles. Hazards of vehicle operation and work as an outside helper are addressed by HO 2. However, youth employed as refuse collection workers also risk injury as vehicle passengers, as pedestrians who move among traffic vehicles while retrieving refuse, and from vehicle-mounted compacting equipment. Workers in this occupation may also be exposed to toxic chemical and biological agents through routine handling of waste materials, the hazards of which may not be readily apparent. No apprentice/student learner exemption is recommended because of the high fatality rates and work in environments frequently outside of the control of individual workers or supervisors.

Fatal Injuries Among Refuse Collectors

CFOI identified 132 fatalities of refuse collectors between 1992-1997 [NIOSH 2001c]. The 6-year fatality rate per 100,000 workers in this occupation was 47.3 [NIOSH 2001c; NIOSH 2001a]. The majority of fatally injured refuse collectors were employed in two transportation industry sectors: refuse systems (SIC 4953, 69 deaths), and local trucking without storage (SIC 4212, 39 deaths). The remaining 22 deaths occurred among employees in public administration.

The primary source of fatal injury for refuse collectors was most commonly a truck (97 deaths, 73.5%) or an automobile (10 deaths, 7.6%). Transportation-related events accounted for 105 (79.5%) of the deaths, and were predominantly related to: a vehicle striking a pedestrian on the roadway or roadside [OIICS event codes 431 and 432] (43 deaths, 32.6%); a noncollision event on the highway [OIICS event code 414] (25 deaths, 18.9%); other transportation events on the highway [OIICS event codes 410-413 and 419] (13 deaths, 9.8%); and a vehicle striking a pedestrian off the roadway [OIICS event code 433] (12 deaths, 9.1%). An additional eight deaths involved workers becoming caught in or compressed by equipment or objects [OIICS event code 03]; five of these resulted from the worker becoming caught in the compactor unit of a refuse collection truck.

Nonfatal Injuries and Illnesses to Refuse Collectors

In 1997, refuse collection workers sustained an estimated 3,811 work-related injuries and illnesses resulting in days away from work. The median days away from work was 10, with 18.5% of the injuries requiring 31 or more days away from work [BLS 1999b]. Overexertion, particularly due to lifting, was reported to be the leading cause of nonfatal injuries to refuse collectors between 1992 and 1997, accounting for nearly one-third of all cases [Drudi 1999]. A study of municipal solid waste workers in Florida estimated that 57 of 100 workers incurred a work-related musculoskeletal or dermal injury annually [Englehardt et al. 2000]. High numbers of lacerations, contusions, fractures, vehicular injuries, and back injuries associated with lifting were found in this worker population.

Refuse Collectors Face Multiple Vehicle-Related Injury Risks

Workers who collect and haul refuse are exposed to risk of injury from vehicle traffic while on daily pickup routes. Refuse collection workers may ride on the outside of the vehicle to allow them to more quickly retrieve refuse at stops along the route. Workers riding on the outside of

refuse collection vehicles are at risk of falling off the truck and being run over by the truck or another vehicle. While retrieving refuse, they may also be backed over by the refuse collection vehicle, or struck by a motorist [NIOSH 1997f; NIOSH 1982; Drudi 1999; Englehardt et al. 2000]. Refuse collection vehicles are also equipped with compactors which are similar in function and operation to stationary compactors and balers already prohibited under HO 12, and which pose similar risks for inadvertent activation, leading to crush and amputation injuries

Refuse Collection Also Poses Health Hazards to Workers

Refuse collectors routinely handle materials of unknown origin which may contain hazardous substances. These materials may be neither properly labeled nor acceptable for disposal through conventional means, and the hazards they present may not be readily apparent to workers [NIOSH 1982]. Workers in refuse collection, including those employed at landfills and transfer stations, are exposed to toxic biological or chemical agents through direct contact (e.g., skin contact, puncture or laceration of the skin, or ingestion) or through aerosol transmission. High concentrations of airborne bacteria, dust, and fungal spores have been reported at landfills and transfer stations [Poulsen et al. 1995]. These exposures have been linked with symptoms such as pulmonary and gastrointestinal disorders, eye inflammation, irritation of the skin and mucous membranes, and organic dust toxic syndrome among refuse collectors [Poulsen et al. 1995; Englehardt et al. 2000].

Water Transportation Industries

Recommendation – Establish a new HO prohibiting work in water transportation industries. No apprentice/student learner exemption is recommended.

Rationale – Fatality data show that work on or around shipping vessels and docks is associated with large numbers of fatalities, high fatality rates, and nonfatal injuries resulting in substantial lost work days. The water transportation industry ranks fifth in lifetime risk of fatal injury. Not only are there obvious hazards such as drowning and ships capsizing and/or sinking associated with work in this industry, but also less obvious hazards such as falls, and being struck by shifting cargo or machinery. Work in water transport industries often occurs at sites outside the control of individual workers or employers (for example multiple contractors and ships at ports), and many of the injury risks are not likely to be substantially reduced or eliminated through training and supervision, particularly those related to fatalities associated with ship worthiness and the environment. For these reasons, no student/learner exemption is recommended for this industry.

High Numbers and Rates of Fatal Injury Associated with Work in Water Transportation

Merchant seamen are exposed to numerous hazards, including water, extremes of weather, mechanical equipment, and toxic cargoes [Hansen 1996]. Studies in Sweden, Denmark, and Iceland have shown an increased risk of injuries involving water transport and a high risk for violent deaths, including suicide and homicide. Alcohol use was a contributing factor in many of the fatalities [Hansen 1996; Rafnsson and Gunnarsdóttir, 1993, Larsson and Lindquist, 1992].

The lack of access to medical assistance in a timely manner is also a contributing factor to the morbidity and mortality resulting from at-sea incidents [Hansen 1996].

The water transportation industry (SIC Code 44) ranked fifth in lifetime risk of fatal injury, with 16 deaths per 1,000 working lifetimes in 1990-1991. Further, water transport occupations (BOC codes 828, 829, 833, and 834) ranked third in lifetime risk for fatal injury with 40 deaths per 1,000 working lifetimes in 1990-1991 [Fosbroke et al. 1997].

CFOI, 1992-1997, identified 377 fatalities in water transportation industries. Fifty-seven percent of these occurred to workers in water transport occupations, such as ship captains, mates, sailors, deckhands, and marine engineers. An additional 10% of fatalities occurred to stevedores who load and unload shipping vessels. Water vehicles, including barges, ships, and tugboats, were the primary or secondary source of death in 45% of the cases. The most common fatality event was water vehicle accidents (171) followed by oxygen deficiency (38), which was primarily associated with drowning (Table 28). The fatality rate for workers in the water transportation industry was 37.5 per 100,000 workers [NIOSH 2001c; NIOSH 2001a].

In 1997, workers in the water transportation industry sustained an estimated 7,107 nonfatal injuries and illnesses requiring days away from work. These injuries and illnesses required a median of 17 days away from work [BLS 1999b].

Table 28. Fatality Events Associated with Deaths in the Water Transportation Industry, United States

Event [OIICS Event Code]	**Deaths, 1992-1997**
Water Vehicle Accident [45]	171
Oxygen deficiency [38]	38
Struck by [02]	38
Fall to lower level [11]	19
Pedestrian, nonpassenger struck by vehicle, mobile equipment [43]	18
Assaults [61]	12
Highway accident [41]	12
Contact with electric current [31]	11
Caught in or compressed by equipment or objects [03]	11
Exposure to caustic, noxious or allergenic substances [34]	10
Other	37
Total	377

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Work in Scrap and Waste Materials Industry

Recommendation – Establish a new HO prohibiting work in the scrap and waste materials industry. An apprentice/student learner exemption is not recommended.

Rationale – The scrap and waste materials industry exposes workers to both injury and health hazards. Workers in the scrap and waste materials industry have extremely high rates of occupational injury deaths. Machinery and industrial vehicles were responsible for over half of the deaths in this industry between 1992 and 1997. Although HO 2 addresses a portion of vehicle-related injury risks for workers in this industry by prohibiting operation of motor vehicles by youth under 17 years of age, vehicle-related injury risks in this industry extend to pedestrian workers. The processing of scrap and waste materials also exposes workers to dangerous levels of lead and polychlorinated biphenyls (PCBs). No student learner/apprentice exemption is recommended due to the high lifetime risk of fatal injury and poor control of hazardous exposures.

Fatalities Associated with Work in the Scrap and Waste Materials Industry

The scrap and waste materials industry (SIC Code 5093) ranked 11th in lifetime risk of fatal injury, with 7 deaths per 1,000 working lifetimes [Fosbroke et al. 1997]. CFOI, 1992-1997, identified 187 fatalities in the scrap and waste materials industry (SIC 5093). Establishments included in this industry are primarily engaged in assembling, breaking up, sorting, and wholesale distribution of scrap and waste materials, including auto wreckers engaged in dismantling automobiles for scrap. Almost half (44%) of the deaths were caused by contact with objects and equipment, which included being struck by an object (42), and being caught in or compressed by equipment or objects (36). Transportation accidents (40), fires and explosions (24), and assaults and violent acts (21) were also associated with deaths in this industry (Table 29). In 22 of the 40 transportation accidents (55%), the fatally injured worker was struck by a highway or railway vehicle. Vehicles (54) and machinery (44) were the most frequent primary source of death. The fatality rate for workers in the scrap and waste materials industry was 15 per 100,000 workers [NIOSH 2001c; NIOSH 2001a].

Table 29. Fatal Events for Deaths in the Scrap and Waste Materials Industry (SIC 5093), United States.

Event [OIICS event code]	**Deaths, 1992-1997**
Contact with objects and equipment [0]	83
Falls [1]	6
Exposure to harmful substances or environments [3]	13
Transportation accidents [4]	40
Fires and explosions [5]	24
Assaults and violent acts [6]	21
Total	187

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Health Hazards in Scrap and Waste Materials Industry

A study examining lead exposure in Washington State found scrap metal handling to be one of the most commonly reported lead-exposed activities. Further, scrap metal dealers and recyclers demonstrated the lowest use of industrial hygiene controls (4.7%) among lead-using employers in the study [Nelson and Kaufman 1998]. Health Hazard Evaluations conducted by NIOSH have discovered high lead and PCB exposures present in the scrap and waste materials industry [NIOSH 1993d; NIOSH 1983; NIOSH 1991b] . Workers can be exposed not only from contaminated soil, but also from dust within work areas and offices [NIOSH 1988a; NIOSH 1983]. The health effects of lead and PCBs are discussed on pages 59 and 133.

Farm Product Raw Materials Wholesale Trade Industry

Recommendation – Establish a new HO prohibiting work in the farm-product raw materials wholesale trade industry (SIC 515). No apprentice/student learner exemption is recommended.

Rationale – Workers in the farm-product raw materials industry have high rates of work-related fatalities. Work in this industry presents a wide range of hazards, including grain entrapments, rail and vehicle accidents, and contact with large animals. Many of the hazardous activities in this industry are equivalent to tasks currently prohibited for youth working in other industry sectors such as agricultural production. No apprentice/student learner exemption is recommended due to the diversity of hazards in this industry.

Fatal and Nonfatal Injuries Associated with Work in the Farm-Product Raw Materials Industry

The farm-products raw materials industry (SIC 515) had a lifetime risk of fatal occupational injuries of 5.7 per 1,000 fulltime workers for the years 1990-1991 [Fosbroke et al. 1997]. CFOI, 1992-1997, identified 86 fatalities among workers of all ages in the farm-products raw materials industry (SIC=515)[NIOSH 2001c]. This industry had a fatality rate of 17.5 per 100,000 workers [NIOSH 2001c; NIOSH 2001a]. The farm-products raw materials industry includes grain elevators, grain and beans wholesale markets, livestock auctions and wholesale markets, and other farm product wholesale markets. The most common fatality events were being caught in or crushed in collapsing materials (20%) most often grain or beans, followed closely by highway accidents (19%) which usually involved tractor trailers. The most common primary source of deaths were trucks (23%), grains (15%) and animals (9%). In 1997, an estimated 2,320 nonfatal injuries and illnesses requiring days away from work were associated with work in the farm-product raw materials industry. These injuries and illnesses required a median of 3 days away from work [BLS 1999b].

> In 1988, a 17-year-old employee was unloading a rail car filled with corn at a commercial grain facility. He was found about an hour later buried under the grain with his legs sticking out from the bottom of the car. The victim apparently climbed or fell into the car [Freeman et al. 1998]

Health Hazards Associated with Work in Wholesale Trade in Farm Product Raw Materials

Similar to farmers and farm workers, workers in the wholesale trade of farm product raw materials, such as grains and livestock, are exposed to a variety of organic and inorganic dusts and substances associated with adverse health effects. Grain dust may contain many

> In 1988, a 17-year-old employee of a commercial grain elevator was buried and suffocated in milo inside a grain storage tank. The victim was standing near the draw-off while two other employees brushed spoiled grain from the sides of the tank. When a fourth employee located outside of the tank started the unloading equipment, the resulting grain slide buried the victim near the draw-off [Freeman et al. 1998].

substances, including vegetable products, insect fragments, animal dander, bird and rodent feces, pesticides, microorganisms, endotoxins, and pollens. The most serious respiratory effects associated with grain handling include farmer's hypersensitivity pneumonitis (farmer's lung), silo filler's disease (discussed on page 87), organic dust toxic syndrome, and other inflammatory and asthma-like respiratory disorders. Farmer's hypersensitivity pneumonitis, associated with allergic sensitization to moldy grains or other dusts, may result in progressive, irreversible lung disease [Kirkhorn and Garry 2000]. Organic dust toxic syndrome, sometimes called silo unloaders disease and grain fever, is less well understood [Blanc 1999], but very common [Von Essen et al. 1999]. It is an acute febrile illness, not associated with allergic sensitization or progressive disease, which occurs soon after exposure to high amounts of endotoxin-containing organic dust [Von Essen et al. 1999; Kirkhorn and Garry 2000].

A review of 5-years of workers' compensation data in Washington State found wholesale trade in farm product raw materials to have one of the ten highest incidence rates of occupational skin disorders [Kaufman et al. 1998]. Other hazards to workers in this industry include exposure to pesticides. Pesticides, in addition to being used on grain in the field, are also applied to harvested grain during storage and transport. Dust generated by abradement from grain handling operations is composed primarily of the outer layer of the grain kernels, where pesticides have been applied. Grain dust has been shown to have a higher concentration of pesticide residue than is found in bulk grain [Palmgren and Lee 1984]. Pesticide exposure is associated with acute and long-term health risks, and developing adolescents may have increased risk of adverse health outcomes (see pages 90 and 132).

Railroad Industry

Recommendation – Establish a new HO prohibiting young workers from working in the railroad industry. An apprentice/student learner exemption is not recommended.

Rationale – Large numbers of fatal and nonfatal injuries have been identified among workers in the railroad industry. Railroad workers are among occupations with the highest lifetime risk of fatal injury. Fatalities in the railroad industry are caused by sources such as being struck by trains, falls, being struck by shifting cargo, and railway accidents. Railroad work is also associated with adverse health effects, including hearing loss and silicosis. Work in the railroad industry is characterized by work environments with multiple hazards that are frequently outside the control of individual supervisors or workers. For these reasons, an apprentice/student learner exemption is not recommended.

Fatal Injuries and Nonfatal Injuries and Illnesses in the Railroad Industry

The railroad industry (SIC code 40) ranked 14th in lifetime risk of fatal injury with 5.7 deaths per 1,000 working lifetimes in 1990-1991. Further, rail transport occupations (BOC codes 823, 824, 825, and 826) ranked 16th in lifetime risk for fatal injury with 8.4 deaths per 1,000 working lifetimes in 1990-1991 [Fosbroke et al. 1997].

CFOI, 1992-1997, identified 208 fatalities in the railroad industry. Sixty-four percent of these

occurred to workers in rail transport occupations, such as conductors and yardmasters (52), locomotive operators (33), brake, signal, and switch operators (41), and other rail vehicle operators (7). Rail vehicles were the primary source of death in 69% of the cases. The most common fatality event was railway accidents (102) which included train derailments and train collisions with other trains or non-rail vehicles, followed by pedestrians being struck by a vehicle (54). The fatality rate for workers in the railroad industry was 12.9 per 100,000 workers [NIOSH 2001c; NIOSH 2001a].

In 1997, workers in the railroad transportation industry sustained an estimated 5,448 nonfatal injuries and illnesses requiring days away from work. These injuries and illnesses required a median of 17 days away from work [BLS 1999b].

Long-Term Health Effects of Railroad Work

In addition to traumatic injuries which occur in the railroad industry, there is also the potential for adverse health effects which may develop over a period of years. Hearing loss is a common problem associated with railroad workers. Noise levels from typical railroad yard activities such as car coupling, air brake application, engine noise, and locomotive horns range from 90 to 120 decibels [Urman 1978]. Railroad workers are also exposed to high levels of silica dust [Bureau of National Affairs 1993]. In workplace evaluations, NIOSH has found high exposures to silica dust among railroad track maintenance workers [NIOSH 1993e, NIOSH 2001n]. Exposure to silica dust is associated with chronic lung disease and cancer, as previously discussed on page 54 and below on page 135.

Work at Heights

Recommendation – Establish a new HO for nonagricultural occupations prohibiting work at a height of 6 feet or more from ladders; scaffolds; trees; and structures including towers, silos, poles, oil rigs, bridges, and antennas; and machinery. An apprentice/student learner exemption is not recommended.

Rationale – Falls to a lower level result in significant numbers of workplace fatalities and injuries among workers of all ages, including fatalities of workers under age 18. Although HO 16 prohibits work in roofing occupations, youth in the workplace face numerous other fall hazards that are not addressed by existing HOs. The above recommendation is consistent with OSHA regulations that use 6 feet as the threshold for the provision of fall protection in many work situations. Because safe work at heights requires use of personal protective equipment and strict adherence to safe work practices, existing OSHA regulations are not sufficient to protect youth. Further, these OSHA regulations are applicable only to certain industries, occupations, and work tasks, and in some instances afford lower levels of protection than the changes proposed here. Additionally, the fit and effectiveness of personal fall arrest systems have not been specifically evaluated for youth workers. An apprentice/student learner exemption is not recommended.

