NIOSH Healthcare and Social Assistance Program:

Evidence Package for 2006-2016

April 2017

Executive Summary

Healthcare and Social Assistance (HCSA) is one of the largest and fastest growing industry sectors in the U.S. Employing a large and diverse workforce, the sector poses unique challenges in protecting the health and safety of workers in a context where patient and client safety and quality of care are also of paramount importance. The National Institute for Occupational Safety and Health (NIOSH) has been addressing occupational safety and health challenges through the generation of new knowledge and the translation of that knowledge in to practice since its establishment in 1970. Based upon available burden and need information at the start of the second decade of the National Occupational Research Agenda (NORA) (2006-2016), the NIOSH HCSA Program chose to focus on four primary areas of research: 1) promoting safe and health workplaces; 2) prevention of musculoskeletal disorders; 3) hazardous drugs and other chemicals; and 4) prevention of occupational infectious disease transmission, which includes sharps injury prevention. The Program also made the decision to direct most of its efforts toward the healthcare industry sector. However, many of the issues that were addressed in healthcare (e.g., overexertion, violence) are also relevant to social assistance.

NIOSH activities described within this document reflect both intramural (work within NIOSH) and extramural (work funded by NIOSH through grants, contracts, and cooperative agreements) efforts. The intramural component of the Program has received an annual average of approximately $9.3M and the extramural component has received approximately $6.8M in funding annually.

This evidence package presents, for each of the four primary areas, inputs, research and translation activities, research findings and products, translators who assist NIOSH in transferring its research into practice, and evidence of utilization of research findings. A brief overview of each area is provided below.

Promoting Safe and Healthy Workplaces

In healthcare, the importance of safety culture in protecting patients is well established. NIOSH identified important knowledge gaps in understanding how safety culture extends to worker health and safety. Research in this area focused on work organization, including work hours, scheduling and workloads) and on workplace violence.

Investigators examined characteristics of work organization including leadership, group behaviors, communications, and structure of work to determine their influence on worker safety and health. For instance, NIOSH partnered with The Joint Commission to identify effective worker/patient safety practices among high reliability healthcare institution in the U.S. Leaders demonstrated synergies between worker safety and patient safety and described essential elements of successful programs.

Research studies explored the relationships between organization of work and musculoskeletal disorders, between work schedules and fatigue, and between fatigue and medical errors and work-related injuries. Some work focused specifically on the impact of 12-hour shifts and further evaluated the challenges to changing these shifts in the contemporary healthcare environment. NIOSH has also developed interventions to address many of these work organization issues including a widely used online training course for nurses and managers. This training has contributed to efforts to improve work schedules for physicians in training and to improve nurse staffing to reduce fatigue and burnout.

A major area of research and translation was the prevention of workplace violence, as the HCSA industry sector had the highest rate of nonfatal workplace assaults among all sectors. Investigators identified work settings and occupations at risk, evaluated interventions to reduce risks, and developed training programs for workers that

have been widely used. The work is reflected in guidelines produced by multiple influential organizations including the Agency for Healthcare Research and Quality (AHRQ), the Occupational Safety and Health Administration (OSHA), and the American Nurses Association (ANA).

Prevention of Musculoskeletal Disorders

The most common occupational injury among healthcare workers are musculoskeletal disorders (MSDs) due to lifting and positioning patients and injuries sustained from slip, trip, and fall incidents. At the start of the second decade of NORA, the HCSA Program directed the bulk of its efforts toward MSDs caused by patient handling due to the considerable amount of slips, trips and falls research conducted prior to the start of the second decade of NORA. NIOSH intramural and extramural researchers have worked extensively on best practices for safe handling of patients and use of assistive devices, safe patient handling and mobility programs, and a business case for implementing safe patient handling programs over the las ten years. Their work has influenced professional organizations [e.g., American Nurses Association (ANA), Association of Occupational Health Professionals (AOHP)], Federal agencies (e.g., Veterans Health Administration and OSHA), and employers to develop and adopt policies, guidance, and educational materials to prevents back injuries, which represent a significant health and economic burden. One example is the release of ANA's Safe Patient Handling and Mobility Interprofessional National Standards which establishes a uniform, national foundation for safe patient handling and mobility. NIOSH activities have also contributed to development of federal and state policy. The impact of these efforts are believed to have contributed to the decline in the non-fatal occupational injury and illness incidence rates associated with overexertion in lifting in the healthcare industry from 2006-2014.

Reducing Health Impacts of Hazardous Drugs and Other Chemicals

Hazardous drugs and other chemicals represent a major concern in the HCSA industry sector because of their potential to cause adverse health effects if exposures are not appropriately controlled. In collaboration with external stakeholders, NIOSH initiated the Hazardous Drugs Exposures in Healthcare Program to identify and prevent healthcare worker exposures to pharmaceutical drugs. Efforts included identification of newly approved drugs that pose an occupational hazard, updates of the NIOSH hazardous drugs list and safe handling guidelines, and recommendations on how to protect pregnant and breastfeeding women and their babies. NIOSH also addressed impediments to adherence to safe handling guidelines, an important research gap identified in a survey of healthcare workers who handle hazardous drugs and other chemicals commonly found in healthcare settings. An increased risk of work-related asthma among healthcare workers prompted numerous research studies to better understand exposure determinants and mechanisms of action. Cleaning and disinfecting (C&D) agents are essential in healthcare for infection control purposes, but information was lacking on approaches to evaluate these chemicals and their effect on worker health. A working group of the HCSA Sector Council co-chaired by a NIOSH investigator and an academic partner published an integrated approach to guide more comprehensive efforts to minimize C&D exposures without reducing the effectiveness of infection prevention. The aforementioned activities resulted in numerous publications which have had significant impact, especially with respect to raising awareness in healthcare of potential health hazards associated with the use a hazardous drugs and hazardous chemicals.

Prevention of Infectious Disease Transmission

Transmission of infectious diseases is a common concern among workers in the HCSA industry sector. Infectious disease transmission is also a patient safety issue since patients and visitors are also at risk from exposure to infectious agents. Some infectious hazards are well recognized, yet continued efforts are needed to address

them. One such effort involved a partnership between NIOSH and the Organization for Safety, Asepsis and Prevention (OSAP) to conduct a survey of private dental practices to examine use of an OSHA-mandated Exposure Control Plan for minimizing occupational exposure to bloodborne pathogens. Other ongoing research efforts sought to improve the technology and use of engineering controls and personal protective equipment to protect healthcare workers from infectious hazards.

Some infectious diseases are emerging due to recent domestic and international outbreaks. Responding to emerging infectious diseases can be very challenging since mode of transmission, severity of disease, and effectiveness of preventive interventions may be unclear. High profile efforts during the second decade of NORA sought to protect healthcare workers from emerging agents such as Ebola and 2009 H1N1 pandemic influenza and subsequently to address gaps in knowledge identified during these outbreak responses.

Outlook for the Next Decade

Going into the next decade, the NIOSH HCSA Program will develop evidence-based goals to appropriately prioritize and focus its efforts over the next 10 years as part of a larger NIOSH Strategic Plan. The program will continue to seek input from experts, stakeholders, and other interested parties and will carefully consider issues such as burden of injury and illness, size of populations with hazardous exposures, research needed to have an impact, and NIOSH's unique capabilities as it establishes the HCSA Program strategic plan. This approach will help to maximize the impact of NIOSH investments to improve occupational safety and health in the HCSA industry sector.

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Chapter 1: Program Overview

Since it was established in 1970, the National Institute for Occupational Safety and Health (NIOSH) has had a long history of research and service relevant to the Healthcare and Social Assistance (HCSA) industry sector. However, it was only in 2006 that NIOSH first developed an organized, cross-institute program that encompassed all activities funded by NIOSH to address occupational safety and health issues in the HCSA sector. The HSCA Program refers to the cross-Institute effort to address occupational safety and health in the HCSA sector. All such efforts funded by NIOSH are encompassed within the program. The catalyst for development of the program was the National Occupational Research Agenda (NORA) initiative. Stewarded by NIOSH, this initiative is a national partnership program to stimulate innovative research and improved workplace practices. In its second decade (2006–2016), NORA was reorganized into 10 industry sectors based on major areas of the U.S. economy, as defined by the North American Industry Classification System (NAICS) (U.S. Census, 2017). Originally, the HCSA Program consisted of occupations classified within NAICS code 62. This code includes four subsectors: ambulatory healthcare services (621), hospitals (622), nursing and residential care facilities (623), and social assistance (624).

Veterinary Medicine and Animal Care (VM/AC) (NAICS code 541940, 812910, 712130) was moved from the Services Sector Program to the HCSA Program in 2013. The rationale for this transfer was that many of the issues faced by VM/AC workers are similar to those faced by their counterparts caring for or providing services to humans. Inclusion of VM/AC in the HCSA sector is also in concert with the One Health movement, which seeks to encourage collaboration between professionals from multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals, and the environment (Centers for Disease Control and Prevention [CDC], 2017). However, VM/AC has been excluded from this review as it is premature for an impact assessment. Also excluded from this review is social assistance which includes the following industries: individual and family services, community food and housing and emergency services, vocational rehabilitation services, and child day care services. The HCSA Program focused on healthcare because it accounts for the vast majority of workers in the HCSA sector (15.8 of the 18.7 million HCSA workers in 2015). Many of the issues that were addressed in healthcare during the past decade (e.g., overexertion, workplace violence) were also relevant to social assistance and produced products (training courses, best practices guidance) that are also applicable to social assistance.

The HCSA Program was involved in many major accomplishments in the last decade. Highlights include:

- ***Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration and Innovation*** **–** This monograph was developed by The Joint Commission with financial and technical support from the HCSA Program. It describes potential synergies between patient and worker health and safety activities and highlights programs that promote these synergies (The Joint Commission, 2012).
- **NIOSH *Workplace Violence Prevention Training for* Nurses –** This online course helps healthcare workers better understand the scope and nature of violence in the healthcare workplace. Since its launch in 2013, over 20,000 participants have completed the course with most obtaining continuing education credits (NIOSH, 2017a).
- **American Nurses Association (ANA)'s *Safe Patient Handling and Mobility Interprofessional National Standards* –** One of the goals included in the NORA HCSA Agenda was for organizations to establish national safe patient handling and mobility standards to guide a reduction in musculoskeletal disorders in healthcare workers. Several members of the NORA HCSA Council (which is co-lead and coordinated by

NIOSH) made significant contributions to this ANA effort, along with other interprofessional national subject matter experts (ANA, 2013).

- **Health and Safety Practices Survey of Healthcare Workers –** NIOSH partnered with 21 professional practice organizations to determine the level of adherence to national guidelines and best practices for minimizing exposure to hazardous chemicals commonly found in healthcare settings. Over 10 papers have been published describing the findings from the 2011 online survey (NIOSH, 2017b).
- **The OSAP Survey of Bloodborne Pathogens Exposure Control Plans in Private Dental Practices –** The Organization for Safety, Asepsis and Prevention (OSAP) surveyed private dental practices to examine use of exposure control plans for reducing the risk of exposure to blood and other potentially infectious materials. Survey findings will be published in a dental journal in April 2017. The HCSA Program provided financial and technical support for this project (Laramie, Bednarsh, Isman, Boiano, & McCrone, in press).

Healthcare and Social Assistance Sector Council

NORA Sector Councils were established to bring together a range of stakeholders to identify and address key research needs on a broad national scale. The HCSA Sector Council brings together experts and stakeholders representing the diverse perspectives of industry, labor, academia, government agencies and others. NIOSH coordinates the logistics of the NORA HCSA Sector Council and co-chairs it with an external stakeholder.

The first formal meeting of the HCSA Sector Council was held in August 2006 in Atlanta. The initial charge to the group was to develop a sector-specific research strategy for the nation based upon the highest priority health and safety issues facing the sector, while maximizing impact through partnerships.

The HCSA Sector Council had several important outputs in the second decade of NORA:

- **State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA –** NIOSH and the NORA HCSA Sector Council worked together to author a comprehensive State of the Sector I Healthcare and Social Assistance report, published as a NIOSH report in 2009 (NIOSH 2009a). This 236 page document describe in detail, a range of occupational research needs within the HCSA sector and the rationale for addressing those issues over the next decade. This document laid the foundation for choosing priorities to be included in the national agenda for occupational research in the healthcare and social assistance sector.
- ***National Healthcare and Social Assistance Agenda –*** The 2009 *National HCSA Research Agenda* was a major output for the NORA HCSA Sector Council (NORA, 2009). This agenda identified a group of high priority occupational safety and health issues facing the HCSA industry sector. This agenda was revised in 2013 to reflect changes and progress in the HCSA industry sector (NORA, 2013).
- **Cleaning and Disinfecting Environmental Surfaces in Health Care: Toward an integrated Framework for Infection and Occupational Illness Prevention** – The Council initiated a working group to grapple with difficult questions facing the infection control and occupational health communities regarding appropriate and safe use of cleaning and disinfecting agents in the healthcare setting. This paper summarizes the current knowledge, research gaps, and future needs in this area (Quinn & Henneberger, 2015).

Table 1 below shows the number of downloads for three other NORA HCSA Sector Council documents as of March 2017.

Table 1. Downloads of select NORA HCSA Sector Council documents

Output Name	Year Published	Number of Downloads
State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA	2009	6,605
National Healthcare and Social Assistance Agenda	2009	1,671
National Healthcare and Social Assistance Agenda	2013	1,635

As the HCSA Program enters the third decade of NORA, we continue to be guided by our logic model and by input from extramural experts and stakeholders, including the HCSA Sector Council. We will complete ongoing efforts, work with the Council to establish an updated research agenda for the nation, and contribute to an overall NIOSH strategic plan, to set priorities and establish goals for the upcoming decade.

Healthcare and Social Assistance Program Resources

Personnel

The HCSA Program has been managed by David Weissman, MD since its inception in 2006. Dr. Weissman is the Director of Respiratory Health Division (RHD), located in Morgantown, WV. The current NORA HCSA Sector Council Co-Chair is Eileen Storey, MD, MPH who has served in this position since 2009. Dr. Storey is the Chief of the Surveillance Branch in the RHD. The Program has had four program coordinators since its inception, although two of those coordinators served the bulk of those years (Teri Palermo, RN six years and Susan McCrone, PhD, PMHCNS-BC, four years). In 2016, Megan Casey, RN, BSN, MPH became the HCSA Program Coordinator. Ms. Casey is a Nurse Epidemiologist in the Surveillance Branch in the RHD. Jim Boiano, MS, CIH has served as the Assistant Program Coordinator since 2006. Mr. Boiano is a Senior Industrial Hygienist in the Surveillance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), located in Cincinnati, OH. As noted above, all of these individuals also serve in roles outside of their HCSA Program leadership positions. In fact, the breakdown of the percentage of time spent serving in their program capacity is as follows: Program Manager is 20%, Sector Council Co-Chair is 10%, Program Coordinator is 50% and Program Assistant Coordinator is 20%.