Falls to a Lower Level Among Leading Causes of Occupational Fatalities

Since CFOI was implemented nationwide in 1992, falls have consistently ranked among the leading causes of workplace fatality [BLS 1999a]. Falls to a lower level accounted for a total of 3,448 worker deaths between 1992 and 1997. The annual number of fatal falls to a lower level increased steadily from 503 in 1992 to 651 in 1997.

Falls from roofs, from ladders, and from scaffolds or staging were the most common types of fatal falls to a lower level [Table 30]. A large number were classified as a "fall to a lower level, n.e.c." Most common among this group of 675 fatalities were falls from structures and surfaces such as towers, poles, and bridges (187); falls from machinery (154); and falls from trees (117) [NIOSH 2001c]. In addition to fatal falls, work in trees is associated with risk of electrocution. One source reported that these two events together accounted for 68% of all occupational fatalities among tree trimmers between 1980 and 1989 [NIOSH 1992c].

Fall fatalities occurred among workers in all industry and occupation groups, but incidence was particularly high in those employed in the construction industry (1,877 deaths, 54.4% of the total) and in precision production, craft and repair occupations (1,598 deaths, 46.3% of the total) [NIOSH 2001c, Table 31].

Table 30. Fatal Falls and Nonfatal Falls to a Lower Level Resulting in Days Away from Work, by Event Type, United States

Event [OIICS event code]	**Deaths, 1992-1997**	**Nonfatal Injuries and Illnesses, 1997**	**Median days away from work, 1997**
Fall to lower level, unspecified [110]	133	2,670	15
Fall down stairs or steps [111]	90	24,482	8
Fall from floor, dock, or ground level [112]	201	6,325	15
Fall from ladder [113]	550	24,859	11
Fall from piled or stacked material [114]	26	1,126	11
Fall from roof [115]	803	3,341	30
Fall from scaffold, staging [116]	481	4,466	22
Fall from building girders or other structural steel [117]	230	649	42

Event [OIICS event code]	Deaths, 1992-1997	Nonfatal Injuries and Illnesses, 1997	Median days away from work, 1997
Fall from nonmoving vehicle [118]	259	18,377	14
Fall to lower level, n.e.c. [119]	675	13,587	10
Total	3,448	99,882	12

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b].

Table 31. Fatal Work-Related Falls to a Lower Level, by Industry and Occupation, United States

	Deaths, 1992-97	
Industry		
Construction	1877	54.4%
Services	352	10.2%
Agriculture/forestry/fishing	334	9.7%
Manufacturing	283	8.2%
Transportation/communications/public utilities	177	5.1%
Wholesale trade	95	2.8%
Retail trade	86	2.5%
Public administration	84	2.4%
Finance/insurance/real estate	65	1.9%
Mining	63	1.8%
Unknown	32	0.9%
Total	3448	100.0%

	Deaths, 1992-97	
Occupation		
Precision production/craft/repair	1598	46.3%
Laborer	592	17.2%
Farming/forestry/fishing	333	9.7%
Executive/administrative/managerial	204	5.9%
Transport and material moving	190	5.5%
Service	189	5.5%
Operatives	137	4.0%
Professional specialty	71	2.1%
Sales	55	1.6%
Clerical	25	0.7%
Technician/support	22	0.6%
Unknown	32	0.9%
Total	3448	100.0%

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Fall Fatalities of Young Workers

CFOI identified 21 fatal falls to a lower level among youth less than age 18 between 1992 and 1997. Twelve (57.1%) occurred in the construction industry, with the remaining nine occurring across six other industry divisions. Six of the construction industry falls were to youth employed by firms engaged in roofing, siding, and sheet metal work. Of the 12 youth who died in fatal construction industry falls, 9 were employed as either roofers or construction laborers. The most common fatal fall event among youth was falls from roofs (9 deaths, 42.9%). The height of the fall, noted in 14 of the 21 case narratives, ranged from 10 to 300 feet [NIOSH 2001d].

In 1992, a 17-year-old courtesy clerk at a grocery store died after falling 8 feet from a 12-foot wooden ladder while attempting to return it to its usual storage location. Stowing the ladder was not part of the youth's assigned duties. Normally, his supervisor performed this task at the end of the work day, and was unaware the youth had attempted to do it. The usual procedure was to place the ladder against the ceiling opening to the second floor, then climb the back stairway and pull the ladder up from above. A nearby co-worker turned to see the youth fall from the ladder, striking the back of his head on the concrete floor. The position in which the ladder was found suggested it had been placed against a wall, and that it had slid across the floor with the youth on it. Paramedics transported the youth to a local hospital, where he died several days later as a result of cranio-cerebral trauma due to blunt force injury [California Department of Health Services 1993].

Nonfatal Falls Result in Substantial Numbers of Injuries

In 1997, falls to a lower level resulted in an estimated 99,882 nonfatal injuries and illnesses

requiring days away from work (Table 30). The most common types of nonfatal falls were falls down stairs or steps and falls from ladders, which together accounted for more than half the total. Though smaller in number, falls from roofs, scaffolds, and building girders or structural steel were associated with the highest median days away from work, ranging from 22 to 42 days [BLS 1999b]. An analysis of this data focusing on youth demonstrated that youth often sustain serious injuries in falls from ladders. For the 6-year period 1992-1997, an estimated 419 youth sustained serious bruises and contusions when they fell from ladders, requiring a median of 20 days away from work [Barkume et al. 2000].

OSHA Regulations Applicable to Workers of All Ages Address Fall Hazards at 6 Feet and Above

OSHA regulations applicable to general industry (29 CFR 1910) and to the construction industry (29 CFR 1926) require fall protection be used in a variety of work situations. In some instances, specified means of fall protection must be used; in other cases, the employer may select from several options. Fall protection may be achieved by means of perimeter guarding systems, lifelines, safety net systems, personal fall arrest systems, or a combination of these.

Some OSHA regulations specify a minimum height at which fall protection is to be provided. Subpart M of 29 CFR 1926 requires that fall protection be used in many work situations in the construction industry when work is performed at a height of 6 feet or more. With some exceptions, varying types of fall protection must be provided when workers are at a height of 6 feet or more above lower levels and are:

- Constructing a leading edge, or working where others are doing so [29 CFR 1926.501(b)(2)]
- Working in hoist areas [29 CFR 1926.501(b)(3)]
- Working where there is danger of falling through holes, including skylights [29 CFR 1926.501(b)(4)]
- Working on the face of formwork or reinforcing steel [29 CFR 1926.501(b)(5)]
- On a ramp, runway, or other walkway [29 CFR 1926.501(b)(6)]
- At the edge of an excavation, well, pit, or shaft 6 or more feet deep [29 CFR 1926.501(b)(7)]
- Less than 6 feet above dangerous equipment (in which case workers must be protected from falling into the equipment through machine guarding or guardrails); or 6 or more feet above dangerous equipment (in which case workers must be protected from fall hazards by personal fall arrest systems, guardrails, or safety nets) [29 CFR 1926.501(b)(8)]
- Performing overhand bricklaying or related work, or having to reach more than 10 inches below the walking or working surface in performing such work [29 CFR 1926.501(b)(9)]
- Performing roofing work on an unprotected low-slope roof or a steep roof [29 CFR 1926.501(b)(10)] and [29 CFR 1926.501(b)(11)]
- Erecting precast concrete members or performing similar work [29 CFR 1926.501(b)(12)]
- Working in residential construction [29 CFR 1926.501(b)(13)]
- Working on, at, above, or near wall openings where the outside bottom edge of the wall opening is 6 feet or more above lower levels and the inside bottom edge of the wall opening is less than 39 inches above the walking or working surface [29 CFR 1926.501(b)(14)]
- On any other walking or working surface at a height of 6 feet or more above lower levels [29 CFR 1926.501(b)(15)]

In other construction settings, various types of fall protection are required at heights greater than 6 feet when workers are:

- On jumbo decks (work platforms used in underground construction) more than 10 feet in height [29 CFR 1926.800(q)(8)(iii)]
- On fixed ladders where the length of the climb is less than 24 feet but the top of the ladder is more than 24 feet above lower levels, or where the total length of the climb is 24 feet or more [29 CFR 1926.1053(a)(18)] and [29 CFR 1926.1053(a)(19)]
- On scaffolds more than 10 feet above a lower level [29 CFR 1926.451(g)(1)]
- More than 25 feet above the ground or water surface where the use of ladders, scaffolds, catch platforms, temporary floors, safety lines, or safety belts is impractical [29 CFR 1926.105(a)] [NOTE: This regulation specifies that safety nets are to be provided under these circumstances.]

Fall protection requirements for certain workers in the electric power generation, transmission, and distribution industry are more stringent than the 6-foot minimum widely applicable in the construction industry. Workers in the electric power industry on structures that support overhead electric power generation, transmission, and distribution lines and equipment must have fall protection while working at elevated locations greater than 4 feet [29 CFR 1910.269(g)(2)(v)].

Other regulations for construction and for general industry state only that fall protection is to be provided when work is done at heights, but do not stipulate a minimum height. These apply to workers:

- On float or ship scaffolds [29 CFR 1910.28 (u) (6)]
- On roofs performing building maintenance who are using powered work platforms [29 CFR 1910.66 (e) (3) (i)]
- On suspended working platforms [29 CFR 1910.66 (f) (5) (ii) (M)] and [29 CFR 1910.66 (f) (5) (iii) (B)]
- On powered work platforms [29 CFR 1910.66 (j)]
- Performing welding tasks on platforms, scaffolds, or runways [29 CFR 1910.252 (b) (1) (i)]
- On aerial lifts [29 CFR 1926.453 (b) (2) (v)]
- On personnel platforms hoisted on load lines of cranes or derricks [29 CFR 1926 (g) (6) (vii)]

Tractors

Recommendation – Establish a new HO for nonagricultural industries prohibiting operating a tractor or connecting or disconnecting an implement or any of its parts to or from such a tractor. An apprentice/student learner exemption is justified, with the condition that tractors must be equipped with ROPS and seat belt use mandated.

Rationale – Although tractors have primarily been associated with farming, tractors are now used in many industries outside of agriculture, and are associated with large numbers of deaths in nonagricultural industries. Tractors are not explicitly covered in the HO in nonagricultural

occupations, although they would be prohibited for youth less than 18 if they were used for transportation purposes as covered in nonagricultural HO 2. The many hazards associated with tractor use have been detailed in Agricultural HO 1 (page 67). A new HO prohibiting the use of tractors in nonagricultural settings is needed due to the widespread use of tractors outside of agricultural production. An exemption for student learners/apprentices is warranted because of compelling evidence about the effectiveness of ROPS, used in conjunction with seat belts, in reducing the risk for tractor-related deaths (see page 71).

Fatalities Associated with Tractor Use

Tractors [OIICS source code 8530 or 3123] were either the primary or secondary source of fatality in 1845 work-related fatalities across all industries between 1992-1997, with 424 deaths in nonagricultural industries, such as construction (54) and manufacturing (41) [NIOSH 2001c] . Almost half (47%) of the fatalities were caused by tractor overturns [OIICS event codes 4141 and 4233; Table 32].

Table 32. Fatal Events for Tractor-Related Fatalities, United States

Event [OIICS event code]	**Deaths, 1992-1997**
Struck by object [02]	158
Caught in or compressed by equipment or objects [03]	115
Fall to lower level [11]	14
Highway accident [41]	220
Nonhighway accident, except rail, air, water [42]	1168
Pedestrian, nonpassenger struck by vehicle, mobile equipment [43]	122
Railway accident [44]	16
Fire – unintended or uncontrolled [51]	5
Other events	27
Total	1845

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Youth Tractor Fatalities

Of the 1845 tractor-related deaths identified in CFOI, 46 were to youth workers under the age of 18. Twenty of these fatalities would not be covered under agricultural HO 1, either because the youth was working in a nonagricultural industry or the youth was 16 or 17 years old. Overturns (OIICS event codes 4141 and 4233) were the primary cause of tractor-related fatalities to youth (63%) [NIOSH 2001d, Table 33).

In 1998, a 14-year-old youth who worked for a food processing plant died after being pinned under the wheel of a lawn tractor that rolled backward toward a pond on the plant grounds. The youth worked during the summer as groundskeeper assistant, and was supervised by his father the company manager. The youth had been using the tractor, which was equipped with a mower deck, to mow grass in the vicinity of the pond. When the rear wheel of the tractor became stuck in mud on the edge of the pond, the youth apparently got off the tractor to push it from the rear, and it rolled backward, pinning him under the tire [Wisconsin Division of Health 1998].

Table 33. Tractor-Related Deaths to Youth by Age Group and Injury Event, United States

Age Group	Deaths, 1992-1997	Events [OIICS event code]
Less than 12	9	Caught in running equipment or machinery [0310], Compressed or pinched by rolling, sliding, or shifting objects [0320], Jack-knifed or overturned – no collision [4141], Overturned [4233], Pedestrian struck by vehicle, mobile equipment in parking lot or non-roadway [4330]
12-13	9	Jack-knifed or overturned – no collision [4141], Fell from and struck by vehicle, mobile equipment [4232], Overturned [4233], Pedestrian struck by vehicle, mobile equipment in parking lot or non-roadway [4330]
14-15	10	Fall from nonmoving vehicle [1180], Jack-knifed or overturned – no collision [4141], Overturned [4233], Collision between railway vehicle and other vehicle [4420]
16-17	18	Struck by falling object [0210], Collision between vehicles, mobile equipment unspecified [4110], Collision between vehicles, mobile equipment moving in same direction [4112], Jack-knifed or overturned – no collision [4141], Fell from and struck by vehicle, mobile equipment [4232], Overturned [4233]

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Heavy Machinery

Recommendation – Establish a new HO for nonagricultural industries prohibiting operating, repairing, assisting in the operation of excavating machinery, loaders, and road grading and surfacing machinery or assisting with tasks performed by these machines. An apprentice/student learner exemption is not recommended.

Rationale – Machinery is responsible for a large number of deaths and serious injuries across all industries. Although some machines are prohibited by other HOs (e.g., mining, agricultural), there are several classes of machinery which do not fall into any of the current HOs, but present many of the same hazards and contribute a substantial number of fatalities. Deaths and injuries are not restricted to operators, but are also associated with work on machines, assisting in the operation of machines, and working in close proximity to the machines. An apprentice/student learner exemption is not recommended because of the diversity of injury hazards which are frequently outside the control of an individual supervisor or worker.

<u>Excavating Machinery, Loaders, and Road Grading and Surfacing Machinery Hazardous to Workers</u>

Excavating machinery and loaders along with tractors, forklifts, and cranes are the types of machinery most often associated with machinery-related fatalities across all industries [Pratt et al. 1996]. A study of machinery-related deaths in the construction industry found excavating machinery, loaders, and road paving machinery to be in the top five for the number of fatalities and for fatality rates [Pratt et al. 1997]. Many of the hazards associated with these types of machines are not related to operating the machines per se, but rather from being on-foot in the vicinity where the machine is being used [Pratt et al. 2001; Pratt et al. 1997]. A review of 22 skid-steer loader fatalities found that in 10 of the cases the worker was standing or working under the raised bucket resulting in the worker being crushed between the bucket and frame when the bucket was lowered [CDC 1996c]

CFOI, 1992-1997, identified 935 fatalities where excavating machinery, loaders, and road grading and surfacing machinery were the primary or secondary source of injury [NIOSH 2001c]. Although the majority of the fatalities occurred in construction (468) and agriculture (134), substantial numbers of deaths also occurred in other industries (Table 34). Currently there are HOs which prohibit youth under 18 from work in mining, and youth under 16 from operating agricultural machinery. Excavating

In 1992, a 16-year-old male landscape laborer died as a result of traumatic injuries received after being struck by the bucket of a skid steer loader. Three landscape workers were using the loader to assist in the removal of the wooden stakes securing a silt fence around a drainage pond. To remove each stake, the bucket of the loader was lowered, the fence wound around the bucket, and the bucket raised. While removing one of the stakes, the loader tipped forwards while the bucket was in the raised position. The operator began lowering the bucket to stabilize the loader. At the same time, the victim, who was standing to the front and side of the loader, slipped and fell beneath the descending bucket. The bucket struck the victim's chest and he died shortly afterwards [Minnesota Department of Health 1992].

machinery, loaders, and road grading and surfacing machinery, which are used across all industries, are not prohibited by any of the current HOs.

Table 34. Excavating, Loaders, Road Grading and Surface Machinery Deaths by Industry Division, United States.

Industry Division	**Deaths, 1992-1997**
Agriculture, Forestry, and Fishing	134
Mining	41
Construction	468
Manufacturing	77
Transportation, Communications, Public Utilities	76
Wholesale and Retail Trade	49
Finance, Insurance, and Real Estate and Public Administration	42
Services	48
Total	935

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Table 35 provides data on fatal and non-fatal injuries by type of machinery. Excavating machinery and loaders were the most common source for both fatal and nonfatal injuries.

The most common events for fatalities were nonhighway accidents (259, OIICS event code 42), being caught in or compressed in equipment (184, OIICS event code 03), being struck by an object (178, OIICS event code 02) and a pedestrian or nonpassenger being struck by equipment (170, OIICS event code 43), most commonly a bucket. In 51% of the fatalities the worker was operating the machinery at the time of the incidents, with the remaining 49% of the cases occurring while the worker was on-foot in the area where the equipment was being operated.