Funding

Table 2. HCSA Program Funding (in millions) and Staff 2006-2016

Fiscal Year	HCSA Intramural Funding*	HCSA Extramural Funding*	HCSA Total Funding*	HCSA FTE*
2006	$4.5	$3.6	$8.1	22
2007	$4.9	$5.4	$10.3	27
2008	$7.3	$7.5	$14.8	36
2009	$12.8	$6.7	$19.5	43
2010	$12.0	$7.6	$19.6	47

Fiscal Year	HCSA Intramural Funding*	HCSA Extramural Funding*	HCSA Total Funding*	HCSA FTE*
2011	$12.0	$6.6	$18.6	47
2012	$11.0	$6.5	$17.5	47
2013	$9.3	$7.7	$17.0	42
2014	$9.5	$8.6	$18.1	42
2015	$9.9	$8.6	$18.5	49
2016	$9.1	$6.2	$12.0	41

*Based on percentages of intramural NIOSH projects attributed to the HCSA sector.

In fiscal year (FY) 2008, NIOSH made a change to its instructions for attributing individual projects to programs to improve the accuracy of sector specific investment. This change, by and large accounts for the substantial increase in funding and FTE between FY 2007 and FY 2008. In addition, NIOSH saw an increase in FY 2009 to design and promote the next generation of personal protective equipment (PPE) for healthcare workers and emergency responders. Otherwise, funding through this period reflects routine fluctuations that occur in project cycles where projects, grants and contracts end and new ones begin, although not necessarily within the same field of research.

Facilities

A number of NIOSH Divisions, Laboratories and Offices from across the Institute support the work of the HCSA Program:

- **Division of Applied Research and Technology (DART), Cincinnati, OH –** DART provides research focused on preventing occupational illness and injury by developing and evaluating methods and tools to identify and quantify workplace hazards and developing strategies and technologies to control exposures to workplace hazards. (NIOSH, 2016a) DART utilizes seven laboratories to conduct research to develop and/or evaluate engineering control technology for biological, chemical, physical, and ergonomic hazards. This also includes space for research on work organization or work redesign prevention strategies to eliminate or minimize workplace injury and illness and to facilitate the development of healthy workplaces. DART has been a research leader in the areas of antineoplastic and other hazardous drugs in healthcare settings, latex allergies, and health effects related to shiftwork and sleep. DART's laboratories have been particularly important for evaluating closed system drug-transfer devices for containment of antineoplastic drugs and the development of sampling and analytical methods for selected chemical contaminants.
- **Division of Safety Research (DSR), Morgantown, WV –** DSR research and prevention programs are aimed at addressing the leading causes of traumatic injuries and fatalities in the workplace (NIOSH, 2016b). DSR research has been a major contributor to addressing safe patient handling, slips, trips and falls, and workplace violence in healthcare settings.
- **Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Cincinnati, OH –** DSHEFS conducts occupational health surveillance, conducts workplace health hazard evaluations (HHEs) and conducts research in the causes of acute and chronic disease in workers (NIOSH 2016c). DSHEFS has led a number of HHEs in healthcare settings, initiated occupational health and hazard surveillance efforts

including the Occupational Safety Health Network (OSHN) (NIOSH, 2016d) and the Health and Safety Practices Survey of Healthcare Workers (NIOSH, 2017b).

- **Education and Information Division (EID), Cincinnati, OH –** EID develops and transfers information, provides recommendations to foster prevention of occupational injuries and disease through targeted information dissemination, training and the development of quantitative and qualitative risk assessments (NIOSH, 2013) EID has supported the efforts of the HCSA Program by providing translational research and risk assessments for the general public and stakeholder groups such as the Stop Sticks campaign (NIOSH, 2011) and NIOSH Fast Facts for Home Healthcare Workers (NIOSH, 2012).
- **Emergency Preparedness and Response Office (EPRO), Atlanta, GA –** EPRO prepares for and responds to chemical, biological, radiological, and natural events. The program integrates occupational safety and health into responses to protect response and recovery workers with the help of partners from industry, labor, trade associations, professional organizations, academia, and other federal agencies (NIOSH, 2016e). This office has provided significant contributions to the HCSA industry sector, most recently through their work in the 2014-2015 Ebola response. EPRO issued interim guidance documents, factsheets, training modules, and communication products that contained recommendations and information to protect HCSA workers.
- **Health Effects Laboratory Division (HELD), Morgantown, WV –** HELD scientists work in the sciences of allergy and clinical immunology, biostatistics and epidemiology, exposure assessment, engineering control, pathology and physiology, and toxicology and molecular biology (NIOSH, 2009). HELD has unique laboratory capabilities for evaluating basic toxicology of a wide range of agents and stressors, including a world-class inhalation exposure facility. HELD has conducted important research documenting the aerobiology of influenza and potential for airborne transmission of influenza. It has also worked in areas such as the evaluation of surgical smoke in medical facilities, dermal and inhalation toxicity and sensitization potential of the high-level disinfectant *ortho*-phthaldehyde, and understanding basic mechanisms of latex allergy. HELD laboratories have played a critical role in evaluating dermal and inhalation toxicity and skin and respiratory sensitizing potential for selected chemical substances in vitro and in vivo rodent models.
- **National Personal Protective Technology Laboratory (NPPTL), Pittsburgh, PA –** NPPTL seeks to prevent work-related injury, illness, and death by advancing the state of knowledge and application of personal protective technologies (PPT) (NIOSH, 2016f). NPPTL has a human subjects' test laboratory in Pittsburgh, which is used to access the wearability and performance of respirators and other PPE. NPPTL has made significant contributions to research in the HCSA industry sector through its work related to respiratory protection, protective gowns and covers, and researching factors for PPE use and tolerance.
- **Office of Extramural Programs (OEP), Atlanta, GA -** OEP leads and supports national occupational safety and health research and training programs to reduce work-related injuries and illnesses through a diversified portfolio of high quality extramural research, education, and training in collaboration with global partners. (NIOSH, 2016g) Many extramural research projects have contributed to the HCSA industry sector including characterizing sharps-related exposures (Myers, et al., 2016) and a training for homecare workers to recognize hazards in homecare workplaces (NIOSH, 2015a).
- **Respiratory Health Division (RHD), Morgantown, WV –** RHD seeks to protect workers against work-related hazards and exposures that cause or contribute to respiratory illness, injury, and death and to promote workplace-based interventions that improve respiratory health (NIOSH, 2015b). RHD

researchers have contributed to research on asthma in healthcare workers, the effects of cleaning and disinfection products on respiratory health and airborne transmission of tuberculosis.

External factors

While great strides have been made to promote safe and healthy workplaces in the HCSA industry sector, continued efforts to expand and improve the body of knowledge in this area is subject to changes in funding, research priorities and the availability of knowledgeable and experienced researchers.

Healthcare and Social Assistance Program Planning

The HSCA Program has had a formal and ongoing planning process throughout its history. This process has considered input from stakeholders, surveillance data, and scientific literature. The administrative structure for the NIOSH HCSA Program during the second decade of NORA included the previously-discussed executive leadership group (Manager, Coordinator, Assistant Coordinator, and NORA HCSA Council Co-Chair) and a cross-Institute Steering Committee that included representatives from all of the NIOSH divisions and from the NIOSH Office of Extramural Programs. The executive leadership group engaged the steering committee in establishing and annually updating the HCSA Program strategic plan. Part of the annual updating process included identifying annual top priorities to focus resources devoted to new projects for NIOSH's intramural research funding. The HCSA program's logic model, which was based on the NIOSH logic model, aided the program in these efforts. In addition, the group provided guidance on priorities for the sector to the NIOSH Office of Extramural Programs, which posted the priorities as a guide to investigators submitting extramural funding proposals to NIOSH.

The intramural-based NIOSH HCSA Program has had the opportunity to consider input from extramural experts and stakeholders on a regular basis. Even before the program was formally in place, stakeholder input was sought. For example, a town hall public meeting was held in Houston, TX in January, 2006 to obtain input about priorities for occupational safety and health in the HCSA industry sector. Participants represented labor, industry, government and academia. Also, a HCSA sector workshop was held at the 2006 NORA Symposium, which served to kick-off the second decade of NORA.

The HCSA Program has also had the benefit of regular input from the NORA HCSA Sector Council, which was established later in 2006 with stewardship provided by the intramural program. The HCSA Program engaged with the NORA HCSA Sector Council to develop the previously described 2009 *State of the Sector: Healthcare and Social Assistance* report and the 2009 *National Healthcare and Social Assistance Agenda* for the nation. Ongoing annual meetings were convened to learn from stakeholders about progress on existing issues and new emerging issues.

Going into the next decade, the NIOSH HCSA Program will develop evidence-based goals to appropriately prioritize and focus its efforts over the next five years as part of a larger NIOSH Strategic Plan. The program will continue to seek input from experts, stakeholders, and other interested parties and will carefully consider issues such as burden of injury and illness, size of populations with hazardous exposures, research needed to have an impact, and NIOSH's unique capabilities as it establishes the HCSA Program strategic plan. This approach will help to maximize the impact of NIOSH investments to improve occupational safety and health in the HCSA sector.

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Chapter 2: Promoting Safe & Healthy Workplaces

Introduction

It was well-recognized at the beginning of the second decade of the National Occupational Research Agenda (NORA) that finding ways to promote and sustain cultures of safety in healthcare institutions was essential. The enormity of medical errors and their impact was documented by the Institute of Medicine (2000) in their report, *To Err is Human*. Early on in the efforts to promote patient safety, it was recognized that a culture of safety necessarily included worker safety. NIOSH made its first strategic goal to promote safe and healthy workplaces and optimize safety culture in healthcare organizations. Research needs were identified with regard to work organization, injury and illness prevention programs, health protection and health promotion programs, and violence prevention. In this chapter, we will describe how NIOSH's work in the areas of safety climate, work organization and workplace violence have contributed to promoting safe and healthy workplaces.

The *State of the Sector* document provides useful definitions for safety culture and climate:

> *"Safety culture has been defined as the underlying principles, norms, values and beliefs of an organization with respect to safety. [Roberts 1990, Schein 1985]. Safety climate, in contrast, is conceptualized as employees' shared perceptions regarding safety within their work organization [Zohar 2007]."* (NIOSH, 2009, p.89]

Health and safety at work is strongly influenced by organizational factors. Management values and structure, how decisions are made and communicated, staffing, and resources are important factors for health and safety across all sectors (R. Brown & Holmes, 1986; S. P. Brown & Leigh, 1996; Clarke, Sloane, & Aiken, 2002; Dedobbeleer & Béland, 1991; Gershon, Qureshi, Gurney, Rosen, & Hogan, 2002; Hofmann & Stetzer, 1996; International Council of Nurses, 2006; Michela, Lukaszewski, & Allegrante, 1995; Stone, Du, & Gershon, 2007; Zohar, 1980). Work organization refers to the design of the job and the way it is performed and managed. The *State of the Sector* report includes an overview of the hazards associated with poor work organization and adverse outcomes reported in the literature (NIOSH, 2009, p. 76).

In the Healthcare and Social Assistance (HCSA) industry sector, the role of organizational variables is critical to both worker and patient safety. For example, a review of contributing factors for medication errors among nurses found that the physical work environment, work hours, staffing levels, and organizational culture and climate are factors that could improve worker safety as well as patient safety (Conklin, MacFarland, Kinnie-Steeves, & Chenger, 1990). However, aspects of the healthcare setting may conflict with safety climate and safe work practices. For healthcare workers, patient-care and well-being may take precedence over personal safety (DeJoy, Murphy, & Gershon, 1995). In addition, 50% of healthcare workers are employed in nonhospital settings where the lack of safety resources acts as a barrier to a strong safety climate (Gershon et al., 2002). Organizational climate and culture, violence, work hours and work load, worker control over their job, support, aspects of job design and content were particularly relevant topics to the HCSA industry sector at the beginning of the second decade of NORA.

Work Hours and Work Load

Work hours, scheduling, and workloads continue to place a significant strain on workers in the HCSA industry sector. As shown in Figure 1, data from the 2010 National Health Interview Survey demonstrated a high prevalence (52.3%) of short sleep duration (<6 hours) among night-shift workers in the HCSA industry sector. Workers who usually worked the night shift were significantly more likely to report short sleep duration (44.0%)

than those who worked the day shift (28.8%). Higher prevalence of short sleep duration among night shift workers was found in the transportation and health-care and social assistance industries (Centers for Disease Control and Prevention [CDC], 2012).

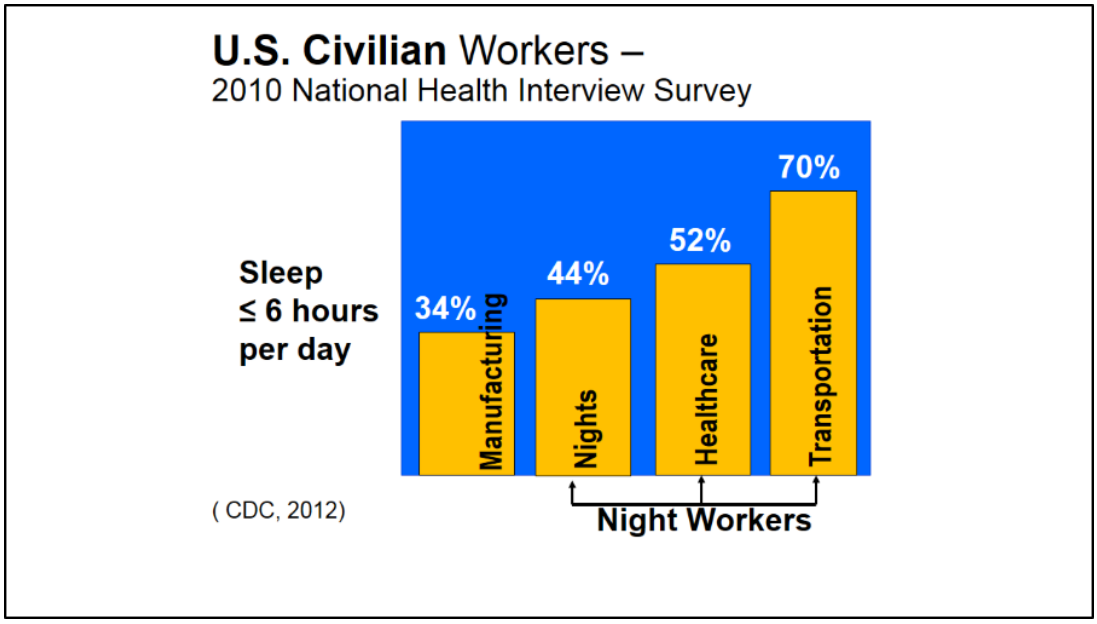

Figure 1. Workers with Short Sleep Duration. "Nights" refers to workers who usually work the night shift.