In 2000, a worker suspected to be less than 18 years of age lost his leg when the earth compactor he was operating overturned in Georgia. The worker reported that he was 17 years old, though employer records showed him to be 20 years of age. The worker was operating the compactor at a municipal landfill. The compactor overturned on a steep embankment. The worker was not wearing a seatbelt and was ejected from the compactor. The rollcage of the compactor landed on his legs, severing his right leg above the knee and injuring his left leg. [Associated Press State & Local Wire 2000a].

Eleven fatalities where excavating machinery, loaders, or road grading and surfacing machinery

were the primary or secondary source of injury occurred to youth under the age of 18 for the years 1992-1997 [NIOSH 2001d]. Loaders were the source of injury in the majority of the deaths. In five of the fatalities, the youth was not operating the machinery but working nearby, most often being struck by the bucket.

Table 35. Deaths and Nonfatal Injuries and Illnesses Requiring Days Away from Work Associated with Excavating Machinery, Loaders, and Road Grading and Surfacing Machinery, United States.

Type of Machinery [OIICS source code]	**1° or 2° Source of Death, 1992-1997**	**Nonfatal Injuries and Illnesses (1° source), 1997**	**Median Days Away from Work, 1997**
Excavating machines [321]	414	1643	16
Loaders [322]	363	1185	15
Road grading and surfacing machines [325]	167	1040	10

Source: Census of Fatal Occupational Injuries (Deaths) [NIOSH 2001c] and Survey of Occupational Injuries and Illnesses (Nonfatal injuries), Bureau of Labor Statistics [BLS 1999b].

Welding

Recommendation – Establish a new HO for nonagricultural industries prohibiting work in welding.

Rationale – Fatality and injury data have identified large numbers of fatal and nonfatal injuries among welders, as well as additional cases involving welding activities among non-welders. Welders are among occupations with the highest lifetime risk of fatal injury. Fatalities of welders and other workers engaged in welding occur under varied circumstances, with fires and explosions quite frequent. Young workers may lack the knowledge to recognize hazards associated with welding around potentially flammable and explosive materials. Welding is also associated with a variety of adverse health effects, including acute and chronic illness from inhalation of metal fumes, allergic reactions to metals, and chronic respiratory symptoms.

Occupational Fatalities Among Welders

Between 1992-1997, CFOI identified 386 fatalities among welders and cutters (BOC occupation code 783). There were 11.5 deaths per 100,000 employed welders during the 6-year period. Nearly two-thirds of the fatalities occurred in the construction (36.0%) and manufacturing (30.1%) industries [NIOSH 2001c; NIOSH 2001a, Table 36].

Fatalities among welders and cutters were associated with a wide variety of fatal events and primary injury sources. The predominant types of fatal events were fires and explosions (21.8%), falls to a lower level (18.4%), and being struck by objects (18.1%). The most common primary injury source was structures and surfaces (20.5%); OIICS coding rules classify most fall events under this primary injury source.

In 1990-1991, welders and cutters had a lifetime risk of fatal work-related injury of 5.6 per 1,000 working lifetimes, 29th highest among all occupations [Fosbroke et al. 1997].

Table 36. Characteristics of Work-Related Deaths of Welders, United States

	Deaths, 1992-1997	
Industry		
Construction	139	36.0%
Manufacturing	116	30.1%
Services	52	13.5%
Transportation/communications/public utilities	25	6.5%
Wholesale trade	23	6.0%
All others	31	8.0%
Total	386	100.0%
Event [OIICS event code]		
Fire or explosion [50, 51, 52]	84	21.8%
Fall to lower level [11]	71	18.4%
Struck by object [02]	70	18.1%
Transportation event [4]	46	11.9%
Caught in or compressed by equipment or objects	25	6.5%
[03]	24	6.2%
Contact with electric current [31]	66	17.1%
All other	386	100.0%
Total		
Primary Source of Injury [OIICS source code]		
Structures and surfaces [6]	79	20.5%
Parts and materials [4]	76	19.7%
Vehicles [8]	62	16.1%
Fire, flame, smoke [934]	38	9.8%
Containers [1]	36	9.3%
Machinery [3]	27	7.0%
Chemicals and chemical products [0]	20	5.2%
All others [2, 5, 7, and 9 (excl. 934)]	48	12.4%
Total	386	100.0%

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Welding-related Fatalities Occur Among Workers Other Than Welders

The above fatality rate for welders does not consider the additional 114 deaths during 1992-1997 of workers in occupations other than welding who were engaged in welding activities at the time of the fatality. These additional cases were identified through text searches of narrative fields for mention of welding. The majority of these workers (73, 64.0%) were employed in precision production, craft, and repair occupations, most frequently as structural metal workers (17 deaths). Fatalities involving fires or explosions made up a much higher proportion of fatalities in this group of non-welders than among workers in welding occupations (51.8% vs. 21.8%). Fatalities due to contact with electric current were also more common among the non-welders (16.7% vs. 6.2%).

Nonfatal Injuries Among Welders

Data from the NEISS, which provides surveillance of nonfatal occupational injuries treated in emergency departments, yielded a national estimate of 34,972 nonfatal injuries among welders in 1998 [NIOSH 2001b]. There were an estimated 22,452 additional injuries that occurred among workers other than welders in which "weld" appeared in the case narrative. Of the total 57,424 injuries to these two groups of workers, an estimated 15,953 involved welding torches (OIICS source code 7263), and 12,751 were caused by chips and particles (OIICS source code 951). The most common injury event was exposure to welding light ("welder's flash" [OIICS event 362], 17,913 injuries). Large numbers of injuries also resulted from being struck by a dislodged flying object (OIICS event code 0221) (7,259 injuries), and rubbing or abrasion by foreign matter in the eye (OIICS event code 053) (4,837 injuries).

Adverse Health Effects of Welding

A wide range of inhalation exposures may occur in welding, depending on the materials and welding processes used and the concentration of substances in the air [Sferlazza and Beckett 1991]. Air contamination by chromium, nickel, manganese, fluorides, ozone, and aluminum oxide may occur in welding of mild steel, stainless steel, and aluminum, resulting in upper respiratory irritation and lung injury [Lewis 1990]. Chemical pneumonitis is caused by inhalation of high concentrations of irritant gas or gas/particulate mixtures, causing acute inflammation of the lung parenchyma, pulmonary infiltrates, hypoxemia, and in severe cases, adult respiratory distress syndrome. Hypersensitivity pneumonitis may be triggered if an allergy to the metal develops. The symptoms of hypersensitivity pneumonitis are similar to and sometimes indistinguishable from chemical pneumonitis [Sferlazza and Beckett 1991]. Allergies to chromium and nickel, both of which are common air contaminants produced during the welding of stainless steel, are common in the general population. Contact dermatitis due to these and other metal ions occurs in 10-15% of the human population [Budinger and Hertl 2000].

Metal fume fever is an acute respiratory illness of welders caused by inhalation of metal fumes formed by welding of zinc (most common), copper, and magnesium. Zinc oxide fumes form when zinc-coated (galvanized) metal or zinc alloys are heated sufficiently to vaporize zinc. Metal fume fever is a self-limited syndrome that occurs several hours after exposure and lasts about 24-48 hours. It is characterized by high fever, cough, myalgias, malaise, sweating,

excessive thirst, and a sweet, metallic taste in the mouth [Sferlazza and Beckett 1991; Lewis 1990]. Exposure to metal fumes has also been shown to cause an acute decrease in lung function from the beginning of a welding shift to the end [Sobaszek et al. 2000; Fishwick et al. 1997].

Chronic respiratory effects of welding exposures include chronic bronchitis, chronic pulmonary function abnormalities, and benign pneumoconiosis due to deposition of iron oxide particles in the lung (also known as welder's siderosis) [Bradshaw et al. 1998; Sferlazza and Beckett 1991]. Other health effects that have been described include increased risk of spontaneous abortion in spouses of welders [Hjollund et al. 2000], neuropsychiatric symptoms in welders exposed to aluminum, lead, or manganese for a long period of time [Sjogren et al. 1990], and occupational asthma [Sferlazza and Beckett 1991]. A review of studies examining the incidence of lung cancer in welders concluded that there is a possible association [Sferlazza and Beckett 1991]. Assessment of lung cancer risk in welders is confounded by other exposures such as cigarette smoking, asbestos exposure (such as in shipyards), and other environmental carcinogens [NIOSH 1988b].

Evidence for Effectiveness of Safety Training

There is little information in the scientific literature about the effectiveness of safety training for welders. One relevant study examined the value of different levels of feedback about performance compared with training and goal-setting without feedback among welders, machine shop, and boiler shop workers [Chhokar and Wallin 1984]. The researchers found that periodic feedback resulted in improved safety performance beyond training and goal-setting interventions, and that withdrawal of the feedback resulted in performance declines.

Confined Spaces

Recommendation – Establish a new HO for nonagricultural industries prohibiting work inside any confined space. No apprentice/student learner exemption is recommended.

Rationale – Confined spaces are extremely dangerous, and result in considerable numbers of work-related fatalities, including deaths among youth. The hazards associated with confined spaces exist in both agricultural and nonagricultural industries. Although work in confined spaces in production agriculture (e.g., silos, grain bins, pits) is prohibited for youth under 16 in agricultural HO 8, there is no protection for youth workers in nonagricultural industries. Confined spaces are associated with atmospheric and physical hazards which have already been detailed in agricultural HO 8 (beginning on page 86). A new hazardous order addressing work in confined spaces is needed for youth working in nonagricultural industries due to the many hazards associated with work in these dangerous environments. The complexity of measures to identify confined space hazards, and the need for personal protective equipment and strict adherence to safe work practices when working in confined spaces argue against an apprentice/student learner exemption.

Fatalities Associated with Work in Confined Space

NIOSH has defined a confined space as a space which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy [NIOSH 1994d; NIOSH 1979]. Confined spaces include such structures as silos, tanks, pits, wells, and pipelines.

Within OIICS, there is no single code which defines confined space incidents. Fatalities were identified in CFOI, 1992-1997, through a combination of event codes [e.g., caught in collapsing materials (0400, 0420, 0490), inhalation of enclosed, restricted, or confined space (3411), and oxygen deficiencies (3930, 3940, 3890)] and keyword search [e.g., confine, silo, etc.]. A review of the case narratives identified 330 fatalities associated with work in a confined space [NIOSH 2001c]. The majority of these were identified by their event code and subsequent narrative review, with only 2% being identified by the keyword search. Of the 330 fatalities, 236 (72%) occurred in industries other than agricultural production, mainly in manufacturing (22%) (Table 37). A large number of fatalities occurred inside bins, silos, and tanks (Table 37).

Risks Associated with Confined Space

Chemicals or chemical fumes were the primary source of injury for over 40% of these fatalities. Breathing in toxins in a confined space (OIICS event code 3411) was associated with over 42% of fatalities. In many instances, workers were cleaning or repairing tanks and were overcome by chemical residue or gases. Another common fatality event was being caught in or crushed in collapsing materials (35%). Confined space incidents often result in multiple fatalities when rescues are attempted. CFOI identified 21 rescue attempts resulting in 37 fatalities.

Youth Fatalities in Confined Space

Fourteen fatalities to youth less than 18 associated with confined spaces were identified in CFOI, 1992-1997 [NIOSH 2001d]. Thirty-six percent of the deaths were in nonagricultural industries. Approximately 70% of the fatalities were caused by being caught in or crushed in collapsing materials, with the remainder attributable to oxygen deficiency. In seven of the fatalities, the youth was working in a bin and became submerged in the contents (e.g., grain, corn, beans).

In 1994, a 17-year-old laborer was cleaning the inside of metal molds used to form plastic containers. This task involved applying tetrachloroethylene, a degreasing agent, to a cloth rag which was then used to wipe the interior surface of the mold. The mold in which the body of the laborer was found formed a 40-gallon container and measured 19 ½ inches in diameter and 32 inches deep. The employee had propped the mold in an upright position and leaned into the mold to clean the bottom. The youth was overcome by the fumes and his body was discovered eight hours later when a co-worker arrived on the scene [Colorado Department of Health 1994b].

Table 37. Characteristics of Confined Space Deaths, United States.

	Deaths, 1992-1997
Industry	
Agriculture/Forestry/Fishing	100
Manufacturing	73
Construction	37
Transportation/communication/public utilities	36
Wholesale and Retail Trade	32
Mining	19
Services	19
All others	14
Total	330
Type of Confined Space	
Bin/Hopper	106
Tank/Vat	72
Silo	47
Manhole	22
Pit	21
Well	11
Pipeline	8
All other	43
Total	330

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Work Involving Powered Conveyors in Manufacturing

Recommendation – Establish a new HO for nonagricultural industries prohibiting work involving powered conveyors in manufacturing. The HO should cover operation, repair, and maintenance of conveyors, as well as cleanup duties in the vicinity of conveyors that are in operation or energized. No apprentice/student learner exemption is recommended.

Rationale – Fatality and injury data identified large numbers of injuries and deaths associated with work on and around powered conveyors in nonagricultural industries. Half of the conveyor-related deaths outside of agricultural production occurred in manufacturing industries. A large number of conveyor-related fatalities were associated with being caught in running machinery. In these events, procedures for controlling hazardous energy may not have been in place or may not have been followed. Young workers are unlikely to have control over implementation of hazardous energy control policies that would reduce their exposure to conveyor-related hazards. For this reason, an apprentice/student learner exemption is not recommended.

Fatalities and Injuries are Associated with Work Involving Powered Conveyors

CFOI identified 219 worker fatalities between 1992 and 1997 in which a powered conveyor was the primary or secondary source of injury. An additional 50 fatalities were identified through a keyword search for "convey." Of the 269 total conveyor-related fatalities, 223 (83%) occurred in industries outside of agricultural production, primarily manufacturing (116 deaths) [NIOSH 2001c, Table 38].

In 1997, there were an estimated 6,020 nonfatal injuries and illnesses requiring days away from work for which the primary source of injury was a powered conveyor. These injuries resulted in a median 8 days away from work [BLS 1999b].

Work with Powered Conveyors Presents a Variety of Injury Hazards

The primary fatal event associated with work on or around powered conveyors was being caught in or compressed by equipment or objects; 155 of the 171 involved being caught in running machinery (Table 38). However, conveyor-related fatalities also occurred as a result of other exposures, including contact with electric current, collapsing materials, falls, and being struck by objects. Almost two-thirds of the case narratives for the 269 conveyor-related fatalities contained enough information to identify the work task associated with the fatality. The most common tasks were repair or maintenance, cleanup, and clearing jammed material.

The predominant risk factor for conveyor-related fatalities was failure to control hazardous energy, particularly for those associated with being caught in running machinery and those involving electric current. Some involved failure to lock out or de-energize the conveyor before performing repair or maintenance, while in other instances a worker was caught after clearing jammed material. Workers who were performing general cleanup duties in the vicinity of running conveyors were also caught in machinery.

Table 38. Characteristics of Deaths Associated with Work with Powered Conveyors, United States

	Deaths, 1992-1997	
Industry Division		
Manufacturing	116	43.1%
Agricultural production	46	17.1%
Transportation/communications/public utilities	30	11.2%
Mining	24	8.9%
Construction	19	5.9%
Wholesale trade	17	6.3%
All others	17	6.3%
Total	269	100.0%
Event [OIICS event code]		
Caught in or compressed by equipment or objects	171	63.6%
[03]	28	10.4%
Fall to lower level [11]	27	10.0%
Contact with electric current [31]	23	8.6%
Struck by object [02]	9	3.3%
Caught in or crushed in collapsing materials [04]	11	4.1%
All other	269	100.0%
Total		
Work Task		
Repair, maintenance	79	29.4%
Cleanup	32	11.9%
Clearing jammed material	25	9.3%
Operating conveyor	17	6.3%
Loading or unloading	13	4.8%
Transporting conveyor	10	3.7%
Not enough information in narrative to identify	93	34.6%
Total	269	100.0%

Source: Census of Fatal Occupational Injuries [NIOSH 2001c]

Pesticide Handling

Recommendation– Establish a new HO for non-agricultural industries prohibiting the performance of any tasks that would fall under the EPA definition of "pesticide handler," in 40 CFR Part 170 - The Worker Protection Standard. The definition of "pesticide handler" as written in the Worker Protection Standard can be found on page 91 under the recommendation for agricultural HO 9, prohibiting the handling of pesticides in agricultural occupations. No apprentice/student learner exemption is recommended.

Rationale– Many young workers are employed in non-agricultural industries where pesticides are used. Approximately one-third of work-related pesticide exposures to young workers occur in these industries. This HO should be consistent with the HO for agricultural occupations (discussed beginning on page 90). An apprentice/student learner exemption is not recommended because of the need for personal protective equipment and strict adherence to safe work practices when handling pesticides.

Pesticides are Used in Nonagricultural Settings where Many Youth Work

Exposure to pesticides may occur in industries other than agricultural production (SIC 01 and 02). In 1997, 151 million pounds of pesticide active ingredients (12% of total U.S. usage) were used in non-agricultural industries. This includes all pesticide applications to industrial, commercial, and government facilities, buildings, sites, and land, as well as commercial applications to homes and lawns [Aspelin and Grube 1999]. A survey of pesticide users in Iowa and North Carolina, where all users must obtain a licence or be certified (70% of all 51,256 applicators completed the questionnaire), revealed that 50% of commercial applicators applied pesticides to homes, lawns, and gardens [Alavanja et al. 1998].

Analysis of data from the 1997 Current Population Survey [NIOSH 2001a] indicates that approximately 45,000 youth age 15 through 17 worked in landscape and horticultural services (BOC code 020) such as lawn mowing, seeding, spraying, and fertilizing services, over 6,000 worked in agricultural services (BOC code 030) such as corn detasseling, irrigation system operation, and other crop services that may not be performed in actual agricultural production industries, and over 5,000 worked in retail nurseries and garden stores.

Pesticide-Related Illnesses Occur in Nonagricultural Occupations

An analysis of survey and poison control data over the period 1988-1999 revealed that about 32% of acute occupational pesticide-related illnesses in workers under 18 occurred in nonagricultural industries (industries other than BOC codes 010 [agricultural production, crops], 011 [agricultural production, livestock], 012 [veterinary services], 020 [landscape and horticultural services], and 030 [agricultural services, n.e.c.]) [Calvert 2001].

Exposure to Lead

Recommendation– Establish a new HO prohibiting youth from performing work with potential exposure to lead. No apprentice/student learner exemption is recommended.

Rationale– Exposure to lead may occur in settings not covered under the current HOs or the proposed HO on construction work. Exposure to lead is associated with severe acute and chronic toxic effects on many organ systems. Lead exposure in children is associated with developmental and neurologic impairment, and has been linked with mental retardation, poor academic performance, and juvenile delinquency. An apprentice/student learner exemption is not recommended because of the need for personal protective equipment and strict adherence to safe work practices when working around potential lead exposures.

Occupational Exposure to Lead

Occupational lead exposure is discussed under nonagricultural HO 15 (Wrecking, Demolition, and Shipbreaking Operations, beginning on page 58) and under the recommendation for a new HO prohibiting work in construction occupations (page 101). Young workers may be exposed to lead in these settings, but exposures may also occur in other settings. The primary use of lead is in the manufacture of storage batteries. Lead compounds and alloys are also used in pipes and cable sheathing, solder material for electrical applications, paints and plastics as pigments and stabilizers, and glazes for ceramics [Lewis 1990]. Exposure to lead may occur via inhalation or ingestion during abrasive blasting, welding, cutting, and torch burning of surfaces coated with lead-based paint, lead pipes, solder, and other lead-containing building materials. Operations involving recycling of batteries may also involve lead exposures. The OSHA lead standard for general industry provides a mechanism for employers to identify those jobs with potential occupational exposure to lead so that youth can be prohibited from working in these positions. It requires employers to determine if any employee may be exposed to lead at or above a defined action level [29 CFR 1910.1025 (d)(2)]. The standard provides several options for how to perform such a determination. The standard was originally promulgated in 1978. In addition, new environmental regulations under EPA's Toxic Release Inventory (TRI) will require facilities that manufacture, process, or otherwise use more than 100 pounds of lead or lead compounds in a given year to submit that information to a publicly accessible database. [40 CFR Part 372]. The first reports under the new rule must be submitted by July 1, 2002 for the 2001 reporting year. This will also serve to increase awareness about overall lead use among employers and community members.

The CDC estimated that approximately 90%-95% of adults with blood lead levels of 25 micrograms per deciliter (μg/dL) or greater were exposed at work [CDC 1999b]. The geometric mean blood level for adults ages 20-49 is 2.1 μg/dL (95% CI 2.0-22) and for adults ages 50-69 is 3.1 μg/dL (95% CI 2.9-3.2) [Pirkle 1998]. Based on data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-1991), an estimated 700,000 adults in the U.S. had blood lead levels ≥ 25 μg/dL [CDC 1999b].

In California, laboratories are required to report blood lead levels ≥ 25 μg/dL to the Occupational Lead Poisoning Prevention Program (OLPPP) [California Department of Health

Services 2001]. The 10 industries that reported the highest number of workers with blood lead levels ≥ 25 µg/dl during 1995 are listed in Table 39.

Table 39. Industries with the Highest Number of Lead-Exposed Workers in 1995 (California)

Industry Description*	**Workers with blood lead levels ≥ 25 µg/dl, 1995**	
	Number	%
Storage battery manufacturing	362	37%
Nonferrous secondary smelting	181	18%
Automotive repair shops (radiator repair)	68	7%
Painting	52	5%
Amusement & recreation (firing ranges)	37	4%
Masonry & other stonework	35	4%
Copper/ brass foundries	35	4%
Scrap & waste materials	21	2%
Industrial inorganic chemicals manufacturing	19	2%
Motor vehicle parts & accessories manufacturing	15	2%

Source: The California Occupational Blood Lead Registry [California Department of Health Services 2001]
* SIC code not given

Health Hazards of Lead Exposure

The hazards of lead exposure are discussed under nonagricultural HO 15 (Wrecking, Demolition, and Shipbreaking Operations, beginning on page 58) and under the recommendation for a new HO prohibiting construction work (page 101). Lead exerts toxic effects on many organ systems by disrupting basic cellular functions, including interfering with enzymes, competing with essential metals, and disturbing ion transport mechanisms. Acute effects include hemolytic anemia, abdominal colic, neurological effects, kidney disorders, and sterility. Seizures and coma may occur if blood lead levels increase rapidly. Long-term effects include chronic anemia, kidney damage, hypertension, neurological, gastrointestinal, and reproductive effects [Levin and

Goldberg 2000]. Lead exposure in children has been linked with mental retardation, poor academic performance, and juvenile delinquency [EPA 2001]. The International Agency for Research on Cancer [IARC 1987] has concluded that lead is a possible human carcinogen.

Exposure to Silica

Recommendation– Establish a new HO prohibiting youth from performing work with potential exposure to crystalline silica dust. No apprentice/student learner exemption is recommended.

Rationale– Exposure to crystalline silica dust is associated with chronic lung disease and cancer. Not all industries and occupations where exposures to silica occur are covered under current HOs. An apprentice/student learner exemption is not recommended because of the need for personal protective equipment and strict adherence to safe work practices when working with silica.

Exposure to Silica Dust is Associated with Chronic Lung Disease

As described in the recommendation for HO 13 (Brick, Tile, and Kindred Products, beginning on page 54), exposure to respirable crystalline silica dust is associated with the development of silicosis, lung cancer, pulmonary tuberculosis, and airway diseases such as chronic obstructive pulmonary disease and bronchitis [NIOSH 2001j; Zuskin et al. 1998; Liou et al. 1996; Burge et al. 1995; Myers and Cornell 1989]. Additionally, exposure may be related to the development of autoimmune disorders, chronic renal disease, and other adverse health effects [NIOSH 2001j]. Crystalline silica is classified by the International Agency for Research on Cancer [IARC 1997] as a Class 1 Carcinogen, meaning there is a causal relationship between exposure to crystalline silica and human cancer.

While silicosis-associated deaths most commonly occur in persons 65 years of age or older with long-term exposures, deaths also occur in younger adults due to recent exposures to high concentrations of crystalline silica [CDC 1998]. A case of a sandblaster who died of acute silicosis at 23 years of age is described in the text box on page 55.

Silicosis Occurs in Industries Not Covered by Other HOs

Industries and occupations most frequently recorded for decedents with silicosis are shown in Table 41 [NIOSH 1999a]. Current HOs would cover some, but not all, of the situations where youth may be exposed to silica dust.

Table 41. Silicosis: Most Frequently Recorded Occupations and Industries on Death Certificate, Residents Age 15 and Over, Selected States[a] and Years, 1987-1996

Occupation [1980 BOC code]	**%**	**Industry [1980 BOC code]**	**%**
Mining machine operators [616]	14.7%	Construction [060]	10.8%
Laborers, except construction [889]	11.1%	Metal mining [040]	10.0%
Managers and administrators, n.e.c.[019]	3.7%	Coal mining [041]	6.5%
Supervisors, production occupations [633]	3.4%	Blast furnaces, steelworks, rolling and finishing mills [270]	6.5%
Janitors and cleaners [453]	3.1%	Miscellaneous nonmetallic mineral and stone products [262]	6.2%
Molding and casting machine operators [719]	2.8%	Nonmetallic mining and quarrying, except fuel [050]	5.6%
Construction laborers [869]	2.6%	Iron and steel foundries [271]	5.0%
Crushing and grinding machine operators [768]	2.4%	Not specified manufacturing industries [392]	4.1%
Farmers, except horticulture [473]	2.4%	Machinery, except electrical, n.e.c. [331]	2.7%
Machine operators, not specified	2.4%	Agricultural production, crops [010]	2.1%
All other occupations	48.7%	Structural clay products [252]	2.1%
Occupation not reported	2.4%	Pottery and related products [261]	2.1%
		Non-paid worker or non-worker [961]	2.1%
		All other industries	31.7%
		Industry not reported	2.8%

Source: NIOSH, Work-Related Lung Disease Surveillance Report 1999, Tables 3-6 and 3-7 [NIOSH 1999a]
[a]Data on industry and occupation were available for 24 states for most years.

Non-Agricultural and Agricultural Occupations

Work Requiring the Use of Respiratory Protection

Recommendation– Establish a new HO for both agricultural and nonagricultural occupations prohibiting young workers from performing any work that requires the use of respiratory protection. No apprentice/student learner exemption is recommended.

Rationale– The use of respiratory protective devices implies the presence of hazardous atmospheric conditions. Effective use of respirators is dependent on proper fit and usage. Young workers may have difficulty with respirator fit due to their smaller physical size. In order to ensure proper use of respirators, workers should be extensively trained. Because youth may have increased susceptibility to toxins, as discussed previously in this report, exposing young workers to hazardous atmospheric conditions where respiratory protection would be required poses unnecessary risk.

Respiratory Protection is Used to Protect Against a Hazardous Atmosphere

Respiratory protective equipment should be used in the following circumstances: when toxic and potentially hazardous chemicals are present in the atmosphere; where atmospheric materials are likely to cause physical discomfort or increase the risk of injury; in an oxygen-deficient atmosphere; or any combination of these situations [Ballantyne 1981]. Tasks where the routine use of respirators is necessary include abrasive blasting, fire fighting, working in confined spaces, and certain maintenance and cleaning tasks [NIOSH 1994a]. Hazardous respirable materials present in the atmosphere may exist as: gases and vapors (substances that exist in a gaseous state depending on temperature, pressure, and molecular weight), aerosolized particles (such as dust, fumes, smoke, mist, or fog), or fibers (such as asbestos or synthetic fibers). These materials may produce local effects (damage or irritation) on the respiratory tract, systemic effects (acute or chronic) due to absorption into the bloodstream through the respiratory tract, or both [Ballantyne and Schwabe 1981].

Respiratory Protection Standards are Based on Research on Adults

Few studies of the use of respiratory protective devices in children have been undertaken [Mauritzson-Sandberg 1995]. Based on studies of adults, the effectiveness of respiratory protection has been found to be highly dependent on fit of the apparatus and its proper use [NIOSH 1987]. A study examining facial dimensions and respirator fit with regard to leakage found a strong association between poor fit and female gender [Oestenstad 1994]. Adolescents would presumably have similar problems with respirator fit. According to the ANSI Standard for Respiratory Protection [ANSI 1992], an effective respiratory protection program for workers includes extensive training for respirator wearers. Wearers should: be aware of the respiratory hazards that exist and engineering and administrative controls being used; be familiar with the respirator's function, capabilities, and limitations; be able to properly wear the respirator and check for appropriate fit; be familiar with respirator maintenance, inspection, and storage; and be able to recognize and react to an emergency situation.

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VI. AREAS REQUIRING FURTHER RESEARCH

There are other serious and potentially fatal occupational safety and health hazards to young workers under age 18 which are of considerable concern, but for which there is insufficient documentation to support recommendations for new HOs at this time. It is also important that further research be initiated to determine the extent and severity of other emerging hazards to young workers, and whether they pose risks of serious injury, illness, or fatality. Additionally, research is needed on the effectiveness of youth safety training programs to help ensure that exemptions for apprentice and student-learner programs are effective in facilitating a safe training environment. The ability of the HOs to protect the health and safety of youth is dependent on employers understanding and complying with these regulations, as well as knowledge and attitudes about HOs among employers, parents, youth, and other stakeholders. Also, research quantifying and characterizing employer best practices, could be used to increase the effectiveness of outreach and educational campaigns.

Little is Known about Risk Factors for Workplace Violence

> In South Carolina, a 17-year-old assistant manager of a fast-food restaurant was shot and killed in an armed robbery, along with an 18-year-old former employee who was on the premises. An 18-year-old employee was also shot, but survived [Associated Press State and Local Wire 2000b].

More research is needed on workplace violence, which has been identified as a leading cause of job-related deaths for youth [Windau et al. 1999; Castillo and Malit 1997; Castillo et al. 1994]. Work-related homicides occur in all types of work places, but the majority occur in retail establishments where cash is handled, such as grocery stores, convenience stores, and restaurants [Sygnatur and Toscano 2001]. Over half of all employed youth 15 to 17 years old work in this sector, and youth are most commonly hired as cashiers [NRC/IOM 1998, pp. 46-47]. Though homicide rates are elevated in these common youth workplaces, the rates are not sufficiently high to warrant industry-wide prohibitions.

Circumstances are not always known, but available data suggest that most work-related homicides of youth and adults are associated with robbery [Windau et al. 1999; Jenkins 1996]. A study of employee injuries in convenience store robberies found that risk factors associated with injury to an employee during the course of a robbery included the presence of customers, the type of weapon used, whether money was stolen, and whether the store had been previously robbed. The number of employees present and the time of day did not appear to influence the percentage of employee injuries in the event of a robbery in this study [Amandus et al. 1997].

Hypothesized risk factors for work-related homicide include handling cash, working alone or in small numbers, and working in the late evening and early morning hours [Jenkins 1996]. However, data are not available to quantify the level of risk for each of these factors making it difficult to identify a reasonable and promising approach for an HO to address the risk for violence to young workers.

Unique Susceptibilities of Youth

Prevention and control measure addressing workplace hazards to which adolescents are exposed were designed for adults. Therefore, further research on the unique susceptibilities and exposures of young workers is needed.

Most research on the special susceptibilities of children has been limited to the effects of chemicals on young children and infants, with little attention to adolescents. Except for infancy, adolescence is the time of most rapid growth and maturation of vital organ systems, including the reproductive, respiratory, skeletal, immune, and central nervous systems [Bruckner and Weil 1999]. Toxic chemicals, such as endocrine disruptors and neurotoxins may affect adolescents by disrupting the function or the maturation of these systems [Golub 2000]. These chemicals may induce reproductive changes, developmental defects, immunologic deficits, and carcinogenesis.

Adolescence is a period of very rapid growth: 15-20% of a person's height is gained during the teenage years [Marks and Cohen 1978]. Injuries during bone growth can result in degeneration and abnormal regrowth of bone [Kao and Smith 1997; Garrick 1992]. Youth are exposed to risks for musculoskeletal disorders known to be work-related among adults, including cumulative trauma disorders and overexertion injuries. Little research to address potential unique susceptibilities of adolescents to musculoskeletal disorders has been conducted [NRC/IOM 1998]. The impact of adolescent occupational musculoskeletal injuries and illnesses on future quality of life is also not known.

Characterization of Young Worker Health Exposures

Available data on youth employment and associated tasks suggest that youth are working in environments and doing tasks that have known health risks. The extent to which work in these environments poses risk for illness that would adversely affect quality and productivity of youth's lives is not known, however. More research is needed to characterize the types of exposures that youth experience at work that may result in debilitating illness, and to assess the effectiveness of existing work controls and practices to sufficiently protect youth from exposures such as noise, vibration, cumulative trauma, dusts, solvents, and temperature extremes [NRC/IOM 1998; National Committee for Childhood Agricultural Injury Prevention 1996].

Little is known about exposure of working youth to bloodborne pathogens in health care settings. An annual average of approximately 67,000 youth ages 15 to 17 worked in health services (hospitals, clinics, nursing homes, doctor's offices and laboratories) at some time between 1992 and 1998 [NIOSH 2001a]. Exposure to bloodborne pathogens is among the recognized health hazards in health care settings [Lipscomb and Borwegen 2000]. Research is needed to identify the degree to which youth are exposed to bloodborne pathogens and other potentially hazardous substances in health care settings, and the extent to which efforts to prevent exposure among health care providers and emergency workers also protect youth in these settings.

Although asthma is the most common chronic disease of childhood [Clark et al. 1999], investigation of occupational exposures may be overlooked. Occupational asthma is another example of a health-related concern for working youth. Occupational asthma has become the most common work-related lung disease in developed nations [Banks and Wang 2000]. Work-related asthma can only be positively diagnosed if a specific exposure has been identified [Banks

and Wang 2000]. Therefore, youth's exposures to agents associated with asthma should be characterized.

The potential for work place exposure to asbestos among young workers also merits further research. As previously noted in the discussion of HO 15 (Wrecking, Demolition, and Shipbreaking Operations), and in the proposed HO for construction work, asbestos exposure is associated with severe debilitation and potentially fatal lung disease. A number of existing and proposed HOs (such as prohibitions against mining, construction work, and work requiring respiratory protection) would limit youth exposure to asbestos. However, potential exposures may also occur in work settings and tasks not covered by existing or proposed HOs. For example, work as a custodian in asbestos-containing schools and buildings, or work in automotive repair shops performing brake and clutch repair may entail exposure to asbestos on occasion, with uncertain frequency. Although asbestos is clearly a very dangerous work-related exposure, it is not clear to what extent working youth are exposed. Also not known is the extent to which employers are aware of the presence of asbestos in the workplace, and the extent to which exposure is controlled through changes in work process and the use of control technologies. Scientific research such as this should be considered prior to proposing new regulations.

Effectiveness of Training Programs

Exemptions from HOs for apprentice and student learner programs facilitate youth gaining valuable work training in jobs recognized to be hazardous by requiring training and supervision to minimize the risk for injury. Although the weight of existing evidence generally supports the value of training, research into the effectiveness of training programs have given mixed and inconclusive results [Cohen and Colligan 1998; NIOSH 1999d]. Evaluations of apprentice, student learner, and tractor and machinery certification programs are needed to ensure they are effective in reducing the risk for serious injury or illness to youth, and to identify modifications that should be made to increase effectiveness [Castillo et al. 1999a].