A 2011 American Nurses Association (ANA) survey of nurses found that 10% reported a motor vehicle crash that was related to workplace fatigue (ANA, 2011). This same survey also found that 53% of nurses worked some mandatory or unplanned overtime each month.

Studies evaluating staff ratios in the HCSA industry sector found significant effects on worker health and safety as well as patient safety. A large research study of 10,000 nurses and 230,000 patients from 168 hospitals in Pennsylvania from 1998–1999 found that for each additional patient above four assigned to a nurse, 30-day patient mortality increased by 7%, failure-to-rescue rate increased by 7%, job dissatisfaction among nurses increased by 15%, and burnout among nurses increased by 23% (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002). In fact, at the beginning of the second decade of NORA, nursing recruitment, retention and burnout were significant issues. Employers in some parts of the country were reporting difficulty in hiring adequate numbers of nurses, for a variety of reasons, including high rates of job dissatisfaction leading to high rates of turnover. (Buerhaus, Donelan, Ulrich, & Norman, 2005; Government Accountability Office, 2001; NIOSH, 2002a). A 2004 survey found that 82% of registered nurses believed there was a nursing shortage and 23% considered this to be very serious (Buerhaus, Donelan, Ulrich, Norman, & DIttus, 2006). In addition to the impending nursing shortage, concerns regarding nurse burnout and retention were a significant concern for the industry.

While research had been done in the area of work organization in the HCSA industry sector, many research gaps existed at the beginning of the second decade of NORA. Surveillance to better understand the prevalence of work organization risk factors, determining the health and safety effects of trends in organizational practices (such as restructuring, lean production and flexible staffing), as well as the need for more intervention research were all identified as research needs (NIOSH, 2002a). In addition, studies that included clearer and more complete descriptions of work schedules, worker characteristics, and the work environment were needed along with consideration of a wider range of possible health, safety, social and economic outcomes for workers, families, employers, and the community (Caruso et al., 2006). These identified research gaps provided a

roadmap to addressing the significant work organization issues faced by the HCSA industry sector in the last decade.

Workplace Violence

NIOSH defines workplace violence as "violent acts (including physical assaults and threats of assaults) directed toward persons at work or on duty" (NIOSH, 2002b, p.1). At the beginning of the second decade of NORA, the HCSA sector led all other industry sectors in the incidence of nonfatal workplace assaults. In 2006, 60% of the assaults and violent acts requiring days away from work occurred in the HCSA industry sector and mainly involved assaults by healthcare patients (Bureau of Labor Statistics [BLS], 2007). In 2005, nursing and residential care facilities experienced the highest incidence rate (per 10,000 workers) in the sector for personal assaults and violent acts with an incidence rate of 20.1, followed by social assistance (9.7) and outpatient care centers (9.5) (BLS, 2006). Assaults and violent acts accounted for 21% of the fatal occupational injuries within the HCSA industry sector, with about the same percent of homicides (9.6%) and suicides (11.5%) (BLS, 2007).

Logic Model

Figure 2 is a logic model illustrating the theory of change by which the HCSA Program has moved its safety culture activities into practice. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. Elements of the logic model – Inputs, Activities, Outputs, Transfer/Translation, Intermediate Outcomes, and End Outcomes -- are described in further detail in the following sections. Activities, outputs and intermediate outcomes are grouped into three lines of work: organization of work, safety climate and workplace violence. The dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

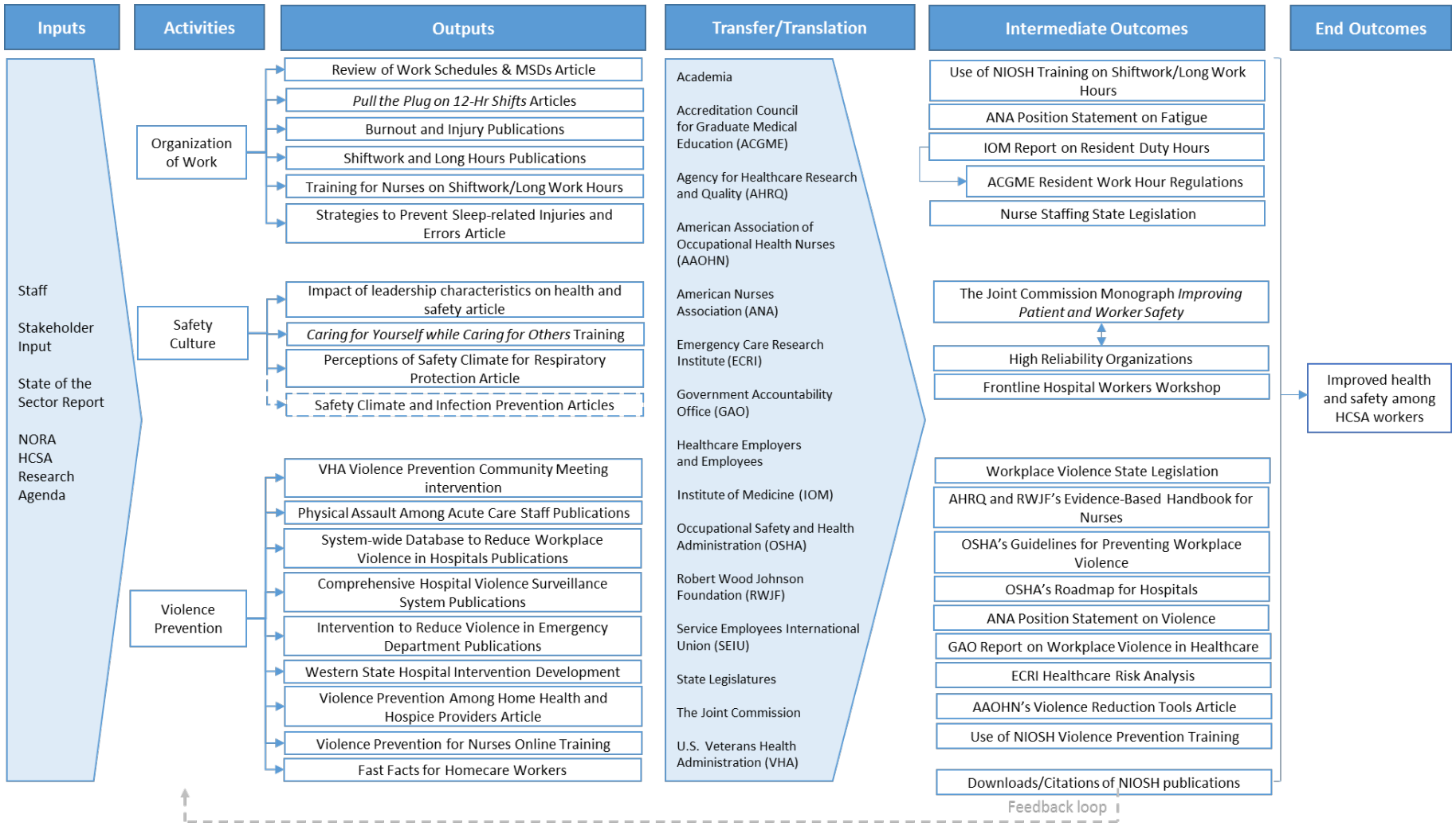

Figure 2. Promoting Safe and Healthy Workplaces Logic Model. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. The dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

Staff Input

NIOSH was particularly well positioned to address research needs in the area of work organization. Several NIOSH researchers provide national and international leadership in this field:

- **Claire C. Caruso PhD, RN, FAAN** is a Research Health Scientist in the Division of Applied Research and Technology (DART) in Cincinnati, OH. She is a subject matter expert in shift work, long work hours, and related workplace sleep and fatigue issues. Dr. Caruso led the NORA Long Work Hour Team consisting of experts from government, labor and industry to help address workplace organization issues.
- **CAPT Marilyn Lou Ridenour RN, MBA, MPH** is a Nurse Epidemiologist in the Division of Safety Research (DSR) in Morgantown, WV. She is a subject matter expert for workplace violence in the healthcare sector. Ms. Ridenour was a member of the American Nurses Association Professional Issues Panel on Incivility, Bullying, and Workplace Violence from the fall of 2014 to the spring of 2015.
- **Dan Hartley, EdD** also works in DSR as NIOSH's Workplace Violence Prevention Coordinator. His workplace violence prevention efforts include projects related to prevention of violence against healthcare workers, teachers, and retail workers. He is the lead project officer for the Workplace Violence Prevention for Nurses On-Line Best Practices Course. He has published and presented numerous times on workplace violence prevention strategies and programs.
- **James M. Boiano, MS, CIH** is a senior industrial hygienist in the Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) in Cincinnati, OH. His extensive experience conducting research in the healthcare and social assistance sector. Mr. Boiano served as an invited expert in the writing and development of The Joint Commission's monograph, *Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration and Innovation* (2012).
- **Eileen Storey, MD, MPH** is co-chair of the NORA HCSA Sector Council and Chief of the Surveillance Branch in the Respiratory Health Division (RHD) in Morgantown, WV. Prior to joining NIOSH, she oversaw the Employee Health Service and Employee Assistance Program at the University of Connecticut Health Center from 1991 to 2008. It interfaced with hospital administration, ambulatory care services, infection control, human resources, workers compensation management, environmental health and safety, public safety, and labor unions.

Stakeholder Input

The HCSA Program coordinates with stakeholders in industry, labor and academia to identify occupational health and safety issues that can be addressed through research.

Work organization and safety culture were significant topics at the 2006 NORA Town Hall Meeting in Houston, TX (NIOSH, 2006). Many stakeholders who participated in the meeting expressed concern related to work organization issues and stressed the importance of organizational safety culture. Below are prominent quotes from two participants:

> *The biggest challenge is creating a culture of safety within the complex hierarchical structure. Healthcare is predominantly practiced by individuals with a high degree of autonomy, and a willingness and openness to give and receive feedback needed in behavioral based safety programs is not the norm.*
>
> - Barbara Smisko, Director of National Environmental Health and Safety for Kaiser Permanente,

A comprehensive culture of safety in healthcare must be crafted and promoted that allows the provision of life-saving therapies to patients while protecting and ensuring the health, lives and livelihood of the caregivers who treat them.

- Melissa McDiarmid, University of Maryland School of Medicine's Occupational Health Program

One of the major activities of the HCSA Program was to facilitate the work of the NORA HCSA Sector Council. During the second decade of NORA, the Sector Council had two major outputs, both of which helped drive research to promote safe and healthy workplaces in the HCSA industry sector.

State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA

This 2009 report was developed by the Council to provide a comprehensive review of current work organization research in the HCSA industry sector. This work highlighted the need for surveillance to identify hazards related to work organization, identification of the numbers of exposed workers and the types of negative outcomes experienced, development of better work organization of work strategies, interventions to reduce risks and testing of interventions (NIOSH, 2009). Specific safety climate interventions and their effectiveness, as well as research into distinctive sub-climates of safety, such as management of blood-borne pathogens and respiratory protection, were identified as research needs. Additional research needs are highlighted in the *State of the Sector* report (NIOSH, 2009).

National Healthcare and Social Assistance Agenda

The 2009 National HCSA Agenda (NORA, 2009) was a major output for the HCSA Sector Council. This national agenda identified a group of high priority occupational safety and health issues facing the HCSA industry sector. The need to promote safe and healthy workplaces was reflected in the council's first strategic goal: "Promote safe and healthy workplaces and optimize safety culture in healthcare organizations." (NORA, 2009, pg.6) This goal remained the same when the agenda was updated in 2013 (NORA, 2013).

Activities and Outputs

NIOSH conducts a range of activities related to safe and healthy workplaces in HCSA, including surveillance to better understand the magnitude problem, a range of research to develop evidence-based solutions, and translation to encourage others to adopt those solutions. Outputs are the products created through these activities, such as guidance documents, peer-review journal articles, curricula and other tools and resources.

Organization of Work

Organization of work refers to how jobs are designed and managed. NIOSH staff and their extramurally funded colleagues conducted research on work schedules and fatigue, safety culture in home-care, the impact of safety climate on respiratory protection use, and workplace violence.

Impact of Work Schedules on Musculoskeletal Disorders in the Healthcare Industry Sector

In 2008, NIOSH researchers conducted a literature review to assess research progress examining the relationship between work schedules and musculoskeletal disorders (Caruso & Waters, 2008). A review of 23 publications found that relatively few studies have adequately examined the relationship of work schedules and musculoskeletal outcomes. Some studies that examined long work hours and controlled for physical job demands reported significant increases in measures of musculoskeletal disorders. Shift work was not

consistently defined and its impact on musculoskeletal disorders not well studied. The paper outlined the methodologic challenges that needed to be addressed to better understand how work schedules affect health outcomes, particularly musculoskeletal disorders.

Sleep Loss, Sleepiness and Fatigue in 12-Hour Nurses

NIOSH-funded researchers at the University of Maryland's School of Nursing set out to examine sleep, fatigue and neurocognitive performance among critical care nurses working in hospitals (Geiger-Brown et al., 2012). Eighty female registered nurses from a large U.S. hospital were enrolled. Occupational fatigue was measured at the beginning of the study. Measures of sleep, sleepiness, vigilance and occupational fatigue were recorded over three consecutive 12-hour (day and night) shifts. While sleep time between shifts was short (mean 5.5 hours), sleepiness scores were lower than expected. However, nurses accumulated sleep debt and showed progressive sleepiness over consecutive shifts.