Knowledge of and Attitudes Toward Child Labor Laws and Health and Safety Issues Among Stakeholders

Information on knowledge and attitudes about child labor laws, and employer best practices, could be used to increase the effectiveness of efforts such as Work Safe This Summer and Spring Into Safety, and to raise awareness and compliance with child labor regulations. The National Research Council report, *Protecting Youth at Work*, stated that based on unpublished data, it is

In 2000, a 17-year-old youth on a hay hauling crew died from injuries he received when he fell from a moving hay truck and was run over by the vehicle's tire. The bed of the hay truck did not have sideboards or rails, and was not equipped with seats and safety belts for all passengers. The youth apparently fell off the truck as he stood up when the driver was negotiating a curve on a paved road [Oklahoma State Department of Health 2000]. One of the recommendations in this report is that the agricultural HO addressing motor vehicle operation be expanded to include serving as an outside helper. Even if this recommendation were acted upon, it would not impact deaths such as this among 16- and 17-year-old youth working in agriculture.

common for employers to be unaware of child labor laws. One survey found that over three-quarters of employers were not familiar with prohibited jobs for youth and hours youth may work [NRC/IOM 1998, pp. 185-186]. Lack of awareness of laws and health and safety issues among these stakeholders has been identified as a major obstacle to preventing injury and illness in young workers by organizations such as the American Academy of Pediatrics, the American Public Health Association, and NIOSH [NRC/IOM 1998, p. 185].

VII. BARRIERS TO PREVENTING YOUTH DEATHS, SERIOUS INJURIES AND ILLNESSES THROUGH REGULATION

Recommendations in this report are limited to changes to HOs which fall within the regulatory authority of DOL. It is expected that changes recommended in this report would help to reduce the incidence of fatal and serious youth work-related injuries and illnesses each year. However, it must be recognized that considerable numbers of youth work-related deaths and serious injuries would not be impacted by these recommended changes. Many deaths and serious injuries occur among youth not covered by the FLSA, or in situations that would be difficult to regulate under the current framework of the FLSA. Additionally, revisions or additions of new HOs alone will not prevent all work-related deaths. Efforts are needed to raise awareness and compliance with HOs to ensure youth are not inappropriately employed in recognized hazardous work settings.

Agricultural Work is Less Stringently Regulated than Nonagricultural Work

Thirty-five percent of the young workers killed over the 1992-1997 period lost their lives in agricultural production jobs (SIC 01 and 02) (136 agricultural production deaths/394 total deaths) [NIOSH 2001d]. Despite the well-documented hazards and consistently high rates of injury and fatalities, youth in agricultural workplaces are afforded less protection than youth in nonagricultural occupations. This is true even with respect to the same hazards, such as machinery. In fact, the current distinctions between HOs for agricultural and nonagricultural occupations are frequently artificial, given that the same machinery, activities and exposures are often present in both settings. Yet the minimum age for similar hazardous work in agriculture is 16, compared to 18 in nonagricultural occupations. For the 6 year period 1992-1997, there were 39 deaths of youth 16- and 17-years of age in agricultural production [NIOSH 2001d]. Changes to HOs could not be expected to impact these young worker injury deaths since they fall outside the coverage of the FLSA. Additionally, youth working on their family's farms are exempt from the FLSA, unlike most other types of family businesses. It is not possible for NIOSH to determine from the CFOI research file provided by BLS the numbers of agricultural production deaths of youth less than 16 years of age that would not be covered by the FLSA because the youth was working on the family farm. A previous analysis of CFOI by BLS researchers suggested that more than half of the farming related deaths of youth less than

> In 1999, an eleven-year-old youth, who worked on his family's farm, died when the tractor he was operating overturned into a drainage ditch. On the day of the incident, the boy and his father were returning from the cattle pasture where they had hauled hay bales. The father had gone ahead of the boy in a pick-up truck. The boy was operating a tricycle-front-end tractor with a homemade two-wheeled round-hay-bale trailer attached on a well-maintained gravel county road. The father had trained the boy on operating the tractor earlier in the year, and had just recently allowed him to operate it alone. The event was not witnessed, but apparently the boy lost control of the tractor as it neared a drainage ditch and culvert. The tractor veered off of the left side of the road and overturned into the ditch. [Missouri Department of Health 2000].

18 years of age occurred on farms owned by the victim's families [Windau et al. 1999].

State Child Labor Laws May Be Less Protective than Federal Laws

Under current law, states are not required to have child labor laws that are at least as protective as federal law (unlike the federal Occupational Safety and Health Act which requires state laws to be at least as protective as federal law). There are numerous cases in which the federal HOs cannot be applied because the jurisdictional thresholds of the Act are not met, and state law does not cover the particular hazards addressed in the federal HOs. Many states have not incorporated all the federal HOs, and some states' child labor regulations are less protective than the federal HOs [NRC/IOM 1998, pp. 229-230].

Workplace Violence Is Not Addressed by HOs

Work-related homicides accounted for 18% of the work-related fatalities to youth between 1992-1997 [Windau et al. 1999]. As discussed on page 139, hypothesized risk factors for workplace violence, such as working late at night or early in the morning and working in high crime areas, cannot be addressed in the form of an HO. For instance, federal child labor laws make no restrictions on hours worked, at what times of day youth 16 years and older may work, or their job location [DOL 2001]. Consequently, none of the existing or recommended HOs specifically address these hypothesized risk factors. Therefore, changes recommended in this report will do nothing to address the hazards of work place violence.

The Extent of Employer Awareness of and Compliance with Child Labor Laws is Unknown

New HOs and revisions of existing HOs will not protect youth unless recognized and complied with by employers. A number of studies have suggested that many young worker deaths are associated with work typically prohibited by child labor laws. Studies of varying geography, jurisdiction, and time periods have reported that between 38 and 85% of young worker injury deaths are associated with work typically prohibited by child labor laws [Castillo et al. 1994; Dunn and Runyan 1993; Suruda and Halperin 1991; GAO 1991b]. Until barriers to employer compliance are better understood, and strategies are developed to address them, little progress can be expected in this arena.

In 1999, one 15-year-old boy was killed and another 15-year-old boy was seriously injured while working in two different chicken processing plants. In Arkansas, the 15-year-old was electrocuted. In Missouri, the boy fell into an auger, seriously injuring both legs [Tagami 2001]. The FLSA prohibits youth less than 16 years of age from working in workplaces where goods are manufactured or otherwise processed. The Department of Labor found three other underage youth at the Missouri plant where the 15-year-old was seriously injured. As a result of surprise inspections in 51 chicken processing plants nationwide, the Department of Labor uncovered a dozen underage youth at two plants [Tagami 2001].

VIII. APPENDIX. Listing of all SIC industry groups with fatality rates (for all workers) higher than 10 per 100,000 workers (twice the average rate for all workers) by descending rate and description of HO coverage.

Industry (SIC Code)	Fatality rate per 100,000 workers	Number of deaths 1992-1997	Covered by current HOs	Covered by recommended HO expansions and additions	Outside the scope of HO recommendations
Fishing, hunting, and trapping (09)	114.2	436		Proposed new HO for fishing	
Logging (241)	103.1	874	Covered by HO 4		
Taxicab service (412)	82.4	556			Primarily assault fatalities
Coal mining (12)	42.2	255	Covered by HO 3		
Agricultural Production, crops (01)	41.1	2324	Covered by Ag HOs		
Water transportation (44)	37.5	377		Proposed new HO for water transportation industries	
Agricultural services, n.e.c. (071, 072, 075, 076)	31.5	329			Primarily crop dusters - covered by age regulations for pilots
Oil and gas extraction (13)	26.0	522		Covered by proposed expansion for HO 9	
Metal mining (10)	24.4	84	Covered by HO 9		
Executive and legislative offices (911-913)	23.2	210			No basis for HO - misclassification of cases from various industries
Trucking service (421, 423)	22.6	2801	Primarily transportation fatalities, covered by HO 2		
Nonmetallic mining and quarrying, except fuel (14)	21.6	143	Covered by HO 9		
National security and international affairs (97)	20.0	867			Primarily military
Miscellaneous petroleum and coal products (295, 299)	18.3	27			Primarily transportation and assault fatalities

APPENDIX (continued). Listing of all SIC industry groups with fatality rates (for all workers) higher than 10 per 100,000 workers (twice the average rate for all workers) by descending rate and description of HO coverage.

Industry (SIC Code)	Fatality rate per 100,000 workers	Number of deaths 1992-1997	Covered by current HOs	Covered by recommended HO expansions and additions	Outside the scope of HO recommendations
Mobile home dealers, retail (527)	18.0	31	Primarily transportation fatalities, covered by HO 2		
Farm products raw materials (515)	17.5	86		Proposed new HO for the farm product raw materials wholesale trade industry	
Liquor stores (592)	16.6	126			Primarily assaults
Forestry (08)	16.6	82		Covered by proposed expansion to HO 4	
Cement, concrete, gypsum, and plaster products (324, 327)	15.9	181	Primarily transportation fatalities, covered by HO 2		
Scrap and waste materials, wholesale (5093)	15.0	187		Proposed new HO for work in scrap and waste materials industries	
Sanitary services (495)	14.8	276		Proposed new HO for work in refuse occupations	
Construction (15, 16, 17)	14.4	6304		Proposed new HO for construction occupations	
Agricultural production, livestock (02)	14.4	1053	Covered by Ag HOs		
Landscape and horticultural services (078)	13.8	606	Covered by HO 5 (machinery) and HO 2 (transportation)		
Petroleum products, wholesale (517)	13.0	101	Primarily transportation fatalities, covered by HO 2		
Railroads (40)	12.8	208		Proposed new HO for the railroad industry	
Gasoline service stations (554)	12.8	306			Primarily assaults

APPENDIX (continued). Listing of all SIC industry groups with fatality rates (for all workers) higher than 10 per 100,000 workers (twice the average rate for all workers) by descending rate and description of HO coverage.

Industry (SIC Code)	Fatality rate per 100,000 workers	Number of deaths 1992-1997	Covered by current HOs	Covered by recommended HO expansions and additions	Outside the scope of HO recommendations
Air transportation (45)	12.5	555			Age regulations for pilots
Administration of environmental quality and housing programs (95)	12.3	188			No basis for HO - misclassification of cases from various industries
Warehousing and storage (422)	11.9	106	Primarily transportation fatalities, covered by HO 2		
Motor vehicles and equipment, wholesale (501)	11.8	151	Primarily transportation fatalities, covered by HO 2		
Fuel dealers, retail (598)	11.7	83			Primarily assaults
Sawmills, planing mills, and millwork (242, 243)	11.4	256	Covered by HO 4		
Iron and steel foundries (332)	11.4	67		Various exposures including machinery, transportation, and falls which are either already covered or would be with proposed changes	
Detective and protective services (7381, 7382)	11.2	325			Primarily assaults
Agricultural chemicals (287)	10.1	25		Various exposures including machinery, transportation, and falls which are either already covered or would be with proposed changes	

Source: Census of Fatal Occupational Injuries [NIOSH 2001c] and Current Population Survey [NIOSH 2001a].

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IX. REFERENCES

Adkins CE [1993]. Occupational safety and health. In Burke TA, Tran NL, Roemer JS, and Henry CJ (eds): "Regulating risk: the science and politics of risk." Washington, DC: ISIC Press, pp 23-24.

Alavanja MC, Sandler DP, McDonnell CJ, Lynch CF, Pennybacker M, Zahm SH et al. [1998]. Factors associated with self-reported, pesticide-related visits to health care providers in the agricultural health study. Environ Health Perspect; 106(7):415-420.

Alaska Trauma Registry [2001]. Unpublished data. Juneau, AK: Alaska Department of Health and Social Services, Division of Public Health, Section of Community Health and Emergency Medical Services.

Althouse RB, Bang KM, Castellan RM [1995]. Tuberculosis comortality with silicosis – United States, 1979 - 1991. Appl Occup Environ Hyg. 10(12):1037-1041.

Amandus HE, Shy C, Castellan RM, Blair A, Heineman ER [1995]. Silicosis and lung cancer among workers in North Carolina dusty trades. Scand J Work Environ Health. 21 Suppl 2:81-83.

Amandus, HE, Hendricks SA, Zahm D, Friedmann R, Block C, Wellford C, Brensilber D, Bynum T, McManus R, Malcan J, Weiss JC, Kessler D [1997]. Convenience store robberies in selected metropolitan areas: risk factors for employee injury. JOEM 39(5):442-447.

American Academy of Pediatrics, Committee on Injury and Poison Prevention [2000]. All-terrain vehicle injury prevention: two-, three-, and four-wheeled unlicensed motor vehicles. Pediatrics *105*:1352-1354.

ANSI (American National Standards Institute) [1992]. American national standard for respiratory protection. New York, NY: American National Standards Institute, ANSI Z88.2 - 1992.

ANSI (American National Standards Institute) [1997a]. American national standard for equipment technology and operations for wastes and recyclable materials - baling equipment - safety requirements. New York, NY: American National Standards Institute, ANSI Z245.5 - 1997.

ANSI (American National Standards Institute) [1997b]. American national standard for equipment technology and operations for wastes and recyclable materials - stationary compactors - safety requirements. New York, NY: American National Standards Institute, ANSI Z245.5 - 1997.

ANSI (American National Standards Institute) [1999]. American national standard: safety requirements for the storage and handling of anhydrous ammonia. New York, NY: American National Standards Institute, ANSI K61.1-1999.

Aspelin AL, Grube AH [1999]. Pesticide industry sales and usage: 1996 and 1997 market estimates. U.S. Environmental Protection Agency, Office of Pesticide Programs. Washington

DC. U.S. EPA Publication No. 733-R-99-001.

Associated Press [1997]. Boy, 12, dies in fall from hay wagon. July 9, 1997.

Associated Press [1999]. Pyrotechnic blowups kill four people. July 5, 1999.

Associated Press [2000]. Business fined for child labor violations following amputation accident. January 20, 2000.

Associated Press [2001]. Teen killed by dough mixer at pizzeria. October 23, 2001.

Associated Press State & Local Wire [2000a]. Additional charges filed in restaurant shooting. October 26, 2000.

Associated Press State & Local Wire [2000b]. Construction worker loses leg in landfill accident. September 14, 2000.

Attkiss KJ, Buncke HJ [1998]. Physeal growth arrest of the distal phalanx of the thumb in an adolescent pianist: a case report. J Hand Surg [Am]; 23(3):532-535.

Balco JJ, McKenna J [1994]. Asbestos assessment in buildings. In: Current asbestos legal, medical, and technical research. Vol. 10 of the Sourcebook on asbestos diseases. Edited by GA Peters and BJ Peters. Salem, New Hampshire: Butterworth Legal Publishers.

Ballantyne B [1981]. Occupational health aspects of respiratory protection. In: Ballantyne B, Schwabe PH, eds. Respiratory protection. Principles and applications. London: Chapman and Hall Ltd. pp. 135-155.

Ballantyne B, Schwabe PH [1981]. Respiratory protection: an overview. In: Ballantyne B, Schwabe PH, eds. Respiratory protection. Principles and applications. London: Chapman and Hall Ltd. pp. 3-38.

Banks DE, Wang M-L [2000]. Occupational asthma: "The big picture." Occup Med 15(2):335-357.

Barkume A, Bishow J, Garris L, Sygnatur E, Zak M [2000]. Occupational illnesses, injuries, and fatalities. In: Report on the youth labor force. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics.

Bearer C [1995]. How are children different from adults? Environ Health Perspect 103(6):7-11.

Becker CE [1990]. Chapter 31. Gases. In LaDou J ed. Occupational Medicine, pp. 440-441. Norwalk, CT: Appleton and Lange.

Bell CA, Stout NA, Bender TR, Conroy CS, Crouse WE, Myers JR [1990]. Fatal occupational injuries in the United States, 1980 through 1985. JAMA 263(21): 3047-3050.

Blair A. [1996]. Pesticides. In Cancer rates and risks, 4th Ed., National Institutes of Health, National Cancer Institute, Publication No. 96-691.

Blanc PD [1999]. Husker days and fever nights: counting cases of organic dust toxic syndrome. Chest;116(5):1157-1158.

Blondell J [1997]. Epidemiology of pesticide poisonings in the United States. Occup Med 12(2):209-220.

BLS (Bureau of Labor Statistics) [1999a]. Fatal workplace injuries in 1997: a collection of data and analysis. Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics.

BLS (Bureau of Labor Statistics) [1999b]. Occupational injuries and illnesses: counts, rates, and characteristics (1997). Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics.

BLS (Bureau of Labor Statistics) [2000].Occupational Injuries and Illnesses in the United States Profiles Data 1992-1999 CD-ROM version 7.6. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics.

BLS (Bureau of Labor Statistics) [2001]. Employment and earnings, household data annual averages (2000). Washington DC: U.S. Department of Labor, Bureau of Labor Statistics. Internet: http://stats.bls.gov/pdf/cpsaat3.pdf Updated January 29, 2001. Accessed April 26, 2001.

Bowling MJ, Runyan C, Miara C et al. [1998]. Teenage worker's occupational safety: results of a four school study. Poster at the 4th World Conference on Injury Prevention and Control, Amsterdam, the Netherlands, May 17-20.

Boffetta P, Gridley G, Gustavsson P, Brennan P, Blair A, Ekstrom AM et al. [2000]. Employment as butcher and cancer risk in a record-linkage study from Sweden. Cancer Causes Control 11(7):627-633.

Boyle D, Gerberich SG, Gibson RW, Maldonado G, Robinson RA, Martin F, Renier C, Amandus H [1997]. Injury from dairy cattle activities. Epidemiology 8: 37-41.

Braddee RW, Myers JR [1997]. Logging-type fatalities in the U.S. production agriculture industry, 1980-1992. J Agromed 4:373-375.

Bradshaw LM, Fishwick D, Slater T, Pearce N [1998]. Chronic bronchitis, work related respiratory symptoms, and pulmonary function in welders in New Zealand. Occup Environ Med *55*(3):150-154.

Brison RJ, Pickett CW [1992]. Non-fatal farm injuries on 117 eastern Ontario beef and dairy farms: a one year study. Am J Ind Med 21: 623-636.