In 2010, these researchers published a three part series, *Is it time to pull the plug on 12-hour shifts?* Part 1 describes the evidence for why 12-hour shift durations may increase patient care errors, needlestick injuries, musculoskeletal disorders, drowsy driving and health consequences related to sleep deprivation (Geiger-Brown & Trinkoff, 2010a). Part 2 lays out the challenges and barriers for nurse executives and hospital administrators to eliminate 12-hour shifts. One of the primary challenges identified in the literature was that nurses had become accustomed to working 12-hour shifts and many preferred this form of scheduling. The authors concluded that moving away from 12-hour shifts would require not only administrative changes, but also a change in healthcare culture (Lothschuetz, Montgomery & Geiger-Brown, 2010). Recognizing the challenges in eliminating 12-hour shifts, the researchers described several harm reduction strategies in Part 3 of the series (Geiger-Brown & Trinkoff, 2010b). Several strategies described in the article include using risk-management software, preventing nurses from being called in to work on days off, assuring coverage for breaks and planned napping for night shift nurses.

University of Maryland researchers also published a number of books, book chapters and other publications related to their work on sleep loss, sleepiness and fatigue among nurses:

- Geiger-Brown, J., Rogers, V.E., & Trinkoff, A.M. (2008). Work schedules and stress among health professionals. In J.R.B. Halbesleben, Eds., *Handbook of stress and burnout in health care, 3rd edition* (127-140), Halbesleben NY: Nova Science Publishers, Inc.
- Trinkoff, A.M., Geiger-Brown, J., Caruso, C.C., Lipscomb, J.A., Johantgen, M., Nelson A.L., Sattler, B.A., & Selby, V.L. Personal Safety for Nurses. In Hughes, R.G., Eds. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses* (1-36) Rockville, MD: U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality.
- Geiger-Brown, J., & McPhaul, K. M. (2011). Sleep promotion in occupational health settings. In Redeker N.S., & McEnany G.P., Eds. *Sleep disorders and sleep promotion in nursing practice* (355-369) New York: Springer Publishing Company.
- Trinkoff, A.M., & Geiger-Brown, J. (2012) Sleep-deprived nurses: sleep and schedule challenges in nursing. Koppel R. & Gordon S., Eds. *First, do less harm: confronting the inconvenient problems of patient safety* (168-179). Ithaca, New York: ILR Press.

Linking Healthcare Workarounds and Burnout to Patient and Worker Safety

NIOSH-funded researchers at the Culverhouse College of Commerce and Business Administration, University of Alabama set out to study three topics related to the effects of work schedules from 2008 to 2011. First, they examined how nurse burnout is associated with occupational injuries by increasing the likelihood that a nurse will bypass safety procedures (called safety workarounds). There had been little to no research linking this problem with the finding of increasing occupational injuries in nursing. Data related to burnout, use of safety workarounds and occupational injuries was collected from 323 health professionals from two hospitals in the Midwest U.S. over three data collection periods (Halbesleben, 2010). These data supported a predicted model that nurse burnout is associated with a higher use of workarounds, which is subsequently associated with a greater incidence of occupational injuries. These findings suggest that steps taken to reduce burnout among nurses could reduce occupational injuries through a greater adherence to safety procedures.

Secondly, this team of researchers built on safety climate literature and theory on behavioral integrity to better understand the relationship between the leader's behavioral integrity regarding safety and work-related injuries. A time-lagged study of 658 nurses partially funded by NIOSH found that behavioral integrity for high safety values is positively associated with greater reporting of occupational injuries (Halbesleben et al., 2013).

Finally, they subsequently developed and tested a model using data from their earlier NIOSH-funded work. This model seeks to predict how workplace injuries affect workers' perceptions of work-family conflict. Data was collected from 194 registered nurses (along with 85 of their spouses) over two years using a series of online surveys. The results indicated that high levels of perceived supervisor support can mediate the effects of workplace injury on work-family conflicts (Lawrence, Halbesleben, & Paustian-Underdahl, 2013).

Negative Impacts of Shift Work and Long Work Hours

A NIOSH researcher provided an overview of risks to nurses, patients and employers that are linked to shiftwork and long work hours in an article published in 2014 (Caruso, 2014). Risks include reduced job performance, obesity, injuries, and chronic diseases. The article also describes how fatigue-related errors could harm patients as well as the danger to the public related to commuting to and from work. The author recommends that employers and nurses prioritize sleep, and that managers and staff nurses participate in training programs regarding shift work and long work hours. The article points to the growing number of U.S. public health organizations that target improving sleep health including The Joint Commission and several organizations in the U.S. Department of Health and Human Services.

NIOSH Training for Nurses on Shift Work and Long Work Hours

To address the many health and safety risks linked to demanding work hours and nurse fatigue, NIOSH released an online training for nurses on shift work and long work hours in May 2015 (NIOSH, 2015b). The purpose is "to educate nurses and their managers about the health and safety risks associated with shift work, long work hours, and related workplace fatigue issues, and describe strategies in the workplace and in the nurse's personal life to reduce these risks" (NIOSH 2015b, p.1). The training course was developed in collaboration with the ANA and faculty from the University of Maryland, School of Nursing. The training program was developed based on scientific literature regarding shift work, long work hours, sleep, and circadian rhythms. Input was also obtained from two focus groups of nursing managers, one focus group of staff nurses, pilot tests with undergraduate and graduate nursing students at the University of Maryland, and a pilot test with nurses at the Centers for Disease Control and Prevention (CDC).

Part 1 of the training program is designed to increase knowledge about risks linked to these work schedules. This knowledge provides background information for Part Two of the program. Part Two is designed to increase knowledge about personal behaviors and workplace systems to reduce these risks. Specifically, the training teaches:

- How shift work and long hours are linked to a wide range of health and safety risks by reducing time for sleep, disturbing circadian rhythms, and disrupting family and non-work responsibilities.
- What vital functions occur during sleep and the relevant physiologic processes that determine the timing of sleep and the development of fatigue.
- Good sleep practices and other coping strategies nurses working shift work and long work hours can adopt in their personal lives to reduce risks.
- Work organization strategies for employers to reduce risks associated with shift work and long work hours.

The course is freely available on the NIOSH website and can be accessed at any time. Continuing education certificates are issued for registered nurses who complete the course. Continuing Education Units (CEUs) and certificates of completion are available for persons who are not registered nurses.

Strategies for nurses to prevent sleep-related injuries and errors

NIOSH researchers published an article in 2010 describing declines in cognitive performance that are associated with inadequate sleep and risk factors for fatigue-related errors. Strategies to reduce these risks are discussed, such as improved work schedule design, better sleep practices, naps, caffeine, exposure to light, and rest breaks (Caruso & Hitchcock, 2010).

Safety Climate

Safety climate in healthcare institutions pertains to both patient safety and worker safety. It reflects employees' shared perception of the priorities given to safety within their work organization (Zohar, 2007). NIOSH conducted and funded research to assess leadership characteristics that strengthen this perception, interventions that can improve safety climate, and factors related to safety climate and use of respiratory protection.

Partnership to Improve Workplace Safety for In-Home Care Workers

NIOSH, in collaboration with the Labor Occupational Health Program at the University of California, Berkley, the Alameda County Public Authority for In-home Supportive Services, and the Service Employees United Long Term Care Workers Union sponsored a community-based participatory research project to develop and evaluate interventions designed to improve the safety and health of homecare workers (Labor Occupational Health Program, 2016a). Materials were developed as part of a training curriculum for homecare workers and their employees nationwide. One of these training materials, *Caring for Yourself While Caring for Others* is a free curriculum to assist trainers in addressing the health and safety training needs for homecare workers and to improve communication between homecare workers and their clients (NIOSH, 2015a).

Through the training, homecare workers and homecare agencies learn to recognize commonly encountered risks in homecare workplaces and to apply practical solutions. Each of the seven modules includes a trainer's guide, customizable PowerPoint slides and participant handouts.

The seven modules include:

- Introduction to Homecare Health and Safety;
- Reducing Strains, Sprains and Falls;
- Reducing Risk from Environmental Exposures;
- Reducing Exposure to Bloodborne and Other Infectious Diseases;
- Staying Safe When Working With Clients with Dementia;
- Setting Healthy and Safe Boundaries to Reduce Stress; and
- Safely Handling Threatening Behavior When Providing Homecare.

Efforts to enhance training effectiveness have included focus groups with workers and patients to identify hazards and solutions, field testing of project materials, a training workshop for homecare workers to help them use the training materials and formal evaluation to assess impact of project intervention (Labor Occupational Health Program, 2016b). Studies evaluating this community-based participatory research found that a strong community partnership, participation and shared values contributed to successful formulation of policy initiatives (Gong et al., 2009).

Perceptions of Safety Climate for Respiratory Protection

In a nationwide study to assess perceptions about the safety climate for respiratory protection in healthcare, NIOSH collaborated with researchers from the University of North Carolina, University of Illinois, and the California Department of Public Health to collect and analyze survey data in 2011-2012 from 215 hospital managers, 245 unit managers, and 1,105 healthcare workers in 98 acute care hospitals in six states (California, Illinois, Michigan, Minnesota, New York, and North Carolina). Each survey included 10 questions designed to measure five key components of safety climate. The researchers found that healthcare workers reported less positive perceptions of their workplace safety climate than both hospital managers and unit managers. Unit managers viewed management's supervision of healthcare workers' respiratory protection practices most favorably. The findings indicated the need for frontline healthcare workers' inclusion to better support effective respiratory protection programs and practices. The findings also suggested that hospital management create formal opportunities for frontline healthcare workers to provide feedback to management about their individual respiratory protection programs, training and ways to improve safe respiratory protection practices at the point of care (Peterson et al., 2016).

Workplace Violence

NIOSH took a multi-pronged approach to the issue of workplace violence. In order to better understand the nature and extent of workplace violence in the healthcare industry, NIOSH funded surveillance studies. Violence varies across healthcare workplaces, so NIOSH also funded studies to create and evaluate interventions in acute and home care settings. Finally, NIOSH created an online training for nurses.

Veteran's Health Administration "Violence Prevention Community Meeting" (VPCM)

The *Violence Prevention Community Meeting* (VPCM) is a targeted type of community meeting in which avoiding violence and promoting non-violent problem solving and interpersonal civility are topics of group conversation. (Lanza, Rierdan, Forester & Zeiss, 2009) A nationwide study to assess the VPCM as an effective intervention to reduce workplace violence was undertaken at seven acute, locked psychiatric units of the Veterans Health Administration (VHA) throughout the United States. During the day shift, VPCM occurred twice weekly and during night shift, once weekly, in four hospitals. In three control hospitals, community meetings were held on the same schedule, a usual standard of care for psychiatry units. All staff recorded violence incidents daily for

twenty one days. The results showed a decrease of incidents of any assault for units with and without the intervention. Control sites experienced a statistically significant decrease in physical aggression and in verbal and physical aggression combined (Lanza et al., 2016). In addition to providing funding, NIOSH researchers and staff were instrumental in this intervention evaluation, with NIOSH researchers Marilyn Ridenour and Scott Hendricks serving as co-authors on the publication (Lanza et al., 2016). NIOSH staff members trained all of the participating healthcare staff on the VPCM and daily incident forms completed by nursing staff were sent to NIOSH on a weekly basis for analysis.

Physical Assault among Nursing Staff Employed in Acute Care

NIOSH funded researchers at Duke University to characterize injuries resulting from physical assault among hospital nursing staff and to identify associated risk factors. A cohort of aides and nurses employed in acute care units at a major healthcare system from 1997 to 2004 was identified by linking workers' compensation reports to human resources data and their reported physical assault events. During the study period, 220 assaults were reported among 197 employees, yielding an incidence rate of 1.65 per 100 full-time-equivalent employees (FTEs). Shorter tenure and younger age were risk factors. Rates were lower among Black workers. Psychiatry, neurology and rehabilitation units experienced higher rates. The researchers concluded that interventions targeting psychiatry, neurology, rehabilitation units and younger and newly hired staff are warranted (Rodríguez-Acosta et al., 2010).

Using a System-wide Database to Reduce Workplace Violence in Hospitals

To better understand the extent of violence in the healthcare industry, Wayne State University received NIOSH funding in 2011 to develop a methodology for identifying hospital units at-risk for workplace violence. Researchers developed a hazard risk matrix reflecting the probability and severity of violence in hospital units. Forty-one hospital units at a large U.S. hospital system were prioritized for intervention because they were considered medium or high on both severity and probability. Both categories were highest in psychiatric care units (Arnetz et al., 2014).

This group also analyzed the content of 214 incidents of patient to worker violence reported by employees in 2011, using a database accessible to seven hospitals with 15,000 employees. Nurses, security staff, and nurse assistants reported the majority of these incidents, 90% of which involved physical violence; 34% resulted in injuries leading to lost worktime. Factors contributing to the violence were organized into three themes: Patient Behavior, Patient Care, and Situational Events. Subthemes such as Cognitive Impairment and Demanding to Leave provided insight into causal factors that could be anticipated and for which training could be provided (Arnetz, Hamblin, Ager, Aranyos, et al., 2015).

To improve documentation of violent incidents, researchers then sought to discover and describe hospital system stakeholders' perceptions of database-generated workplace violence data reports. A focus group was conducted to identify stakeholders' preferences for standardized, computerized reports of workplace violence data to be generated by a central database. In general, stakeholders wanted data reports to provide ``the big picture,'' e.g., rates of occurrence; reasons for and details regarding incident occurrence; consequences for the individual employee and/or the workplace; and organizational efforts that were employed to deal with the incident (Arnetz, Hamblin, Essenmacher, et al., 2015).

Researchers examined the differences between self-report and actual documentation of workplace violence incidents in a cohort of healthcare workers. In 2013, employees (n = 2010) received a questionnaire asking about workplace violence experienced in the prior year. Responses were compared with events entered into an electronic system providing reports directly to the occupational health service. Of those who answered that they

had experienced a violent event in the past year, 88% had not reported the incident in the electronic system. However, more than 45% did report the violence informally, for example, to a supervisor. Violence education and prevention efforts should be informed by knowledge of reporting behaviors among the workforce (Arnetz, Hamblin, Ager, Luborsky, et al., 2015).

An analysis of content of 141 incidents reported in 2011 in a large hospital system focused on worker-to-worker violence. More than half of the events were reported by nurses. Few events involved physical violence. Two primary themes were identified: Dissatisfaction with Employee Behavior and Work Organization. The investigator concluded that most factors were work-related and modifiable, providing opportunities for intervention and prevention (Hamblin et al., 2015).

Finally, to evaluate an intervention on patient-to-worker violence and injury, the researchers conducted a randomized controlled trial. Forty-one hospital units among seven Midwest U.S. hospitals were selected as intervention and control sites. The intervention included a review of the unit's violence data and the development and implementation of an action plan. Six months post-intervention the incidence of violent events was significantly lower on intervention units compared with controls (Arnetz et al., 2017).

Development and Evaluation of a Comprehensive Hospital Violence Surveillance System

Building on previous workplace violence activities, University of Texas Health Science Center researchers began developing and evaluating a violence surveillance system from 2010 to 2015. They had reviewed the literature and identified a need for rigorous surveillance methods to assess the frequency of workplace violence and associated circumstances (Pompeii et al., 2013).

In order to better understand violent events, researchers invited hospital workers (n=11,000) from two large hospital systems in Texas and North Carolina to participate in an anonymous survey. Survey results showed that 2,098 (39%) of 5,385 respondents experienced 1,180 physical assaults, 2,260 physical threats and 5,576 incidents of verbal abuse in the past 12 months. Direct care providers were at significant risk, as well as some workers that do not provide direct care. Perpetrator circumstances attributed to violent events included altered mental status, behavioral issues, pain/medication withdrawal, and dissatisfaction with care (Pompeii et al., 2015).

They observed that hospital sitters, who continuously observe patients at risk of harming themselves or others, had a high proportion, relative to other occupational groups, of violence in the previous 12-months. Follow-up focus groups and key interviews among sitters, nurses, sitter managers and nurse managers provided more detailed information. Clarification of roles, need for support for sitters when requested, training and communication were areas needing attention (Pompeii et al., 2015).

Duke University and University of Texas researchers also explored relationships between workplace violent events involving hospital employees and patients or visitors and the employee use of psychotropic medications or mental health services. Violent events were linked with health claims. Experiencing workplace violence appeared to be associated with increased use of psychotropic drugs, including anti-depressants and anxiolytics. No increased use of mental health services was documented (Dement, Lipscomb, Schoenfisch, & Pompeii, 2014).

A Multi-site Intervention to Reduce Violence in Hospital Emergency Departments (EDs)

In 2008, NIOSH invited grant applications for research to reduce the risk of injuries due to violence in the workplace through a Request for Applications (RFA). Areas of interest for the applications included reducing the risk of injuries due to workplace violence through the development and evaluation of new intervention strategies, the evaluation of existing interventions and the adoption of these strategies in the workplace (NIOSH,

2016). One of the awards funded under this RFA allowed the University of Cincinnati to partner with six hospitals (three as intervention sites and three as comparison sites) to test a multi-dimensional intervention to prevent assaults against ED workers and reduce the related negative consequences. The intervention was implemented from June-August 2010 after a year of planning and nine months of pre-intervention data collection.

The planning phase of this project involved gathering information from 97 ED employees, managers and patients through 12 focus groups at 3 hospitals. These discussions identified concerns regarding rising rates of violence in EDs, perceptions that violence is a concern for those who work in or visit an ED and that interventions are needed (Gates, Gillespie, Smith, et al., 2011).

A baseline questionnaire collected demographic and occupational characteristics associated with violence from 213 workers from six participating hospitals. Researchers found that all ED workers are at risk for violence, regardless of personal and occupational characteristics; feelings of safety are related to job satisfaction and turnover (Gates, Gillespie, Kowalenko, et al., 2011). Longitudinal survey collection described the incidence of violence in ED healthcare workers over nine months. Specific aims were to "(1) identify demographic, occupational and perpetrator factors related to violent events and (2) identify predictors of acute stress in victims and predictors of loss of productivity". Researchers concluded that workers in EDs are frequent victims of violence perpetrated by visitors and patients. This results in injuries, acute stress, and lost productivity. Acute stress has negative consequences on workers' ability to perform their duties (Kowalenko, Gates, Gillespie, Succop, & Mentzel, 2013). Another study compared posttraumatic stress symptomatology based on verbal and verbal plus physical aggression and found that fewer than half of the ED workers reported traumatic stress symptomatology with no difference based on type of aggression experienced (Gillespie, Bresler, Gates, & Succop, 2013).

The researchers developed and evaluated a comprehensive intervention consisting of three components: environmental changes; policies and procedures; and education and training. It was implemented over a period of three months at the three ED intervention sites. Three control sites made no changes related to workplace violence activities in the study period. On average, participants experienced more than six incidents of violence during the 18-month study period. As groups, both sets of three hospitals experienced a significant decrease in the rate of assaults and threats. However, when evaluated by site, two intervention sites had a significant decrease in violence, while none of the control sites did. Researchers concluded that future research needs to be conducted to test additional comprehensive workplace violence prevention interventions (Gillespie, Gates, Kowalenko, Bresler, & Succop, 2014).

As part of this study, a workplace violence prevention educational program was tested with 315 employees from three EDs. A web-based program was compared to a combined web and classroom-based program. Knowledge attainment was the same in both groups and was substantial. (Gillespie, Gates, & Mentzel, 2012).

Developing an Intervention to Reduce Workplace Violence in Healthcare Settings (Western State Hospital Intervention Development)

NIOSH also provided monetary support to the Washington Work, Stress, and Health Project, a collaboration between the Washington State Psychiatric Hospitals and the Washington State Department of Labor & Industries Safety and Health Assessment & Research for Prevention research program. In early 2012, 485 direct care providers and supervisors completed a survey assessing workplace violence assaults, disruptive behavior, and workplace context characteristics expected to influence workplace violence and health, family, and work outcomes. The findings from the survey are now being used by the Western State Hospital (WSH) Intervention Development Team, consisting of key WSH management, union, and direct care provider stakeholders to

develop and pilot a workplace violence prevention intervention with supervisory nurses and care providers (Yragui, Demsky, Hammer, Van Dyck, & Neradilek, 2016). In addition, data from two psychiatric hospitals indicated that family-supportive supervisor behavior can moderate the harmful effects of workplace aggression. This study suggested that training healthcare supervisors to be family-supportive may benefit employee work and well-being through reduced burnout, stress-related physical symptoms, and intention to quit the organization (Yragui et al., 2016).

Characteristics of Workplace Violence Prevention Training and Violent Events among Home Health and Hospice Care Providers

NIOSH-funded researchers from the University of North Carolina examined the characteristics of workplace violence prevention training and estimated violent event rates among 191 home health and hospice care providers from six agencies in California. Between 2008 and 2009, 66.5% (n=127) of providers reported receiving workplace violence prevention training when newly hired or as recurrent training. On average, providers rated the quality of their training as 5.7 (1=poor to 10=excellent). Among all providers, there was an overall rate of 17.1 violent events per 1,000 visit-hours. Researchers concluded that efforts to increase the number of home healthcare workers who receive workplace violence prevention training and to improve training quality are needed (Vladutiu, C. J., Casteel, C., Nocera, M., Harrison, R., & Peek-Asa, C., 2016).

NIOSH Violence Prevention for Nurses Online Training

To help address issues of violence for nurses, NIOSH researchers developed an online violence prevention training for nurses in 2013 (NIOSH, 2013). The purpose of this course is to help healthcare workers better understand the scope and nature of violence in the healthcare workplace. Participants learn how to recognize the key elements of a comprehensive workplace violence prevention program, how organizational systems impact workplace violence, how to apply individual strategies and develop skills for preventing and responding to workplace violence. NIOSH worked with healthcare stakeholders, including nursing and labor organizations, academic groups, other government agencies and Vida Health Communications, Inc. to develop the course. Content was generated from these stakeholders and from the Occupational Safety and Health Administration (OSHA) *Guidelines for Preventing Workplace Violence for Health Care & Social Service Workers* (OSHA, 2004). The multi-media training incorporates lesson text, videos depicting workplace violence incidents, testimonials from real nurses, and lesson quizzes. Focus groups and stakeholder meetings were used to develop and test the course content and design.

NIOSH Fast Facts: Home Healthcare Workers - How to Prevent Violence on the Job

Home healthcare workers face an unpredictable environment each time they enter a client's community and home. The spectrum of violence ranges from verbal abuse, to stalking or threats of assault, to homicide. Verbal abuse from the client, family members, or people in the community is a form of workplace violence. Verbal abuse may be subtle, such as asking for help beyond the scope of the job (such as with cleaning), or it may be obvious, such as unjustified complaining about job performance or worker appearance - or even threatening to cause harm. To help educate home healthcare workers and their managers, NIOSH published a document in 2012 entitled, *How to Prevent Violence on the* Job (NIOSH, 2012). This brief document explains what employees and employers should do to prevent violence in home healthcare. It also list specific strategies when faced with a violent situation.

Transfer/translation

A number of organizations have used NIOSH research to address the various needs of their constituents, including:

- **Accreditation Council for Graduate Medical Education (ACGME)** - ACGME is the organization that sets standards for U.S. graduate medical education (residency and fellowship) programs and the institutions that sponsor them. In 2015-2016, there were approximately 800 ACGME-accredited institutions sponsoring approximately 10,000 residency and fellowship programs in 150 specialties and subspecialties (ACGME, 2016).
- **Agency for Healthcare Research and Quality (AHRQ)** – As part of the U.S. Department of Health and Human Services, the mission of AHRQ works to "produce evidence to make healthcare safer, higher quality, more accessible, equitable, and affordable" (AHRQ, 2016, para 1)
- **American Association of Occupational Health Nurses (AAOHN) –** Professional association of nearly 5,000 nurses practicing occupational and environmental nursing (AAOHN, 2016).
- **American Nurses Association (ANA)** - Representing approximately 3.6 million registered nurses, ANA is an advocate for "the nursing profession by fostering high standards of nursing practice, promoting a safe and ethical work environment, bolstering the health and wellness of nurses, and advocating on healthcare issues that affect nurses and the public" (ANA, 2016, para 1).
- **Emergency Care Research Institute (ECRI)** – A non-profit organization that evaluates medical procedures, devices, drugs and processes to improve emergency care (ECRI, 2016).
- **Government Accountability Office (GAO)** – The GAO is an independent agency working for Congress to investigate how taxpayer dollars are spent by the federal government (GAO, 2016).
- **Institute of Medicine (IOM)** – Provides advice to the nation and international community on issues related to health and medicine. It was recently renamed the Health and Medicine Division (HMD) within the National Academies of Sciences, Engineering, and Medicine (the National Academies) (National Academies, 2016).
- **Occupational Safety and Health Administration (OSHA)** - OSHA is the federal agency in the U.S. Department of Labor charged with the enforcement of safety and health legislation. OSHA assures safe and healthful working conditions for workers by "setting and enforcing standards and by providing training, outreach, education and assistance" (OSHA, 2016a, para 2).
- **Robert Wood Johnson Foundation (RWJF)** – RWJF is the largest philanthropy in the U.S. devoted entirely to health. It supports research and programs in healthcare (RWJF, 2016)
- **Service Employees International Union (SEIU)** – A union representing more than one million healthcare workers in North America (SEIU, 2016).
- **The Joint Commission** - The Joint Commission accredits and certifies nearly 21,000 healthcare organizations and programs in the United States. Joint Commission accreditation and certification is recognized nationwide as a symbol of meeting or exceeding performance standards (The Joint Commission, 2016).
- **U.S. Veterans Health Administration (VHA)** - As the largest healthcare system in the world, VHA provides training for a majority of America's medical, nursing and allied health professionals. The VHA

healthcare system includes 152 hospitals, 800 community-based outpatient clinics, 126 nursing home care units and 35 domiciliaries (VHA, 2016).

Intermediate Outcomes

NIOSH has been diligent in its efforts to inform and partner with individuals and organizations who are in a position to use Institute findings to make impact. The following are examples of instances when NIOSH research has contributed to impact in this area:

Work Schedules and Fatigue

Use of online NIOSH Training for Nurses on Shift Work and Long Work Hours

This training (described on pgs.20-21) has been completed by almost 3,000 individuals as of December 2016. About 37,000 visits were made to the website since launch in May 2015. The evaluation results showed about 95% agreed or strongly agreed with positive characteristics about the training (such as: addressed a need or a gap in my knowledge or skills; level of difficulty, length, and pace were appropriate; and met the learning objectives). In addition to ANA, at least 45 other external websites provide information about the training and a link including nursing organizations (e.g. American Association of Nurse Anesthetists, American Association of Critical Care nurses, American Psychiatric Nurses Association, Emergency Nurses Association), American Hospital Association, organizations of safety professionals (e.g. Association of Occupational Health Professionals, Board of Certified Safety Professionals, Ohio Board of Workers Compensation), and federal and state government agencies including the military.

Addressing Nurse Fatigue to Promote Safety and Health: Joint Responsibilities of Registered Nurses and Employers to Reduce Risks

At the invitation of the ANA, NIOSH researcher Claire Caruso, co-chaired a professional issues panel on nurse fatigue and led the panel in updating their position statement: *Addressing Nurse Fatigue to Promote Safety and Health: Joint Responsibilities of Registered Nurses and Employers to Reduce Risks* (ANA, 2014). This revised position statement released in 2014 incorporates strategies to reduce risks given in NIOSH Training for Nurses on Shift Work and Long Work Hours (NIOSH 2015b).

IOM's Resident Duty Hours: Enhancing Sleep, Supervision, and Safety

In 2009, the IOM published a report entitled *Resident Duty Hours: Enhancing Sleep, Supervision, and Safety*, calling for revisions to medical residents' duty hours and workloads to decrease the chances of fatigue-related medical errors and to enhance the learning environment for these doctors in training. Specifically, the report recommended the maximum number of hours that residents can work without time for sleep to 16, increased the number of days residents must have off and restricted moonlighting during residents' off-hours (IOM, 2009).

In the report, the IOM highlighted evidence from NIOSH research regarding overtime and long work hours:

- National Institute for Occupational Safety and Health. (2004). *Overtime and extended work shifts: Recent findings on illnesses, injuries, and health behaviors.* (DHHS (NIOSH) Publication No 2004-143). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2004-143/default.html

- Caruso, C.C., Bushnell, T., Eggerth, D., Heitmann, A., Kojola, B., Newman, K., Rosa, R.R., Sauter S.L., & Vila, B. (2006). Long working hours, safety, and health: Toward a national research agenda. *American Journal of Industrial Medicine 49*, 930-942.

ACGME Resident Work Hour Regulations

As the body responsible for the accreditation of more than 8,000 programs that collectively provide for the education of 100,000 residents, the ACGME is the entity that sets and enforces resident duty hour limits. In July 2003, the ACGME instituted common standards that limit duty hours for resident physicians in all accredited programs based, in part, on NIOSH-funded research that examined the impact of long and extended work hours on medical interns' clinical performance and risk for car crashes in 2005 (Barger et al., 2005).