Budinger L, Hertl M [2000]. Immunologic mechanisms in hypersensitivity reactions to metal

ions: an overview. Allergy *55*(2):108-15.

Bruckner JV, Weil WB [1999]. Biological factors which may influence an older child's or adolescent's responses to toxic chemicals. Regul Toxicol Pharmacol 29:158-164.

Bureau of National Affairs [1993]. NIOSH finds track maintenance workers exposed to excessive levels of silica dust. Occupational Safety and Health Reporter 22(33):1438.

Bureau of the Census [1992]. Alphabetical index of industries and occupations (1990 Census of Population and Housing, Pub. No. 1990 CPH-R-3). Washington, DC: U.S. Department of Commerce, Bureau of the Census. January 1992.

Burge PS, Calvert IA Trethowan WN, Harrington JM [1995]. Are the respiratory health effects found in ceramic fibers due to the dust rather than the exposure fibers? Occup Environ Med 52:105-109.

California Department of Health Services [1993]. Courtesy clerk at grocery store falls from a ladder and dies in California. Berkeley, CA: Fatality Assessment and Control Evaluation (FACE) Program, FACE Report No. 92CA17.

California Department of Health Services [1995]. Recycling packer dies after being crushed by a recycling ram in California. Oakland CA: California Fatality Assessment and Control Evaluation Program, FACE Report No. 95 CA006.

California Department of Health Services [2001]. California occupational blood lead registry Internet: http://www.dhs.ca.gov/ohb/OLPPP/occ-reg.htm Accessed March 28, 2001.

Calvert GM [2001]. Acute occupational pesticide-related illness among children, 1988-1999. 2001 North American Congress of Clinical Toxicology. Montreal, Quebec, Canada. October 2001 [Abstract]. J Toxicol Clin Toxicol 39:477.

Cameron D, Bishop C, Silbert JR [1992]. Farm accidents in children. Br Med J 305:23-25.

Campbell DS [1999]. Health hazards in the meatpacking industry. Occup Med 14(2):351-372.

Carrabba JJ, Field WE, Tormoehlen RL, Talbert BA [2000]. Effectiveness of the Indiana 4-H tractor program at instilling safe tractor operating behaviors and attitudes in youth. J Agric Saf Health 6(3): 179-189.

Castillo DN, Landen DD, Layne LA [1994]. Occupational injury deaths of 16- and 17-year-olds in the United States. Am J Public Health 84: 646-649.

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

Castillo DN, Davis L, Wegman DH [1999a]. Young workers. Occup Med 14: 519-536.

Castillo DN, Adekoya N, Myers JR [1999b]. Fatal work-related injuries in the agricultural production and services sectors among youth in the United States. J Agromed 6(3):27-41.

CDC (Centers for Disease Control) [1982]. Epidemiologic notes and reports silo-filler's disease in rural New York. MMWR 31(28):389-391.

CDC (Centers for Disease Control) [1989]. Epidemiologic notes and reports fatalities attributed to methane asphyxia in manure waste pits - - Ohio, Michigan, 1989. MMWR 38(33): 583-586.

CDC (Centers for Disease Control and Prevention) [1993a]. Public health focus: effectiveness of rollover protective structures for preventing injuries associated with agricultural tractors. MMWR 42(3):57-59.

CDC (Centers for Disease Control and Prevention) [1993b]. Fatalities attributed to entering manure waste pits – Minnesota, 1992. MMWR 42(17):325-329.

CDC (Centers for Disease Control and Prevention) [1993c]. Commercial fishing fatalities – Alaska, 1991-1992. MMWR *42*(18):350-351, 357-359.

CDC (Centers for Disease Control and Prevention) [1994]. Fatalities associated with harvesting of sea urchins – Maine, 1993. MMWR *43*(13):235, 241-242.

CDC (Centers for Disease Control and Prevention) (1995) . Injuries associated with self-unloading forage wagons – New York, 1991-1994. MMWR 44(32):595-597.

CDC (Centers for Disease Control and Prevention) [1996a]. Fatalities associated with improper hitching to farm tractors - - New York, 1991-1995. MMWR 45(15):307-311.

CDC (Centers for Disease Control and Prevention) [1996b]. Suffocations in grain bins – Minnesota, 1992-1995. MMWR 45(39):837-841.

CDC (Centers for Disease Control and Prevention) [1996c]. Skid-steer loader-related fatalities in the workplace – United States, 1992-1995. MMWR 45(29):624-628.

CDC (Centers for Disease Control and Prevention) [1998]. Silicosis deaths among young adults - United States, 1968-1994. MMWR 47(16):331-335.

CDC (Centers for Disease Control and Prevention) [1999a]. Childhood work-related agricultural fatalities – Minnesota, 1994-1997. MMWR 48(16):332-335.

CDC (Centers for Disease Control and Prevention) [1999b]. Adult blood lead epidemiology and surveillance – United States, second and third quarters, 1998, and annual 1994-1997. MMWR 48(10):213-223.

CDC (Centers for Disease Control and Prevention) [2001a]. Nonfatal occupational injuries and illnesses treated in hospital emergency departments--United States, 1998. MMWR;50(16):313-

17.

CDC (Centers for Disease Control and Prevention) [2001b]. Fatal occupational injuries – United States, 1980-1997. MMWR;50(16):317-320.

CFR. Code of federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Chen L, Baker SP, Braver EL, Li G [2000]. Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. JAMA *283*:1578-1582.

Chen G, Fosbroke D [1998]. Work-related fatal-injury risk of construction workers by occupation and cause of death. Human and Ecological Risk Assessment 4: 1371-1390.

Chhokar JS, Wallin JA [1984]. A field study of the effect of feedback frequency on performance. J Appl Psychol *69*:524-530.

Clark NM, Brown RW, Parker E, Robins TG, Remick DG, Philbert MA, Keeler GJ, Israel BA [1999]. Childhood asthma. Environ Health Perspect 107 (Suppl 3): 421-429.

Cogbill TH, Busch, Jr HM, Stiers GR [1985]. Farm accidents in children. Pediatrics 76(4): 562-566.

Cohen R [1990]. Chapter 15. Occupational infections. In: LaDou J (ed.). Occupational Medicine, pp. 178-179. Norwalk, Connecticut: Appleton and Lange.

Cohen A, Colligan M [1998]. Assessing occupational safety and health training: a literature review. 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. 98-145.

Colorado Department of Health [1994a]. A 38-year-old recycle technician died as a result of injuries sustained when he fell into a cardboard compactor. Denver, CO: Colorado Fatality Assessment and Control Evaluation (FACE) Project, CO FACE Investigation 94CO029.

Colorado Department of Health [1994b]. 17-year-old worker at a plastic products manufacturing plant died as a result of overexposure to tetrachloroethylene (also known as perchloroethylene). Denver, CO: Colorado Fatality Assessment and Control Evaluation (FACE) Project, CO FACE Investigation 94CO006.

Consumer Product Safety Commission [1998]. All-terrain vehicle exposure, injury, death, and risk studies. Internet: http://www.cpsc.gov/library/foia/foia98/os/3548a4b.pdf *and* http://www.cpsc.gov/library/foia/foia98/os/3548a5dc.pdf Accessed February 19, 2001.

Consumer Product Safety Commission [2000]. 1999 annual report of all-terrain vehicle deaths and injuries. Internet: http://www.cpsc.gov/library/foia/foia00/brief/atvdth.pdf Accessed

February 19, 2001.

Cotten PR [1997]. Improving child safety amid the farm culture. Prof Saf 42(12): 18-23.

Coye MJ [1985]. The health effects of agricultural production: I. The health of agricultural workers. J Public Health Policy; 6(3):349-370.

Coye MJ, Barnett PG, Midtling JE, Velasco AR, Romero P, Clements CL, Rose TG [1987]. Clinical confirmation of organophosphate poisoning by serial cholinesterase analyses. Arch Intern Med; 147(3):438-442.

De Smet L, Claessens A, Fabry G [1993]. Gymnast wrist. Acta Orthop Belg; 59(4):377-380.

DOL (Department of Labor) [1990]. Child Labor Requirements in Agriculture Under the Fair Labor Standards Act (Child Labor Bulletin No. 102). Washington, DC: U.S. Department of Labor, Employment Standards Administration, Wage and Hour Division.

DOL (Department of Labor) [2001]. Child Labor Requirements in Nonagricultural Occupations Under the Fair Labor Standards Act (Child Labor Bulletin No. 101). Washington, DC: U.S. Department of Labor, Employment Standards Administration, Wage and Hour Division.

Doss HJ, Person HL, McLeod W [1993]. Beware of manure pit hazards. Center for Michigan Agricultural Safety and Health: East Lansing, MI..

Driscoll TR, Ansari G, Harrison JE, Frommer MS, Ruck EA [1994]. Traumatic work related fatalities in commercial fishermen in Australia. Occup Environ Med *51*:612-616.

Drudi D [1999]. Job hazards in the waste industry. In: Fatal workplace injuries in 1997: A collection of data and analysis (Report 934). Washington, DC: Bureau of Labor Statistics, pp. 30-33.

Dunn KA, Runyan CW [1993]. Deaths at work among children and adolescents. Am J Dis Child 147: 1044-1047.

Dunn KA, Runyan CW, Cohen L, Schulman M [1998]. Teens at work: A statewide study of jobs, hazards, and injuries. J Adolesc Health 22: 19-25.

Edmiston S, Maddy KT [1987]. Summary of illnesses and injuries reported in California by physicians in 1986 as potentially related to pesticides. Vet Hum Toxicol; 29(5):391-397.

Elmes PC [1994]. Chapter 20. Inorganic dusts. In Hunter's Diseases of Occupations, 8th Ed., Raffle PAB, Adams PH, Baxter PH, and Lee WR, eds. Edward Arnold Publishers.

Emery RJ, Cooper SP [1998]. Prudent management of minors with occupational exposures to hazardous agents: the radiation protection "standard of care". Inj Prev 4(3):232-235.

Englehardt JD, Fleming LE, Bean JA, An H, John N, Rogers J, Danits M [2000]. Solid waste management health and safety risks: epidemiology and assessment to support risk reduction. Gainesville, FL: Florida Center for Solid and Hazardous Waste Management, Report #00-01.

Englund W, Cohn G [1997]. The shipbreakers: scrapping ships, sacrificing men. The Baltimore Sun [online]. Originally published December 7, 8, and 9, 1997. Internet: http://www.pulitzer.org/year/1998/investigative-reporting/works/ Accessed January 22, 2001.

EPA (Environmental Protection Agency) [1980]. Ambient water quality criteria for polychlorinated biphenyls (PCBs). Washington, DC: Environmental Protection Agency. EPA Publication No. 440-5-80-068.

EPA (Environmental Protection Agency) [1998a]. Hazard assessment of the organophosphates. A report of the hazard identification assessment review committee. Environmental Protection Agency. Office of Pesticide Programs. Health Effects Division. July 7, 1998.

EPA (Environmental Protection Agency) [1998b]. U.S. EPA IRIS substance file - ammonia: CASRN 7664-41-7. U.S. Environmental Protection Agency Integrated Risk Information System (IRIS). Internet: http://www.epa.gov/iris/subst/0422.htm. Updated May 5, 1998. Accessed February 28, 2001.

EPA (Environmental Protection Agency) [2000]. Chemical accident prevention: anhydrous ammonia theft. U.S. Environmental Protection Agency Chemical Safety Alert, Office of Solid Waste and Emergency Response. EPA Publication No. EPA-F-00-005.

EPA (Environmental Protection Agency) [2001]. Residential lead hazard standards - TSCA Section 403. Internet: http://www.epa.gov/lead/leadhaz.htm Accessed March 28, 2001.

Equipment Manufacturers Institute [1995]. Aerial platforms (EMI Safety Manual series). Chicago, IL: Equipment Manufacturers Institute.

Etherton JR, Myers JR, Jensen RC, Russell JC, Braddee RW [1991]. Agricultural machine-related deaths. Am J Public Health 81(6): 766-768.

Evansville Courier [1997]. 'I guess he slipped and fell.' July 9, 1997.

43 Fed. Reg. 52952 [1978]. Occupational Safety and Health Administration; Occupational Exposure to Lead. Final Rule.

59 Fed. Reg. 25164 [1994]. Department of Labor: Child labor regulations, orders and statements of interpretation: proposed rule.

64 Fed. Reg. 67130 [1999]. Department of Labor, Wage and Hour Division, Employment Standards Administration: 29 CFR Parts 570 and 579: Child labor regulations, orders and statements of interpretation; child labor violations – civil money penalties; proposed rules.

66 Fed. Reg. 4500 [2001]. Environmental Protection Agency. Lead and Lead Compounds; Lowering of Reporting Thresholds; Community Right to Know Toxic Chemical Release Reporting. Final Rule http://www.epa.gov/tri/tri1045.pdf

Finkel ML [1985]. The effects of repeated mechanical trauma in the meat industry. Am J Ind Med 8(4-5):375-379.

Finkelstein MM [1998]. Radiographic silicosis and lung cancer risk among workers in Ontario. Am J Ind Med 34:244-251.

Fishwick D, Bradshaw LM, Slater T, Pearce N [1997]. Respiratory symptoms, across-shift lung function changes and lifetime exposures of welders in New Zealand. Scand J Work Environ Health *23*(5):351-358.

Ford GL, Picha DL [2000]. Teenage driver understanding of traffic control devices. Presented at the 79th Annual Meeting of the Transportation Research Board, Washington, DC, January 9-13, 2000.

Fosbroke D, Kisner S, Myers J [1997]. Working lifetime risk of occupational fatal injury. Am J Ind Med 31: 459-467.

Foss RD, Evenson KR [1998]. Effectiveness of graduated driver licensing in reducing motor vehicle crashes. Am J Prev Med 16 (1S): 47-56.

Freeman SA, Kelley KW, Maier DE, Field WE [1998]. Review of entrapments in bulk agricultural materials at commercial grain facilities. J Safety Research 29(2):123-134.

Fritschi L. [2000] Cancer in Veterinarians. Occup Environ Med;57(5):289-297.

GAO (General Accounting Office) [1991a]. Child labor: characteristics of working children. Washington, DC: U.S. General Accounting Office, No. GAO/HRD 91-83BR.

GAO (General Accounting Office) [1991b]. Child Labor: Increases in Detected Child Labor Violations Throughout the United States. Washington DC: GAO, No. GAO/HRD-90-116.

GAO (General Accounting Office) [1995]. Pesticides on farms: limited capability exists to monitor occupational illnesses and injuries. Washinton DC. U.S. General Accounting Office. Publication No. PEMD-94-6.

Garrick JG [1992]. Sports injuries and the osteochondroses. In: McAnarney ER, Kreipe RE, OrrDP, Comerci GC, eds. Textbook of adolescent medicine. Philadelphia: W.B. Saunders Co.

Golka K, Bandel T, Schlaefke S, Reich SE, Reckwitz T, Urfer W et al. [1998]. Urothelial cancer of the bladder in an area of former coal, iron, and steel industries in Germany: a case-control study. Int J Occup Environ Health;4(2):79-84.

Golub MS [2000]. Adolescent health and the environment. Environ Health Perspect 108(4):355-362.

Guillette EA, Meza MM, Aquilar MG, Soto AD, Garcia IE [1998]. An anthropological approach to the evaluation of preschool children exposed to pesticides in Mexico. Environ Health Perspect; 106(6):347-353.

Hansen HL [1996]. Surveillance of deaths on board Danish merchant ships, 1986-1993; implications for prevention. Occup Environ Med 53(4): 269-275.

Harmon GE, Reigart JR, Sandifer SH [1975]. Long-term follow-up of survivors of acute pesticide poisoning. J S C Med Assoc 71:253-6.

Hard D, Layne LA [1995]. A national sample of nonfatal occupational injuries incurred by youth presenting to hospital emergency departments: agriculture compared to other industries. Abstract presented at: Child and Adolescent Rural Injury Control Conference March 8-9, 1995, Middleton, Wisconsin.

Hard D, Myers J, Snyder K, Casini V, Morton L, Cianfrocco R, Fields J [1999]. Young workers at risk when working in agricultural production. Am J Ind Med, Supplement 1:31-33.

Helmers S, Top FH Sr., Knapp LW Jr. [1971]. Ammonia injuries in agriculture. J Iowa Med Soc 61(5): 271-280.

Heyer N, Fanklin G, Rivara F, Parker P, Haug J [1992]. Occupational injuries among minors doing farm work in Washington state: 1986- 1989. Am J Public Health 82: 557-560.

Hjollund NH, Bonde JP, Jensen TK, Henriksen TB, Andersson AM, Kolstad HA et al. [2000]. Male-mediated spontaneous abortion among spouses of stainless steel welders. Scand J Work Environ Health *26*(3):187-192.

Hnizdo E, Murray J, Klempman S [1997]. Lung cancer in relation to exposure to silica dust, silicosis and uranium production in South African gold miners. Thorax 52:271-275.

Holmstrom E, Moritz U, Engholm G [1995]. Musculoskeletal disorders in construction workers. Occup Med *10*(2):295-312.

Hoskin AF, Miller TA [1979]. Farm accident surveys: a 21-state summary with emphasis on animal-related injuries. J Safety Research 11(1):2-13.

Husberg B [2000]. Non-fatal injuries in the Alaskan commercial fishing industry. In: Proceedings of the Second National Fishing Industry Safety and Health Workshop, November 21-22, 1997, Seattle, Washington, pp. 30-39. 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. 2000-104.

IARC (International Agency for Research on Cancer) [1977]. IARC monographs on the evaluation of carcinogenic risk of chemicals to man: asbestos. Vol. 14. Lyon, France: World Health Organization, International Agency for Research on Cancer.

IARC (International Agency for Research on Cancer) [1987]. IARC monographs on the evaluation of carcinogenic risks to humans: overall evaluations of carcinogenicity: An Updating of IARC Monographs Volumes 1 to 42. Supplement 7. Lyon, France: World Health Organization, International Agency for Research on Cancer.