In 2009, ACGME began a comprehensive evaluation of the effectiveness of their 2003 standard and to identify areas for refinement (ACGME, 2011). Echoing the findings of the IOM's *Resident Duty Hours* report, ACGME found that work-hour standards would need to go far beyond limits on resident hours to promote high-quality education and safe patient care. In 2011, ACGME revised their work hour standards to reflect many of the recommendations in the IOM report. This included limiting the maximum duty period length to 16 hours for first-year residents, requiring 14 hours of time off after 24 hours on in-house duty and limiting in-hospital night float to 6 consecutive nights (ACGME, 2011). In 2017, ACGME lengthened maximum duty hours for first-year residents to match the requirements that had been established in 2011 for more experienced residents (ACGME, 2017).

Nurse Staffing Legislation

Fourteen states have some form of legislation that governs nurse staffing and seven have specific rules regarding nurse staffing in emergency departments (ANA, 2017; Emergency Nurses Association [ENA], 2014). Legislation across these states ranges from mandating that hospitals have a nurse staffing committee, to requiring the development of a nurse staffing plan to specific nurse-to-patient ratios. A 2010 study conducted in California, the first state to regulate nurse-to-patient ratios, found that the mandated nurse staffing ratio guidelines significantly reduced emergency department wait time and throughput time compared to time periods when the ratio guidelines were not met (Chan, Kileen, Vilke, Marshall & Castillo, 2010). In proposing legislation, California cited NIOSH research and training programs (Little Hoover Commission, 2016).

Safety Climate

Joint Commission's Improving Patient and Worker Safety

> *"In healthcare, the primary ethical imperative is 'First, do no harm.' Although we have traditionally applied this obligation to our patients, this monograph helps to establish it also as our obligation to those with whom we work—and to all within the healthcare setting."*
>
> - Paul M. Schyve, MD, Senior Advisor, Healthcare Improvement, The Joint Commission

In 2012, the Joint Commission published a monograph, *Improving Patient and Worker Safety*. Although NIOSH provided some financial and technical support, The Joint Commission led the process and authored the document. The purpose of monograph was to create greater awareness of the potential synergies between patient and worker health and safety activities. Specifically, the monograph

- Highlights examples of practices that address patient and worker safety and the benefits and potential cost savings through collaboration between employee and patient safety departments;

- Identifies management systems and processes that have been used to successfully integrate health and safety activities;
- Describes barriers to addressing patient and worker safety issues and suggests strategies for overcoming the barriers by making safety a priority;
- Recommends steps that healthcare organizations can take to improve safety for patients and workers; and
- Identifies topics for future research (The Joint Commission, 2012)

A key concept described in the monograph is "High Reliability Organizations" or HROs. HROs are described as "systems operating in hazardous conditions that have fewer than their fair share of adverse events" (Reason, 2000, p. 769). The HRO concept was originally developed in industries such as nuclear power, aircraft carriers and air traffic control. In these industries, human error or system failure associated with equipment or devices carry enormous risk. Therefore, HROs are distinguished by their intense concern for the possibility of failure (Reason, 2000). These organizations strive to identify and report potential and actual problems to prevent errors and mitigate their impact. For this reason, HROs are deeply concerned with safety, and they view near-miss events as learning opportunities for improvement (Hines, Luna, Lofthus, Marquardt, & Stelmokas, 2008).

Safety must include both patient and worker safety simultaneously, since staff working conditions are related to patient safety as well as occupational safety (Hickam et al., 2003). The monograph provides management principles, strategies and tools that advance both patient and worker safety and contribute to the concept of high reliability. Using case studies and specific examples of activities and interventions, the monograph addresses issues such as musculoskeletal injuries, infection prevention and control, exposure to hazardous substances, workplace violence, staffing and fatigue. Since its publication in November 2012, the monograph has been downloaded 21,581 times.

In addition, NIOSH documents and recommendations are used throughout the document and include:

- Goetzel, R.Z. (2005). Examining the Value of Integrating Occupational Health and Safety and Health Promotion Programs in the Workplace. Policy and Practice Working Group Final Report.
- National Institute for Occupational Safety and Health. (2002). *The changing organization of work and the safety and health of working people*. (DHHS (NIOSH) Publication Number 2002-116). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/2002-116/
- National Institute for Occupational Safety and Health. (2012). *NIOSH fast facts: Home healthcare workers - How to prevent violence on the job*. (DHHS (NIOSH) Publication No. 2012-118). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2012-118/default.html As described on pg.26)
- National Institute for Occupational Safety and Health. (2002). Violence: Occupational Hazards in Hospitals (DHHS (NIOSH) Publication No. 2002-101)). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/2002-101/default.html
- Caruso, C.C., & Waters, T.R. (2008). A review of work schedule issues and musculoskeletal disorders with an emphasis on the healthcare sector. *Industrial Health, 48*(6):523–534.

In addition, the *State of the Sector* (NIOSH, 2009) written by the NORA HCSA Sector Council was also cited.

Frontline Hospital Workers and the Worker Safety/Patient Safety Nexus

While much of the research regarding work organization and safety culture has focused on nurses and homecare workers, less attention has been paid to nursing assistants, orderlies, aides, food service workers, janitors and other environmental service workers, ward clerks and others. These workers, collectively referred to as "frontline healthcare workers," were the focus of a day-long workshop in Washington, DC on October 25, 2012. Eighty-five representatives from academia, the federal government, hospitals, unions, and patient organizations participated in the event. It was sponsored by Georgetown University and co-sponsored by NIOSH, the Johns Hopkins Bloomberg School of Public Health, the University of Illinois at Chicago School of Public Health, the Service Employees International Union (SEIU), the Occupational Safety and Health Administration (OSHA), the Agency for Healthcare Research and Quality (AHRQ), in collaboration with the Veterans Health Administration (VHA) Office of Public Health and The Joint Commission (Sokas et al., 2013).

Workshop sessions focused on the intersection of worker safety and patient safety and on specific steps that healthcare institutions have used to implement a culture of safety in the workplace. Attendees broke out into small groups to identify barriers and opportunities for specific topics. Highlights from the workshop are outlined in a 2013 report in The Joint Commission Journal on Quality and Patient Safety (Sokas et al., 2013).

Workplace Violence

Workplace Violence State Legislation

While state legislation typically does not include references to evidence used to draft or pass legislation, there is some evidence that suggests that state governments, nursing advocacy groups, labor unions, and professional organizations used NIOSH research findings to advocate for workplace violence legislation. In 1993, California was the first state to require healthcare facilities to initiate and maintain workplace violence prevention programs (California Hospital Security Act, 1993). In 2014, two healthcare worker unions filed petitions requesting that a new standard be adopted to provide healthcare workers with specific protections against workplace violence. The petition from SEIU cited NIOSH's 2002 document, "Violence: Occupational Hazards in Hospitals" (NIOSH, 2002b). In addition, several NIOSH or NIOSH funded documents were cited as part of the initial statement of reasons for the law (CA Code of Regulations, 2015):

- Gomaa, A.E. Tapp, L.C., Luckhaupt, S.E., MD, Vanoli, K., Sarmiento, R.F., Raudabaugh, R.M., Nowlin, S., & Sprigg, S.M. (2013). Occupational traumatic injuries among workers in health care facilities - United States, 2012–2014. *MMWR Morbidity and Mortality Weekly Report 64*, 4051.
- National Institute for Occupational Safety and Health. (2013). *Workplace violence prevention for nurses*. (CDC Course No. WB1865 - DHHS (NIOSH) No. 2013-155). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/topics/violence/training_nurses.html (Described on pg.26)
- Peek-Asa, C., Allareddy, V., Casteel, C., Nociera, M., Harrison, R., Goldmacher, S., Curry, J.; Valiante, D., Blando, J., & O'Hagan, E. (2007). Evaluation of Safety and Security Programs to Reduce Violence in Health Care Settings Final Report (NIOSH Contract 200-2001-08014).

A total of nine states have enacted workplace violence prevention laws in healthcare facilities. These are described in Appendix B.

AHRQ and RWJF's Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Chapter 39: Personal Safety for Nurses

The Department of Health and Human Service, Agency for Healthcare Research and Quality (AHRQ) and the Robert Wood Johnson Foundation (RWJF) partnered to develop a comprehensive handbook for nurses on patient safety and quality (AHRQ, 2008). While the focus of the book is on techniques to enhance patient outcomes, the book also explores personal safety issues for nurses and draws the connection between worker safety and patient safety. *Chapter 39: Personal Safety for Nurses*, co-authored by NIOSH researcher Claire Caruso, explores the workplace stressors as well as the physical and psychological demands that nurses experience. Other relevant chapters include: *Chapter 40, The Effects of Fatigue and Sleepiness on Nurse Performance and Patient Safety*, *Chapter 41, Preventing Health Care–Associated Infections*, *Chapter 27, Temporary, Agency, and Other Contingent Workers*, *Chapter 28, The Impact of Facility Design on Patient Safety*, *Chapter 25, Nurse Staffing and Patient Care Quality and Safety, and Chapter 21, Creating a Safe and High-Quality Health Care Environment*. NIOSH research is cited throughout the book as it explores the relationship between healthcare worker and patient safety:

- National Institute for Occupational Safety and Health. (2004). *Overtime and extended work shifts: Recent findings on illnesses, injuries, and health behaviors.* (DHHS (NIOSH) Publication No 2004-123). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2004-143/default.html
- National Institute for Occupational Safety and Health. (1997). Musculoskeletal disorders (MSDs) and workplace factors—a review of epidemiologic evidence for work -related musculoskeletal disorders of the neck, upper extremity and low back (DHHS (NIOSH) Publication No 97–141). Washington, DC: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/97-141/default.html
- Collins, J. W., & Owen, B. D. (1996). NIOSH research initiatives to prevent back injuries to nursing assistants, aides, and orderlies in nursing homes. *American Journal of Industrial Medicine, 29*, 421-424.
- National Institute for Occupational Safety and Health. (2006). *Glutaraldehyde*. Retrieved from https://www.cdc.gov/niosh/topics/glutaraldehyde/default.html

OSHA's Updated Guidelines for Preventing Workplace Violence for Healthcare and Social Service Workers

In 1996, 2004 and again in 2015, OSHA issued voluntary guidelines for preventing workplace violence in the HCSA industry sector (OSHA, 2015). The guidelines include evidence based best practices to reduce the risk of violence in the workplace. It also acknowledges that these best practices may differ depending on the healthcare setting. For this reason, the guidelines are written to address the unique characteristics of hospitals, residential treatment facilities, non-residential treatment facilities and services, community care settings and field work settings. Employers are encouraged to use the guidelines to develop appropriate workplace violence prevention programs, engage workers to ensure their perspective is recognized and their needs are incorporated into the program. NIOSH is specifically described in the document as a resource to assist in workplace investigations of violence. In addition, two NIOSH publications are cited in the document:

- National Institute for Occupational Safety and Health. (2002). *Violence: occupational hazards in hospitals*. (DHHS (NIOSH) Publication No. 2002–101). 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. Retrieved from https://www.cdc.gov/niosh/docs/2002-101/default.html

- National Institute for Occupational Safety and Health. (2012). *NIOSH fast facts: Home healthcare workers - How to prevent violence on the job*. (DHHS (NIOSH) Publication No. 2012-118). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2012-118/default.html (Described on pg.26)

OSHA's Safety and Health Management Systems: A Roadmap for Hospitals

This document provides specific case studies and best practices from a variety of healthcare facilities on how to apply the OSHA guidelines (OSHA, 2015). Published in 2013 and updated in 2015, the road map complements OSHA's guidelines by providing real-world examples of violence policies and procedures in practice. OSHA obtained most of the information from the facilities through site visits, meetings and interviews. NIOSH's *Violence: Occupational Hazards in Hospitals* is listed as a resource for control and prevention strategies and NIOSH's web-based training for nurses is also highlighted (NIOSH, 2002b, 2013).

ANA Position Statement on Incivility, Bullying, and Workplace Violence

In July 2015, the ANA issued a position statement on workplace violence in healthcare (ANA, 2015). The ANA declared that the nursing profession will no longer tolerate violence of any kind from any source. Recognizing the link between patient safety and worker safety, the ANA states:

"[Registered nurses] and employers across the healthcare continuum, including academia, have an ethical, moral, and legal responsibility to create a healthy and safe work environment for [registered nurses] and for all members of the healthcare team, healthcare consumers, families, and communities." (ANA, 2015, p.1)

Several NIOSH documents were cited in the position statement:

- National Institute for Occupational Safety and Health. (2002). *Violence occupational hazards in hospitals* (DHHS (NIOSH) Publication No 2002-101). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2002-101/default.html
- National Institute for Occupational Safety and Health. (2006). *Workplace violence prevention strategies and research needs.* (DHHS (NIOSH) Publication No. 2006-144). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2002-101/default.html
- National Institute for Occupational Safety and Health. (2013). *Workplace violence prevention for nurses*. (CDC Course No. WB1865 - DHHS (NIOSH) No. 2013-155). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/topics/violence/training_nurses.html (As described on pg.26)

GAO Report: "Additional Efforts Needed to Help Protect Health Care Workers from Workplace Violence"

GAO issued a report in March 2016 entitled "Additional Efforts Needed to Help Protect Health Care Workers from Workplace Violence." (GAO, 2016) The report reviews: (1) what is known about the degree to which workplace violence occurs in healthcare facilities and its associated costs, (2) steps OSHA has taken to protect healthcare workers from workplace violence and assess the usefulness of its efforts, (3) how selected states have addressed workplace violence in healthcare facilities and (4) research on the effectiveness of workplace violence prevention programs in healthcare facilities (GAO, 2016).

GAO analyzed data on workplace violence incidents, reviewed information from states with workplace violence prevention requirements for healthcare employers, conducted a literature review and interviewed OSHA and state officials. NIOSH research and data sources are cited throughout the report, including NIOSH's National Electronic Injury Surveillance System-Work Supplement (NEISS-Work), the Fatality Assessment and Control Evaluation Program and *Violence: Occupational Hazards in Hospitals* (NIOSH, 2002b).