IARC (International Agency for Research on Cancer) [1997]. IARC monographs on the evaluation of carcinogenic risks to humans: silica, some silicates, coal dust and para-aramid fibrils; coal dust. Vol. 68. Lyon, France: World Health Organization, International Agency for Research on Cancer. pp. 337-406.

Insurance Institute for Highway Safety [2001]. U.S. licensing systems for young drivers as of November 2000. Internet: http://www.hwysafety.org/safety%5Ffacts/state%5Flaws/licensing_systems.pdf Accessed February 19, 2001.

Jaques LC [1994]. Shipboard asbestos use: an historical perspective. In: Current Asbestos Legal, Medical and Technical Research. Vol. 10 of the Sourcebook on Asbestos Diseases, edited by GA Peters and BJ Peters. Salem, New Hampshire: Butterworth Legal Publishers.

Jenkins L [1996]. Current Intelligence Bulletin 57: Violence in the workplace: risk factors and prevention strategies. 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. 96-100.

Jensen R, Sinkule E [1988]. Press operator amputations: is risk associated with age and gender? J Safety Research 19:125-133.

Johnson L [1975]. The effects of anhydrous ammonia on the environment and its direct effect on humans. J Environ Health 37(5):462-465.

Johnson ES, Griswold CM [1996]. Oncogenic retroviruses of cattle, chickens and turkeys: potential infectivity and oncogenicity for humans. Med Hypotheses; 46(4):354-356.

Johnson D, Lino M [2000]. Teenagers: employment and contributions to family spending. Monthly Labor Review, September.

Johnson ES, Dalmas D, Noss J, Matanoski GM [1995]. Cancer mortality among workers in abattoirs and meatpacking plants: an update. Am J Ind Med 27(3):389-403.

Kahn E [1976]. Pesticide related illness in California farm workers. J Occup Med; 18(10):693-696.

Kao SC, Smith WL [1997]. Skeletal injuries in pediatric patients. Radiol Clin N Am 35(3):727-746.

Kass I, Zamel N, Dobry CA, Holzer M [1972]. Bronchiectasis following ammonia burns of the respiratory tract. A review of two cases. Chest 62(3):282-5.

Kaufman JD, Cohen MA, Sama SR, Shields JW, Kalat J [1998]. Occupational skin diseases in Washington State, 1989 through 1993: using Workers' Compensation data to identify cutaneous hazards. Am J Public Health 88(7): 1047-1051.

Kimbrough RD, Doemland ML, LeVois ME [1999]. Mortality in male and female capacitor workers exposed to polychlorinated biphenyls. J Occup Environ Med; 41(3):161-171.

Kirkhorn SR, Garry VF [2000]. Agricultural lung diseases. Environ Health Perspect 108 Suppl 4:705-712.

Klitzman S, Goldberg M, Olmstead E, O'Brien S [1994]. Health hazards to construction workers during the demolition of two tenement buildings. Center to Protect Workers' Rights (CPWR). Report OSH2-94.

Kreuzer M, Pohlabeln H, Ahrens W, Kreienbrock L, Bruske-Hohlfeld I, Jockel KH et al. [1999]. Occupational risk factors for lung cancer among young men [published erratum appears in Scand J Work Environ Health 2000 Feb;26(1):83]. Scand J Work Environ Health. 25(5):422-429.

Kuempel ED, Stayner LT, Attfield MD, Buncher CR [1995]. Exposure-response analysis of mortality among coal miners in the United States. Am J Ind Med. 28(2):167-184.

Larsson TJ, Lindquist C [1992]. Traumatic fatalities among Swedish seafarers 1984-1988. Safety Science 15:173-182.

Layde PM, Nordstrom DL, Stueland D, Wittman LB, Follen MA, Olson KA [1996]. Animal-related occupational injuries in farm residents. J Agric Saf Health 2:27-37.

Leduc K, Gris P, Lheureux P, Gevenois PA, De Vuyst P, Yernault JC [1992]. Acute and long term respiratory damage following inhalation of ammonia. Thorax 47(9):755-757.

Leslie Jr JH, Adams SK [1973]. Programmed safety through programmed learning. Hum Fact 15:223-236.

Levin SM, Goldberg M [2000]. Clinical evaluation and management of lead-exposed construction workers. Am J Ind Med. 37:23-43.

Lewis R [1990]. Metals. In: LaDou J (ed.). Occupational Medicine, pp. 297-326. Norwalk, Connecticut: Appleton and Lange.

Lewis MQ, Sprince NL, Burmeister LF, Whitten PS, Torner JC, Zwerling C [1998]. Work-

related injuries among Iowa farm operators: an analysis of the Iowa farm family health and hazard surveillance project. Am J Ind Med 33: 510-517.

Light A [1995]. High school employment: national longitudinal survey discussion paper. Report No. NLS 95-25. Washington D.C: US. Department of Labor.

Lincoln J [2000]. Epidemiology of vessel casualties and commercial fishing fatalities in Alaska. In: Proceedings of the Second National Fishing Industry Safety and Health Workshop, November 21-22, 1997, Seattle, Washington, pp. 25-29. 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. 2000-104.

Liou S-H, Chen Y-P, Shih W-Y, Lee C-C [1996]. Pneumoconiosis and pulmonary function defects in silica-exposed fire brick workers. Arch Environ Health 51(3): pp. 227-233.

Lipscomb J, Borwegen B [2000]. Health care workers. In: Levy BS and Wegman DH, eds. Occupational Health: Recognizing and Preventing Work-Related Disease and Injury, Fourth Edition. Philadelphia, PA: Lippincott Williams & Wilkins, pp767-778.

Litovitz TL, Klein-Schwartz W, Caravati EM, Youniss J, Crouch B, Lee S [1999]. 1998 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med; 17(5):435-487.

Lofgren DJ [1993]. Silica exposure for concrete workers and masons. Appl Occup Environ Hyg *8*:832-835.

Marks A, Cohen MI [1978]. Developmental processes of adolescence. The Volta Review 80(5):275-285.

Massachusetts Department of Public Health [1996]. Massachusetts temporary laborer is crushed in baler at recycling facility. Boston, MA: Fatality Assessment and Control Evaluation (FACE) Report No. 96MA011.

Massachusetts Department of Public Health [1998a]. Work-related injuries to teens. Newsletter from the Teens at Work: Injury Surveillance and Prevention Project. Boston, MA: Occupational Health Surveillance Program.

Massachusetts Department of Public Health [1998b]. Construction laborer dies in trench cave-in at oil tank removal site in Massachusetts. Boston, MA: Fatality Assessment and Control Evaluation (FACE) Report No. 97-MA-031-01.

Mauritzson-Sandberg E [1995]. An evaluation of respiratory protective devices used in children's evacuation. Ergonomics; 38(4):707-713.

Mayhew D [2000]. Effectiveness of graduated licensing laws: evidence thus far. Presented at

the 79th Annual Meeting of the Transportation Research Board, Washington, DC, January 9-13, 2000.

Meijers JM, Swaen GM, Slangen JJ, van Vliet C [1988]. Lung cancer among Dutch coal miners: a case-control study. Am J Ind Med;14(5):597-604.

Meijers JM, Swaen GM, Slangen JJ, van Vliet K, Sturmans F [1991]. Long-term mortality in miners with coal workers' pneumoconiosis in The Netherlands: a pilot study. Am J Ind Med 19(1):43-50.

Melnick RL [1999]. Introduction–workshop on characterizing the effects of endocrine disruptors on human health at environmental exposure levels. Environ Health Perspect 107(Supplement 4):603-604.

Merke D, Miller R [1992]. Age differences in the effects of ionizing radiation. In: Guzelian PS, Henry CJ, Olin SS, eds. Similarities and Differences between Children and Adults. Washington, DC: ILSI Press, pp 139-149.

McLaurin S [1999]. Status of graduated driver licensing. Presented at the 25th International Forum on Traffic Records and Highway Information Systems, Danvers, MA, July 18-22, 1999.

Micheli LJ, Fehlandt AF, Jr. [1992]. Overuse injuries to tendons and apophyses in children and adolescents. Clin Sports Med; 11(4):713-726.

Midtling JE, Barnett PG, Coye MJ, Velasco AR, Romero P, Clements CL, O'Malley MA, Tobin MW, Rose TG, Monosson IH [1985]. Clinical management of field worker organophosphate poisoning. West J Med; 142(4):514-518.

Miller M, Kaufman J [1998]. Occupational injuries among adolescents in Washington state, 1988-1991. Am J Ind Med 34:121-132.

Miller TR, Waehrer GM [1998]. Costs of occupational injuries to teenagers, United States. Inj Prev 4: 211- 217.

Minnesota Department of Health [1992]. Landscape laborer dies after being struck by the bucket of a case skid steer loader. Minneapolis, MN: Fatality Assessment and Control Evaluation (FACE) Report No. 92-MN-09.

Minnesota Department of Health [1994]. Farm youth dies after tractor he was driving rolled over on him. Minneapolis, MN: Fatality Assessment and Control Evaluation (FACE) Report No. 94-MN-041-01.

Minnesota Department of Health [1995]. Farm youth dies after being engulfed in corn inside a steel grain bin. Minneapolis, MN: Fatality Assessment and Control Evaluation (FACE) Report No. 95-MN-045-01.

Minnesota Department of Health [1997]. Farmer youth dies after being run over by a grass seeder. Minneapolis, MN: Fatality Assessment and Control Evaluation (FACE) Report No. 97-MN-038-01.

Minnesota Department of Health [1998]. Laborer dies after being crushed by caterpillar that fell from railroad trestle. Minneapolis, MN: Fatality Assessment and Control Evaluation (FACE) Report No. 98-MN-044-01.

Missouri Department of Health [2000]. Eleven-year-old farm-boy dies following tractor accident. Jefferson City, MO: Fatality Assessment and Control Evaluation (FACE) Report No. 99MO022.

Missouri Department of Health [2001]. Child laborer electrocuted while working at sawmill in Missouri. Jefferson City, MO: Fatality Assessment and Control Evaluation (FACE) Report No. 99MO022.

Mullan R, Murthy L [1991]. Occupational sentinel health events: an up-dated list for physician recognition and public health surveillance. Am J Ind Med *19*:775-799.

Myers JE [1989]. Respiratory health of brick-workers in Cape Town, South Africa: appropriate dust exposure indicators and permissible exposure limits. Scand J Work Environ Health 15:198-202.

Myers JE, Cornell JE [1989]. Respiratory health of brickworkers in Cape Town, South Africa: symptoms, signs, and pulmonary function abnormalities. Scand J Work Environ Health 15:188-194.

Myers JR [1998]. Injuries among farm workers in the United States, 1994. Cincinnati, OH: US Department of Health and Human Services, National Institute of Occupational Safety and Health. NIOSH Pub. No. 98-153.

Myers JR, Fosbroke DE [1994]. Logging fatalities in the united states by region, cause of death, and other factors – 1980 through 1988. J Safety Research 25(2): 97-105.

Myers J, Snyder K, Hard D, Casini VJ, Cianfrocco R, Fields J, Morton L. [1998a]. Statistics and epidemiology of tractor fatalities--a historical perspectives. J Agric Saf Health. 4(2): 95-108.

Myers JR, Kisner SM, Fosbroke DE [1998b]. Lifetime risk of fatal occupational injuries within industries, by occupation, gender, and race. Human Ecol Risk Assess *4*:1291-1307.

National Committee for Childhood Agricultural Injury Prevention [1996]. Children and agriculture: opportunities for safety and health: a national action plan. Marshfield, WI: Marshfield Clinic.

National Fire Protection Association [1997]. Explosives and blasting agents. In: Fire Protection Handbook, Eighteenth Edition, pp 4-143-4-151.

National Safety Council [1995]. American National Standard: ANSI Z16.2-1995 American National Standard for information management for occupational safety and health. Itasca, IL: National Safety Council.

National Transportation Safety Board [1987]. Safety study: uninspected commercial fishing vessel safety. Washington, DC: National Transportation Safety Board, PB87-917003.

Nelson NA, Kaufman JD [1998]. Employees exposed to lead in Washington state nonconstruction workplaces: a starting point for hazard surveillance. Am Ind Hyg Assoc J 59(4): 269-277.

New Jersey Department of Health and Senior Services [1993]. Worker dies from multiple injuries after falling into baling machine. Trenton, NJ: New Jersey Fatality Assessment and Control Evaluation (FACE) Report No. 93NJ040.

New Jersey Department of Health and Senior Services [1995]. Operator crushed in a recycling center baling machine. Trenton, NJ: New Jersey Fatality Assessment and Control Evaluation (FACE) Report No. 95NJ108.

New Jersey Department of Health and Senior Services [1996]. Recycling center laborer crushed in a vertical upstroke baling machine. Trenton, NJ: New Jersey Fatality Assessment and Control Evaluation (FACE) Report No. 96NJ026.

NHTSA (National Highway Traffic Safety Administration) [1998a]. Traffic Safety Facts 1997: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, Publication No. DOT HS 808 806.

NHTSA (National Highway Traffic Safety Administration) [1998b]. Saving teenage lives: the case for graduated licensing. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration. Publication No. DOT HS 808 801.

NIOSH [1979]. Criteria for a recommended standard: working in confined spaces. Washington, DC: U.S. Government Printing Office. DHEW (NIOSH) Publication No. 80-106.

NIOSH [1982]. Residential waste collection: hazard recognition & prevention. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 82-113.

NIOSH [1983]. Health hazard evaluation report: Swissvale Auto Surplus Parts, Inc., Pittsburgh, Pennsylvania. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Report No. HETA-82-246-1275.

NIOSH [1986a]. Current Intelligence Bulletin 45. Polychlorinated biphenyls (PCB's): potential health hazards from electrical equipment fires or failures. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 86-111.

NIOSH [1986b]. Part-time laborer electrocuted in Ohio. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report No. 86-27-II.

NIOSH [1987]. NIOSH guide to industrial respiratory protection. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-116.

NIOSH [1988a]. Health hazard evaluation report: Klotz Brothers, Inc., Staunton, Virginia. Cincinnati, OH:.U.S. Department of Health and Human Services, Public Health Service, National Institute for Occupational Safety and Health, Report No. HETA-97-410-1868.

NIOSH [1988b]. Criteria for a recommended standard: welding, brazing and thermal cutting. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 88-110.

NIOSH [1990a]. NIOSH Alert: Request for assistance in preventing deaths of farm workers in manure pits. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 90-103.

NIOSH [1990b]. Five family members die after entering manure waste pit on dairy farm. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 89-46.

NIOSH [1990c]. NIOSH Alert: Request for assistance in preventing knee injuries and disorders in carpet layers. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 90-104.

NIOSH [1991a]. NIOSH Alert: Request for assistance in preventing lead poisoning in construction workers. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-116. .

NIOSH [1991b]. Health hazard evaluation report: G.T. Jones Tire and Battery Distributing Inc., Birmingham, Alabama. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Report No. HETA-91-213-2123.

NIOSH [1992a]. Health hazard evaluation report: Simmons Industries, Inc., Siloam Springs,

AR. Cincinnati OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. HETA-91-165-2199.

NIOSH [1992b]. NIOSH Alert: Request for assistance in preventing silicosis and deaths from sandblasting. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-102.

NIOSH [1992c]. NIOSH Alert: Request for assistance in preventing falls and electrocutions during tree trimming. 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. 92-106.

NIOSH [1993a]. Health hazard evaluation report: The Lundy Packing Company, Clinton, NC. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HETA-93-0775-2398.

NIOSH [1993b]. NIOSH warns: manure pits continue to claim lives. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 93-114.

NIOSH [1993c]. Commercial fisherman drowned after fishing vessel capsized – Alaska. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 92-32.

NIOSH [1993d]. Health hazard evaluation report: Curio Scrap Metal, Cirello Iron and Steel, Saddle Brook, New Jersey. Cincinnati, OH:.U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Report No. HETA -93-0739-2364.

NIOSH [1993e]. Health hazard evaluation report: Norfolk Southern Railway Company. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HETA-90-341-2288.

NIOSH [1994a]. Comments of the National Institute for Occupational Safety and Health on the Department of Labor/Wage and Hour Division advance notice of proposed rule-making on child labor regulations, orders and statements of interpretation. 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.

NIOSH [1994b]. Health hazard evaluation report: Tyson Foods, Monett, MO. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. HETA- 93-0230-

2405.

NIOSH [1994c]. NIOSH Alert: Request for assistance in preventing drownings of commercial fishermen. 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. 94-107.

NIOSH [1994d]. Worker deaths in confined spaces: a summary of surveillance findings and investigative case reports. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-103.

NIOSH [1995a]. Special topic: working children and adolescents— New Mexico. Morgantown, WV: Division of Safety Research.

NIOSH [1995b]. Special topic: working children and adolescents— Massachusetts. Morgantown, WV: Division of Safety Research.

NIOSH [1996a]. Recycling center laborer crushed in baling machine— Tennessee. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 96-23.

NIOSH [1996b]. Sixteen-year-old electrical-contractor laborer electrocuted – Texas. Morgantown, WV: Division of Safety Research, Fatality Assessement and Control Evaluation (FACE) Report 96-19.

NIOSH [1997a]. Special hazard review: child labor research needs: recommendations from the NIOSH child labor working team. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 97-143.

NIOSH [1997b]. Musculoskeletal disorders and workplace factors. A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. Second Printing. Bernard BP, ed. 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. 97-141.

NIOSH [1997c]. Laborer's legs amputated inside paper baler at resource recovery center. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 97-02.

NIOSH [1997d]. Laborer dies after falling into baler at paper products plant— South Carolina. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 97-15.

NIOSH [1997e]. Current intelligence bulletin 58: Commercial fishing fatalities in Alaska: risk

factors and prevention strategies. 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. 97-163.