The report recommends three areas of improvement:

- Provide OSHA inspectors additional information on developing citations for workplace violence prevention violations.
- When OSHA does not find reason to issue a citation, a warning or hazard alert letter is issued. The GAO report recommends follow up on facilities where a hazard alert letter has been issued.
- Fully assess OSHA's efforts to address workplace violence to determine if additional action, such as a national standard, may be needed.

This document helped provide the impetus for OSHA's proposed workplace violence standard, which is discussed in the "Future Plans" section below.

ECRI Report: Healthcare Risk Control: Violence in Healthcare Facilities

In 2011, ECRI published a risk analysis of violence committed by patients, visitors, employees or trespassers in healthcare settings. The document outlines the current standards and requirements, liability, how to recognize potential perpetrators, training, how to conduct a violence audit and action recommendations. NIOSH research is cited in this document including NIOSH (2002b) *Violence: Occupational Hazards in Hospitals.* (ECRI, 2011)

AAOHN Article: Strategies and Tools to Reduce Workplace Violence

In 2008, the AAOHN journal featured an article that evaluated the components of a workplace violence prevention program (Gallant-Roman, 2008). NIOSH's *Violence: Occupational Hazards in Hospitals* was cited in this article (NIOSH, 2002b).

NIOSH Violence Prevention for Nurses Online Training

Since its release in 2013, over 28,000 individuals have registered for this online training with over 20,000 nurses receiving continuing education credits. This training is discussed in greater detail on page 26.

Other documents

NIOSH has tracked the number of downloads of its guidance documents since 2010. The reach of earlier guidance, like *Violence: Occupational hazards in hospitals* (2002), is unfortunately unknown, because documents tend to have a high number of downloads in the first few years after publication and taper off over time. Table 1 below shows the number of downloads for three more recent NIOSH documents as of March 2017.

Table 1. Total downloads of select NIOSH guidance documents

Document	Publication date	Number of Page Views/Downloads
Caring for Yourself While Caring for Others	2015	26,134 page views 14,475 downloads
How to Prevent Violence on the Job	2012	3,989 downloads
Safe Movement and Lifting of Nursing Home Residents	2006	26,015 downloads

Many other publications by NIOSH scientists and extramural researchers have been cited extensively in the literature. Table 2 lists the number of citations for journal articles by NIOSH and extramural researchers from Google Scholar as of March 2017.

Table 2. Citations of select journal articles

Article Name	Author(s)	Number of Citations
A review of work schedule issues and musculoskeletal disorders with an emphasis on the healthcare sector	Caruso &Waters 2008	80
Sleep, Sleepiness, Fatigue, and Performance of 12-Hour-Shift Nurses	Geiger-Brown et al. 2012	101
Is it time to pull the plug on 12-hour shifts?: Part 1	Geiger-Brown & Trinkoff 2010	80
Is it time to pull the plug on 12-hour shifts?: Part 2	Lothschuetz Montgomery & Geiger-Brown 2010	22
Is it time to pull the plug on 12-hour shifts? Part 3	Geiger-Brown & Trinkoff 2010	29
The Role of Exhaustion and Workarounds in Predicting Occupational Injuries: A Cross-Lagged Panel Study of Health Care Professionals	Halbesleben 2010	80
Living up to safety values in health care: the effect of leader behavioral integrity on occupational safety	Halbesleben et al. 2013	17
The influence of workplace injuries on work-family conflict: job and financial insecurity as mechanisms	Lawrence et al. 2013	10
Negative impacts of shift work and long work hours. Rehabilitation Nursing	Caruso 2014	69
Strategies for Nurses to Prevent Sleep-Related Injuries and Errors	Caruso et al 2010	30
The role for community-based participatory research in formulating policy initiatives: promoting safety and health for in-home care workers and their consumers	Gong et al. 2009	13

Article Name	Author(s)	Number of Citations
Understanding patient-to-worker violence in hospitals: a qualitative analysis of documented incident reports	Arnetz, Hamblin, Essenmacher, et al. 2015	17
Underreporting of workplace violence: comparison of self-report and actual documentation of hospital incidents	Arnetz, Hamblin, Ager, Luborsky, et al. 2015	11
Perpetrator, worker and workplace characteristics associated with patient and visitor perpetrated violence [Type II] on hospital workers: A review of the literature and existing occupational injury data	Pompeii et al. 2013	30
Physical assault, physical threat, and verbal abuse perpetrated against hospital workers by patients or visitors in six U.S. hospitals	Pompeii et al. 2015	10
Impact of hospital type II violent events: use of psychotropic drugs and mental health services	Dement et al. 2014	10
Using action research to plan a violence prevention program for emergency departments	Gates, Gillespie, Smith, et al. 2011	40
Occupational and demographic factors associated with violence in the emergency department	Gates, Gillespie, Kowalenko, et al. 2011	22
Prospective study of violence against ED workers	Kowalenko et al. 2013	54
Posttraumatic stress symptomatology among emergency department workers following workplace aggression	Gillespie et al. 2013	19
An educational program to prevent, manage, and recover from workplace violence	Gillespie et al. 2012	11
Strategies and tools to reduce workplace violence	Gallant-Roman 2008	49

End outcomes

There is no national surveillance system that tracks safety climate and safety culture in healthcare settings, so it is not possible to routinely track changes at the national level over time. Still, specific institutions have been able to demonstrate reductions in adverse events for patients and workers, as described in The Joint Commission monograph. Also, many important initiatives with plausible potential for leading to end outcomes were implemented during the past decade, as evidenced by the numerous intermediate outcomes. These included regulations, guidelines and training programs for improving organization of work (e.g., shiftwork, long work hours and staffing), an educational monograph providing examples of healthcare organization practices that simultaneously address patient and worker health and safety, and guidelines and training programs for preventing workplace violence.

Alternative Explanations

While the unique contributions of NIOSH research in this area has been documented, other factors have contributed to changes in healthcare workplaces. The efforts to improve patient safety and worker safety

through attention to organization of work, safety culture and safety climate have engaged every segment of the sector including industry, labor, regulatory agencies and professional associations.

OSHA VPP Program

Since 1982, OSHA's Voluntary Protection Programs (VPP) recognize employers who have achieved excellence in occupational safety and health through adoption of a safety and health management system. These employers maintain injury and illness rates below national Bureau of Labor Statistics averages for their respective industries. VPP participants are re-evaluated every three to five years to remain in the programs (OSHA, 2016b). Healthcare facilities that are awarded VPP status may help to decrease rates of worker injuries from violent events.

Lucian Leape Institute "Through the Eyes of the Workforce"

The Lucian Leape Institute at the National Patient Safety Foundation held two roundtables and multiple focus groups to discuss joy, meaning and workforce safety to improve the safety of the healthcare system. In 2013, the Institute published the findings of these roundtables in a report (Lucian Leape Institute, 2013). This report looks at the current state of healthcare as a workplace, highlights vulnerabilities common in healthcare organizations, discusses the costs of inaction and outlines what a healthy and safe workplace would look like. The report concludes with seven recommendations for actions that organizations need to pursue to effect real change

"Resilient Nurses" featured on NPR's "Humankind"

In February 2015, University of Virginia School of Nursing's Compassionate Care Initiative sponsored a new Public Radio documentary series – Resilient Nurses. In addition to chronicling the challenges that nurses face on the job, the series also highlights healthcare facilities where administrators realize the financial and personal stake they have in helping their nurses effectively handle stress (National Public Radio, 2016).

ENA Government Relations Team

ENA's government relations team tracks emergency medical and nursing-related legislation in all 50 states. Monthly legislative reports are provided to state leaders that include background on any relevant legislation. ENA also provides an Advocacy Toolkit to help their membership on strategies to educate legislators and others on issues (ENA, 2016).

The Joint Commission's *Quick Safety: Preventing Violent and Criminal Events*

In August 2014, The Joint Commission issued an advisory on safety and quality topics called *Preventing Violent and Criminal Events*. This advisory provides guidance on how to identify and reduce risks, environmental design changes to enhance safety, administrative controls, training and other strategies (The Joint Commission, 2014).

The Joint Commission's Sentinel Event Alert: *Preventing violence in the health care setting*

In June 2010, The Joint Commission issued an alert on preventing violence in the healthcare setting. The alert includes strategies for identifying high risk areas, remaining alert for potential perpetrators, implementing prevention strategies and other suggested actions (The Joint Commission, 2010).

IAHSS Handbook: Healthcare Security Basic Industry Guidelines

International Association for Healthcare Security & Safety (IAHSS) (a professional association with more than 2,000 members in healthcare security, law enforcement, and safety and emergency management) complied all available industry guidelines to "assist healthcare administrators in providing a safe and secure environment and support national, state/provincial, county and local requirements and are also intended to be in harmony with all regulatory, accreditation and other healthcare professional association requirements."(IAHSS 2012)

Report of the Massachusetts Department of Mental Health Task Force on Staff and Client Safety

In 2011, the Massachusetts Department of Mental Health (DMH) convened a task force on staff and client safety. The Task Force was asked to review current practices, policies and processes related to safety. The report summarizes the Task Force's findings and recommendations (Massachusetts Department of Mental Health, 2011). As a result of this report, DMH took the following steps (National Alliance on Mental Illness, 2011):

Personal safety training

DMH developed and provided safety training for all DMH and vendor community staff.

- Partnerships: DMH has been taking an active role in engaging with police and emergency service providers to learn and develop best practices to help manage acute issues in the community.
- Risk Management: Each DMH Area currently has regularly scheduled risk management meetings with its providers. As recommended by the Task Force, DMH has standardized this activity.

Future plans

NIOSH will continue to identify the HCSA industry sector as a priority area for research in the third decade of NORA. Specific research needs include evaluation of High Reliability Organizations and factors that make them sustainable, impact of state workplace violence legislation, issues of presenteeism in healthcare and defining occupational health and safety leadership in healthcare (NIOSH, 2002a).

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Chapter 3: Musculoskeletal Disorders

Introduction

In the *State of the Sector* report, a work-related musculoskeletal disorder (MSD) is defined as "an injury of the muscles, tendons, ligaments, nerves, joints, cartilage, bones, or blood vessels in the extremities or back that is caused or aggravated by manual handling work tasks such as lifting, pushing and pulling, and carrying; as well as working in awkward postures with very repetitive or static forceful exertions [IOM 2001; NIOSH 1997]." (NIOSH, 2009a, pg.141)

At the beginning of the second decade of NORA, injury surveillance data indicated work-related MSDs were a problem in the HCSA industry sector. In 2005, the incidence of nonfatal occupational injuries for the HCSA sector was 5.5 cases per 100 full-time workers, compared to 4.4 and 3.9 cases per 100 full-time workers in the private and service-providing industries, respectively. The number of nonfatal injuries for this sector (624,000) accounted for 15.7% of the total number of injury cases in private industry (U.S. Bureau of Labor Statistics [BLS], 2005a).

In 2005, the incidence rate of sprains and strains involving days away from work in the HCSA industry sector was 82.3 cases per 10,000 workers (BLS, 2005b). The part of the body most affected was the trunk, with an incidence rate of 66.8 cases per 10,000 workers, nearly 1.5 times greater than the rate in the private industry as a whole (BLS, 2005c). The healthcare patient was the most frequent cause of injury at a rate of 47.5 cases per 10,000 workers (BLS, 2005d). The average workers' compensation cost for back pain was $10,689 per case, making back injury alone a significant health and economic burden. The single greatest risk factor for MSDs in healthcare workers was the manual lifting, moving, and repositioning of patients, residents, or clients (BLS, 2004).

Training alone did not effectively reduce the risk of injuries to nursing personnel while lifting patients (Dehlin & Linberg, 1974; Dehlin, Berg, Andersson & Grimby, 1980; Nelson, Lloyd, Menzel, & Gross, 2003; Snook, Campanelli & Hart, 1978; Wood, 1987). Research focused on ergonomic factors rather than behavioral factors to identify opportunities for prevention by evaluating challenges associated with specific tasks, and evaluating patient lifts to assist in moving patients.

As summarized in the *State of the Sector* document,

> *"for patient-handling tasks, one must consider (1) the weight of the patient, (2) the patient's ability to bear weight and assist with the transfer, and (3) the safest equipment and techniques for transferring and repositioning patients based on specific patient characteristics. The challenge of lifting and moving patients is further complicated by the patient's size, shape, deformities, level of fatigue, cognitive functioning, and cooperation as well as the worker's physical impairments, lower limb function, balance, and coordination (Lloyd, 2004). Cognitively impaired patients can be unpredictable and may suddenly become combative, resist the caregiver, or go limp during a transfer, creating a sudden unexpected load on the caregiver (Lloyd, 2004) and resulting in excessively high forces that can injure the spinal muscles (Andersen, Schibye, & Skotte, 2001)." (NIOSH, 2009a, pg.148)*

Further,

> *"the most physically demanding tasks are repositioning patients in bed, transferring physically dependent residents to and from the toilet and in and out of beds and chairs, and transferring residents for bathing and weighing (Gagnon, Sicard & Sirois ,1986; Garg, Owen & Carlson, 1992; Lloyd 2004; Marras, Davis, Kirking, & Bertsche, 1999; Ulin et al., 1997; Zhuang, Stobbe, Hsiao, Collins, & Hobbs,*

1999). Extensive research has documented high levels of biomechanical stress on caregivers when performing patient-lifting and repositioning tasks. Research has shown that the use of portable or ceiling-mounted mechanical lifts could significantly reduce the back compressive forces of the caregiver and remove about two-thirds of the exposure to lifting activities per transfer as compared to the manual methods (Garg et al., 1992; Harber et al 1985; Marras et al., 1999; Owen, 1987; Zhuang et al., 1999)." (NIOSH, 2009a, pg.148)

However, having the right equipment at the right time and used by the right people in the right way is affected by equipment availability, usability, staffing, turnover, training, and facility design as well as economic health of the institution and commitment of top management (NIOSH, 2009a).

In 2006, U.S. nursing students were graduating without being trained on how to use mechanical lifts to safely lift patients despite the technological, scientific, and evidence-based revolution affecting all other aspects of care. Nurses' licensure exams continued to include outdated and unsafe manual patient-handling techniques (National Council of State Boards of Nursing, 2006).