NIOSH [1997f]. NIOSH Alert: Preventing worker injuries and deaths from moving refuse collection vehicles. 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. 97-110.

NIOSH [1998]. 9-year-old child helping with a blueberry harvest dies after being run over by cargo truck on field road. Morgantown, WV: Fatality Assessment and Control Evaluation (FACE) Report 98-15.

NIOSH [1999a]. Work-related lung disease surveillance report 1999. 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. 2000-105.

NIOSH [1999b]. NIOSH Hazard ID: Injury associated with working near or operating wood chippers. 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. 99-145.

NIOSH [1999c]. Roofer helper dies after falling 16 ½ feet from roof to concrete basement way – Kansas. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report No. 98-16.

NIOSH [1999d]. A model for research on training effectiveness. 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. 99-142.

NIOSH [2000a]. Comments of the National Institute for Occupational Safety and Health on the Department of Labor notice of proposed rule-making and request for comments on child labor regulations, orders, and statements of interpretation. Child Labor Violations—Civil Money Penalties: 29 CFR Parts 570 and 579. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, January 28, 2000.

NIOSH [2000b]. Three tower painters die after falling 1,200 feet while riding the hoist line. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 00-07.

NIOSH [2000c]. 15-year-old part-time worker at retail grocery store suffers amputation while assembling meat grinder–Utah. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report No. 2000-13.

NIOSH [2000d]. A 16-year-old male died after falling 27 feet at a residential construction site - Alabama. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report No. 2000-16.

NIOSH [2000e]. Worker deaths by falls. A summary of surveillance findings and investigative case reports. 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. 2000-116.

NIOSH [2000f]. Youth laborer dies in trench collapse – Michigan. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 2000-03.

NIOSH [2001a]. Unpublished data from computer tapes of the Current Population Survey. Morgantown, WV: Division of Safety Research, National Institute for Occupational Safety and Health.

NIOSH [2001b]. Unpublished analyses of the National Electronic Injury Surveillance System (NEISS). Morgantown, WV: Division of Safety Research, NIOSH.

NIOSH [2001c]. Unpublished analyses of the 1992-1997 Census of Fatal Occupational Injuries Research File provided to NIOSH by the Bureau of Labor Statistics. Morgantown, WV: Division of Safety Research, NIOSH.

NIOSH [2001d]. Unpublished analyses of the 1992-1997 Census of Fatal Occupational Injuries Special Research File provided to NIOSH by the Bureau of Labor Statistics (includes more detailed data than the research file, but excludes data from New York City). Morgantown, WV: Division of Safety Research, NIOSH.

NIOSH [2001e]. 14-year-old youth pulled into operating wood chipper – Florida. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 2000-21.

NIOSH [2001f]. Seventeen-year-old laborer at salvage lumber operation crushed by forklift that tipped over – New York. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 2000-22.

NIOSH [2001g]. Fourteen-year-old rental equipment worker dies from asphyxiation after becoming entangled in an electric chain hoist – Colorado. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 2001-13. In preparation.

NIOSH [2001h]. National Occupational Research Agenda for Musculoskeletal Disorders. Research Topics for the Next Decade. A report by the NORA Musculoskeletal Disorders Team. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-117.

NIOSH [2001i]. 16-year-old produce-market worker dies from crushing injuries after being caught in a vertical downstroke baler – New York. Morgantown, WV: Division of Safety Research, Fatality Assessment and Control Evaluation (FACE) Report 2000-19.

NIOSH [2001j]. NIOSH hazard review: Health effects of occupational exposure to respirable crystalline silica. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-134.

NIOSH [2001k]. Unpublished analysis of the Traumatic Injury Surveillance of Farmers (TISF) survey. Morgantown WV: Division of Safety Research, National Institute for Occupational Safety and Health.

NIOSH [2001l]. Childhood Agricultural Injuries Survey, 1998 (research file). Unpublished analysis by the NIOSH Division of Safety Research.

NIOSH [2001m]. Hazard review: health effects of occupational exposure to asphalt. 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. 2001-110.

NIOSH [2001n]. Health hazard evaluation report: CSX Transportation, Inc. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Report No. HETA-92-0311-2826.

NRC (National Research Council) [1987]. Counting occupational injuries and illnesses in the workplace: proposals for a better system. Pollack ES, Keimig DG (Eds): Panel on Occupational Safety and Health Statistics, Committee on National Statistics. Washington, DC: National Academy Press.

NRC (National Research Council) [1993]. Pesticides in the diets of infants and children. National Academy Press, Washington , D.C.

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

Nordstrom DL, Layde PM, Olson KA, Stueland D, Brand L, Follen MA [1995]. Incidence of farm-work-related acute injury in a defined population. Am J Ind Med 28: 551-564.

Oestenstad RK [1994]. Factors affecting respirator leak sites and shapes. Birmingham, AL: University of Alabama at Birmingham, School of Public Health. NIOSH Grant 1K01OH00085.

Oklahoma State Department of Health [2000]. A 17-year-old on a hay hauling crew died from injuries received when he fell from a moving hay truck and was apparently run over by the

vehicles tire. Oklahoma City, OK: Fatality Assessment and Control Evaluation (FACE) Report No. 00-OK045-01.

Oliver CL [1994]. Asbestos in buildings: management and related health effects. In: Mehlman MA and Upton A, eds. Advances in Modern Environmental Toxicology (Series editor, Mehlman MA) Volume XXII: The Identification and Control of Environmental and Occupational Diseases: Asbestos and Cancers. pp. 175-188.

OMB (Office of Management and Budget) [1987]. Standard industrial classification manual, 1987. Washington, DC: Government Printing Office.

Osorio AM, Melius J [1995]. Lead poisoning in construction. Occup Med *10*(2):353-361.

Palmgren MS, Lee TC [1984]. Malathion and diazinon levels in grain dust from New Orleans area grain elevators. Am Ind Hyg Assoc J 45(3): 168-171.

Parks CG, Conrad K, Cooper GS [1999]. Occupational exposure to crystalline silica and autoimmune disease. Environ Health Perspect 107 Suppl 5:793-802.

Pavelchak N, Church L, Roerig S, London M, Welles W, Casey G [1999]. Silo gas exposure in New York state following the dry growing season of 1995. Appl Occup Environ Hyg 14: 34-38.

Phebo L, Dellinger A [1998]. Young driver involvement in fatal motor vehicle crashes and trends in risk behaviors, United States, 1985-95. Inj Prev 4: 284-287.

Pigg BJ [1994]. The uses of chrysotile. Ann Occup Hyg. 38:pp453-458.

Pirkle JL, Kaufmann RB, Brody DJ, et. al. [1998]. Exposure of the U.S. population to lead, 1991-1994. Environ Health Perspect 106:745-750.

Poulsen OM, Breum NO, Ebbehoj N, Hansen AM, Ivens UI, van Lelieveld D, Malmros P, Matthiasen L, Nielsen BH, Nielsen EM, Schibye B, Skov T, Stenbaek EI, Wilkins KC [1995]. Sorting and recycling of domestic waste. Review of occupational health problems and their possible causes. The Science of the Total Environment *168*:33-56.

Pratt SG, Kisner SM, Helmkamp JC (1996). Machinery-related occupational fatalities in the United States, 1980-1989. J Occup Environ Med 38(1): 70-76.

Pratt DS, Marvel LH, Darrow D, Stallones L, May JJ, Jenkins P [1992]. The dangers of dairy farming: the injury experience of 600 workers followed for two years. Am J Ind Med 21: 637-650.

Pratt SG, Kisner SM, Moore PH [1997]. Machinery-related fatalities in the construction industry. Am J Ind Med 32: 42-50.

Pratt SG and Hard DL [1998]. Injury risk factors associated with agricultural workplace

fatalities. J Agric Saf Health Special Issue 1:29-38.

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, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2001-128.

Preusser DF, Ferguson SA, Williams AF [1998]. The effect of teenage passengers on the fatal crash risk of teenage drivers. Accid Anal Prev *30*:217-222.

Purschwitz MA, Field WE [1990]. Scope and magnitude of injuries in the agricultural workplace. Am J Ind Med 18: 179-192.

Rafnsson V, Gunnarsdóttir H [1993]. Risk of fatal accidents occurring other than at sea among Icelandic seamen. Br Med J 306(6889): 1379-1381.

Reilly MSJ [1985]. Mortality from accidents to United Kingdom fishermen 1961-1980. Br J Ind Med *42*:806-814.

Resnick MD, Bearman PS, Blum RW, Bauman KE, Harris KM, Jones J et al. [1997]. Protecting adolescents from harm. Findings from the National Longitudinal Study on Adolescent Health [see comments]. JAMA; 278(10):823-32823.

Rettig BA, Klein DK, Sniezek JE [1987]. The incidence of hospitalizations and emergency room visits resulting from exposure to chemicals used in agriculture. Nebr Med J; July, 1987:215-219.

Reynolds SJ, Groves W [2000]. Effectiveness of roll-over protective structures in reducing farm tractor fatalities. Am J Prev Med 18(4S):63-69.

Ringen K, Englund A, Seegal J [1995]. Construction workers. In: Occupational Health: Recognizing and Preventing Work-Related Disease [3rd edition], pp. 685-701. Boston, MA: Little, Brown, and Company.

Robinson CF, Halperin WE, Alterman T, Braddee RW, Burnett CA, Fosbroke DE, Kisner SM, Lalich NR, Roscoe RJ, Seligman PJ, Sestito JP, Stern FB, Stout NA [1995]. Mortality patterns among construction workers in the United States. Occup Med *10*(2):269-283.

Rosenberg J [1990]. Chapter 30: Pesticides. In: LaDou J ed. Occupational Medicine. Appleton and Lange, Norwalk, Connecticut.

Rosenstock L, Daniell W, Barnhart S, Schwartz D, Demers PA [1990]. Chronic neuropsychological sequelae of occupational exposure to organophosphate insecticides. Am J Ind Med 18:321-325.

Rothstein D, Herz D [2000]. A detailed look at employment of youths aged 12 to 15. In Report

on the Youth Labor Force. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics.

Rubinksy S, Smith NF [1971]. Final Report, University of Rhode Island, Providence RI, PHS Contract 86-68-207, Injury Control Research Laboratory, Providence, RI.

Ruhl R, Kluger N [1995]. Hazardous substances in construction work. Occup Med *10*(2):335-351.

Ruser JW [1998]. Denominator choice in the calculation of workplace fatality rates. Am J Ind Med; 33(2):151-6.

Savage EP, Keefe TJ, Mounce LM, Heaton RK, Lewis JA, Burcar PJ [1988]. Chronic neurological sequelae of acute organophosphate pesticide poisoning. Arch Environ Health;43:38-45.

Schilling RSF [1971]. Hazards of deep sea fishing. Br J Ind Med *28*:27-35.

Schwab CV, Hanna M, Miller L [1993]. Play it safe with anhydrous ammonia. Iowa State University Extension, Ames IA. Fact Sheet Pm-1518d.

Sferlazza SJ, Beckett WS [1991]. The respiratory health of welders. Am Rev Respir Dis *143*:1134-1148.

Sharp JC [1965]. Properties of ammonia. In: McVickar MH, Martin WP, Miles IE, Tucker HH, eds. Agricultural Anhydrous Ammonia: Technology and Use. Proceedings of a symposium sponsored by the Agricultural Ammonia Institute, the American Society of Agronomy, and the Soil Science Society of America. Chase-Park Plaza Hotels, St. Louis MO, September 29-30, 1965.

Shaver CS, Tong T [1991]. Chemical hazards to agricultural workers. Occup Med 6(3):391-413.

Shutske J [1994]. Using anhydrous ammonia safely on the farm. St. Paul, MN. University of Minnesota Extension Service Publication No. FO-2326-C.

Shutske J [1999]. Flowing grain is killer; danger is high this year. News Information. University of Minnesota Extension Service.

Sjögren B, Gustavsson P, Hogstedt C [1990]. Neuropsychiatric symptoms among welders exposed to neurotoxic metals. Br J Ind Med 47: 704-707.

Smith NF, Rubinsky S [1972]. Long-term retention of safety procedures through accident simulation. DHEW Publication No. (HSM) 72-10016. Injury Control Research Laboratory, Providence, RI.

Sobaszek A, Boulenguez C, Frimat P, Robin H, Haguenoer JM, Edme JL [2000]. Acute respiratory effects of exposure to stainless steel and mild steel welding fumes. J Occup Environ Med *42*(9):923-931.

Sobonya R [1977]. Fatal anhydrous ammonia inhalation. Hum Pathol 8(3):293-299.

Springfeldt B, Thorsen J, Lee BC [1998]. Sweden's thirty-year experience with tractor rollovers. J Agric Saf Health 4(3): 173-180.

Stayner L [1992]. Methodologic issues in using epidemiologic studies for quantitative risk assessment. In Clewell HJ III (ed). "Conference on Chemical Risk Assessment in the Department of Defense (DoD): Science, Policy, and Practice." Cincinnati, OH: American Conference of Governmental Industrial Hygienists, Inc, pp 43-51.

Steenland K, Jenkins B, Ames RG, O'Malley M, Chrislip D, Russo J. Chronic neurological sequelae to organophosphate pesticide poisoning. Am J Public Health 1994;84:731-736.

Steinberg L, Cauffman E [1995]. The impact of employment on adolescent development. In Vasta, R. (Ed): Annals of Child Development (11). Philadelphia, PA: Jessica Kingsley Publishers.

Sullivan PA, Bang KM, Hearl FJ, Wagner GR [1995]. Respiratory disease risks in the construction industry. Occup Med *10*(2):313-334.

Suratt PM, Winn WC Jr, Brody AR, Bolton WK, Giles RD [1977]. Acute silicosis in tombstone sandblasters. Am Rev Respir Dis. 115:521-529.

Suruda A, Halperin WH [1991]. Work-related deaths of children. Am J Ind Med 19: 739-745.

Swaen GM, Aerdts CW, Sturmans F, Slangen JJ, Knipschild P [1985]. Gastric cancer in coal miners: a case-control study in a coal mining area. Br J Ind Med; 42(9):627-630.

Swaen GM, Meijers JM, Slangen JJ [1995]. Risk of gastric cancer in pneumoconiotic coal miners and the effect of respiratory impairment. Occup Environ Med 52(9):606-610.

Sygnatur EF, Toscano GA [2001]. Work-related homicides: the facts. BLS Fatal Workplace Injuries in 1998 and 1999: A Collection of Data and Analysis: 7-12.

Tagami, T [2001]. Kids as young as 12 held jobs at chicken plant, ex-workers say fake ID cards got young immigrants through interviews. Lexington Herald-Leader, January 14, 2001.

Texas Worker's Compensation Commission [1998]. A computer support technician at a communications company in Texas died after being crushed in a stationary trash compactor. Austin, TX: Texas Fatality Assessment and Control Evaluation Report No. 98TX071.

Thelin A [1998]. Rollover fatalities – Nordic perspectives. J Agric Saf Health 4(3): 157-160.

Transportation Research Board [1996]. Graduated licensing: past experiences and future status (Transportation Research Circular #458). Washington, DC: National Academy of Sciences, Transportation Research Board.

University of Iowa [1995a]. 12-year-old boy dies from a tractor rollover in a roadside ditch - - Iowa. Iowa City, Iowa: Fatality Assessment and Control Evaluation (FACE) Report No. 95-IA-009.

University of Iowa [1995b]. Farmer killed from tractor rollover while loading hay on hillside – Iowa. Iowa City, IA: Fatality Assessment and Control Evaluation (FACE) Report 95-IA-029.

Urman, S [1978]. Overview: the control of railroad occupational noise. Prof Saf 23(10):47-51.

Von Essen S, Fryzek J, Nowakowski B, Wampler M [1999]. Respiratory symptoms and farming practices in farmers associated with an acute febrile illness after organic dust exposure. Chest;116(5):1452-1458.

Wagner GR [1994]. Mineral dusts. In: Rosenstock L, Cullen MR, editors. Textbook of Clinical Occupational and Environmental Medicine. Philadelphia: W.B.Saunders:832-834.

Wagner GR [1997]. Asbestosis and silicosis. Lancet. 349(9061):1311-1315.

Washington State Department of Labor and Industries [2001]. Sixteen year old worker falls from roof of building in Washington state. Seattle, WA: SHARP Program, Fatality Assessment and Control Evaluation Program, Investigation #98WA11301, SHARP Report; # 00-0-2000 (in preparation).

Weiss B [1997]. Pesticides as a source of developmental disabilities. Mental Retardation and Developmental Disabilities Research Reviews 3: 246-256.

Wilk V [1993]. Health hazards to children in agriculture. Am J Ind Med 24:283-290.

Wilkinson TL, Schuler RT, Skjolaas CA [1993]. The effect of safety training and experience of youth tractor operators. Technical Paper at the Conference of the National Institute for Farm Safety, June 13-17, 1993, Coeur d'Alene, Idaho, Paper No. 93-6.

Windau J [1999]. Worker fatalities from being caught in machinery. BLS Fatal Workplace Injuries in 1997: A Collection of Data and Analysis: 18-21(1999); Compensation and Working Conditions. Winter 1999.

Windau J, Sygnatur E, Toscano G [1999]. Profile of work injuries incurred by young workers. Monthly Labor Review June 1999.

Wisconsin Division of Health [1998]. Youth worker dies after being pinned under tractor at a food processing plant. Madison, WI: Fatality Assessment and Control Evaluation (FACE) Report No. 98WI07401.

Wright JL [1989]. Lung disease in farm workers: Pathological reactions. In: Dosman JA and Cockcroft DW eds. Principles of Health and Safety in Agriculture. Boca Raton, FL: CRC Press, p. 26.

Zuskin E, Mustajbegovic J, Schachter EN, Kern J, Doko-Jelinic J, Godnic-Cvar J [1998]. Respiratory findings in workers employed in the brick-manufacturing industry. J Occup Environ Med. 40(9):814-820.