NIOSH has a long history of conducting research in MSDs, dating as far back as the 1980s. The Institute began by actively attempting to identify risk factors for the development of low back pain and conducting laboratory studies to examine potential strategies for mitigating exposure to MSD related hazards. Research was primarily focused on personnel in nursing homes, as this population of workers was suffering MSD related problems at the highest rates (131.4 cases per 10,000 workers) in the sector (NIOSH 2009a). In the mid-90s, NIOSH researchers in the Division of Safety Research (DSR) initiated a large field study in six nursing homes over a period of six years to evaluate the effectiveness of a model MSD prevention program (Collins, Wolf, Bell & Evanoff, 2004). The pilot program included the use of lifting devices, repositioning aids, a zero life policy, and training for lift usage. The study results showed reductions in injuries due to patient handling, workers' compensation costs, and lost workdays. These findings would provide a foundation for the research that proceeded it during the second decade of the National Occupational Research Agenda (NORA).

Slip, trip, and fall (STF) incidents represent another important cause of injury in the HCSA industry sector. In 2005, the rate for STF incidents in HCSA workers was 38.6 per 10,000, 80% greater than for private industry as a whole (BLS, 2005e). During the first decade of NORA, NIOSH researchers conducted a 10-year longitudinal study in hospitals and found that STF prevention programs can significantly reduce STF injury claims (Bell et al., 2008). During the second decade, NIOSH researchers, in collaboration with The Joint Commission, Kaiser Permanente, Liberty Mutual, Veteran's Health Administration, and other healthcare systems, developed a STF prevention guide for healthcare workers (NIOSH, 2011b). Although STF research continued during the second decade, there was much greater emphasis on MSDs and, for this reason, the contribution analysis focuses on MSDs.

Logic Model

Figure 1 is a logic model illustrates key relationships characterizing how the Healthcare and Social Assistance (HCSA) Program contributes to musculoskeletal disorders as they apply to occupational safety and health. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. Elements of the logic model – Inputs, Activities, Outputs, Transfer/Translation, Intermediate Outcomes, and End Outcomes -- are described in further detail in the following sections. The grey dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

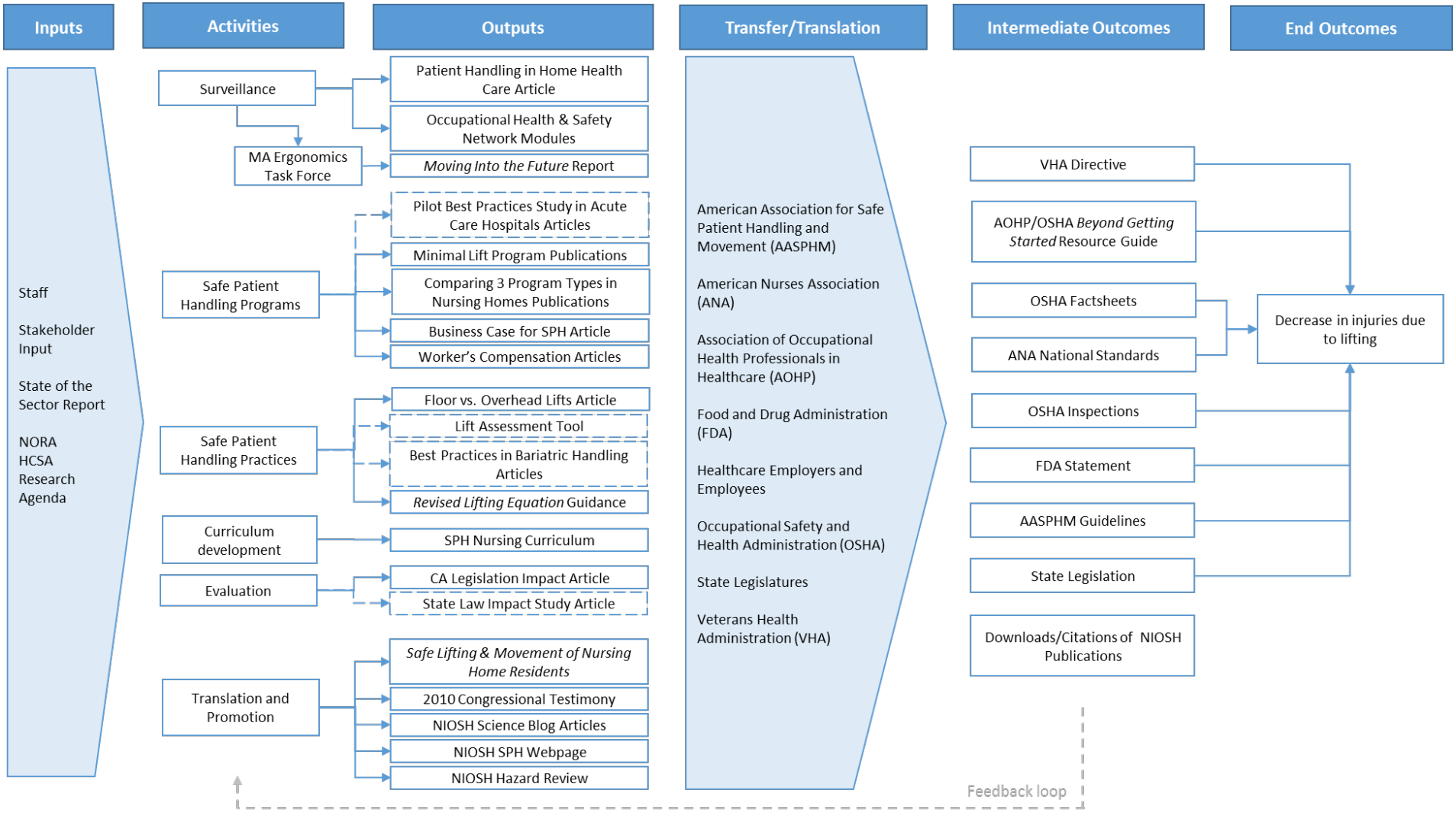

Figure 1. Musculoskeletal Disorders Logic Model. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. The grey dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

Inputs

Staff Input

NIOSH was particularly well positioned to address research needs in the area of safe patient handling. Several NIOSH researchers provide national and international leadership in the field of occupational MSDs:

- **Thomas R. Waters, PhD**, a former research safety engineer in the Division of Applied Research and Technology (DART), was a renowned researcher in the field of occupational MSDs. He was best known for his work in the development of the Revised NIOSH Lifting Equation to assess the risk of low-back disorders in jobs with repeated lifting.
- **James W. Collins, MS, PhD**, Chief of the Analysis and Field Evaluations Branch in the Division of Safety Research (DSR), is a national leader in safe patient handling and movement and slip, trip, and fall prevention. Dr. Collins conducted a biomechanical lab study to identify safer ways to lift and move patients and enlisted partners to conduct a 9-year intervention field study to demonstrate the effectiveness of a best practices safe patient handling program.
- **Traci Galinsky, PhD**, Senior Science Officer in DART, is a member of the Human Factors and Ergonomics Research Team. Her research has focused on physiological and psychophysical measurements of musculoskeletal fatigue and patient handling hazards and interventions in healthcare.

Stakeholder Input

NORA Town Hall Meetings

While mechanical lifting devices may reduce the physical load for caregivers, successful implementation of their use can be challenging. Each healthcare setting (i.e., ambulatory care, hospitals, nursing homes) has unique challenges in implementing safe patient-handling programs. Better understanding of the barriers in these sub-sectors was needed to assist in successful, future implementation. These challenges were highlighted during the 2006 NORA Town Hall Meeting (NIOSH, 2006a):

> *"Patient handling technology, although we've seen research that demonstrates that injuries are lowered with this technology, many nurses continue to resist its use because it's awkward to use and it's inconvenient and it takes a long time."*
>
> Nancy Menzel, University of Florida College of Nursing occupational health nurse researcher, during the 2006 NORA Town Hall Meeting, Houston, TX

In addition, existing lifting equipment did not address all types of patient lifting:

> *"We still don't have any equipment that assists a nurse to turn a patient from side to side, and that's one of the biggest exposure points."*
>
> Nancy Menzel, University of Florida College of Nursing occupational health nurse researcher, during the 2006 NORA Town Hall Meeting, Houston, TX

State of the Sector Document

As mentioned in the Overview Chapter, one of the major activities of the HCSA Program was to facilitate the work of the HCSA Sector Council. During the second decade of NORA, two major outputs of the Sector Council,

the *State of the Sector* document (NIOSH, 2009a) and the 2009 *HCSA National Occupational Research Agenda* (NORA, 2009), helped drive research on safe patient handling in the HCSA industry sector.

The *State of the Sector* provided a comprehensive review of current MSD research in the HCSA industry sector. The research highlighted the ineffectiveness of body mechanics training, interventions to reduce hazards and their benefits, and the barriers to implementing these interventions. NIOSH identified a number of risk factors associated with the development of MSDs in healthcare workers who manually lift and move patients in hospitals, nursing homes, and homecare settings (NIOSH, 2009a). The *State of the Sector* also included recommendations for future research to address MSD hazards:

- Address barriers to implementation of known interventions
- Determine how work system interactions between environment, technology, organization, task requirements, and individual factors can lead to MSDs
- Improve interventions at all levels of work system interactions
- Evaluate MSD interventions in the home healthcare setting where lifting equipment are generally unavailable
- Improve surveillance systems for tracking injuries and illnesses among HCSA workers in the home healthcare setting

NORA HCSA Agenda

The 2009 National Occupational Research Agenda identified a group of high priority occupational safety and health issues facing the HCSA Sector. The need to reduce MSDs in this population was reflected in the agenda's second strategic goal. The Council revised this goal to also include slip/trip/fall hazards in the 2013 research agenda: "Reduce the incidence and severity of musculoskeletal disorders (MSDs) and injury events associated with slips, trips and falls among workers in the HCSA Sector**."** (NORA, 2013, p.11).

Activities and Outputs

NIOSH has engaged in variety of activities, including surveillance on injuries related to lifting, economic and intervention research on safe patient handling programs and practices, and translation of these research findings into practice. Outputs, which are the products of activities, include guidance documents, peer-reviewed publications, a new surveillance module, and a curriculum, among others.

Safe Patient Handling Guidelines

In 2006, NIOSH published, *Safe Lifting and Movement of Nursing Home Residents* (NIOSH, 2006b). The guide is intended for nursing home owners, administrators, nurse managers, safety and health professionals, and workers who are interested in establishing a safe resident lifting program. The guide advocates a safe resident lifting program that includes:

- Mechanical lifting equipment;
- Worker training on the use of the equipment; and
- A written resident lifting policy.

The guide provides a business case for safe patient handling (SPH) program, describing the cost of implementing such a program and how quickly a facility can expect to recover the cost of their investment. For example, a 100-bed facility can expect to spend $25,000 to $30,000 on portable (not ceiling-mounted) mechanical lifts depending on how many residents in the facility require the use of a lift. As a general rule, one full-body lift

should be provided for approximately every eight to ten non-weight bearing residents, and one stand-up lift should be provided for approximately every eight to ten partially-weight bearing residents. The average cost of a mechanical lift can vary from $3,000 to $6,000 per lift. The average cost for a ceiling-mounted lift is approximately $4,000 per room. An effective combination of both floor and ceiling lifts is generally accomplished with a $50,000 to $60,000 investment per 100 bed facility. Citing NIOSH research, the guide estimates that the cost of initial investment and employee training can be recovered in two to three years through the reduction in workers' compensation expenses (Collins et al., 2004; Tiesman et al., 2003)

Safe Patient Handling Surveillance

Patient Handling in Home Healthcare

Although home healthcare is the fastest growing segment of the healthcare industry, it is also one of the least studied. NIOSH conducted a pilot study to explore home work hazards. Survey questionnaires were administered to 744 geographically-diverse home healthcare workers from 11 participating agencies. Results pertaining to overexertion hazards indicated that patient handling, done predominantly without assistive devices, was significantly associated with reports of pain in the back, neck/shoulders, and legs/feet. Patient handling remained a significant predictor of pain after statistically adjusting for the effects of potentially confounding factors such as worker age, weight, non-work-related physical activities, smoking status, medical conditions, work durations, and non-work-related caretaking of children and disabled family members (Waters, Collins, Galinsky & Caruso, 2006).

NIOSH Occupational Health Safety Network (OHSN)

The OHSN is a secure electronic surveillance system designed to promote analysis and benchmarking of existing occupational health data to prevent injury and illness among healthcare facilities (NIOSH, 2017). Occupational health staff and workplace safety managers can use OHSN tools to convert data to OHSN format, then upload without worker identifiers to the secure web portal. Current modules focus on traumatic injuries among healthcare workers including musculoskeletal injuries from patient handling events; slips, trips, and falls; and workplace violence.

Massachusetts Hospital Ergonomics Task Force and "Moving into the Future" Report

In 2010, Occupational Health Surveillance Program (OHSP) in the Massachusetts Department of Public Health (MDPH) received funding from NIOSH for a state level effort to explore approaches to surveillance and prevention of MSDs among workers in Massachusetts hospitals. In January 2012, MDPH established the Massachusetts Hospital Ergonomics Task Force to develop recommendations for reducing the high rate of MSDs and disability among Massachusetts hospital workers, with a focus on MSDs associated with patient handling. The 21 member Task Force included representatives of hospitals, hospital workers and government agencies, ergonomic experts, and academic researchers.

The Task Force was asked "to review available injury surveillance data, the research on SPH interventions and existing practice guidelines, information about current SPH practices in Massachusetts hospitals, and SPH policy initiatives in other states."(Massachusetts DPH, 2014). The Task Force met quarterly over an 18 month period (January 2012 – June 2013) and operated by consensus in developing its recommendations.

In April 2012, OHSP conducted a survey by mail of all 98 hospitals licensed by MDPH to characterize current SPH policies and practices in the state. Eighty-eight hospitals responded, with a response rate of 90%. The survey showed that Massachusetts hospitals were in different stages of developing comprehensive SPH programs that

minimize manual handling of patients, and there is an opportunity for hospitals to learn from each other, across service types, as they move forward. Overall, 44% (37) of respondents reported having a written SPH policy in practice. Non-acute care hospitals were more likely to have a written SPH policy compared to acute care hospitals.

The Task Force also found that from 2004-2011, the rates of all MSDs and of MSDs associated with patient handling were consistently higher among workers in Massachusetts hospitals than the comparable rates for workers in hospitals nationwide. In 2010, an estimated 1,000 workers in Massachusetts hospitals suffered patient handling MSDs that resulted in lost work time. Close to 70% of these workers lost at least five days, with 30% losing at least a month. It is conservatively estimated that in 2010, Massachusetts hospital workers lost at least 21,500 days of work as a result of patient handling MSDs (Davis et al., 2014).

The Task Force also reviewed established research on safe patient handling and concluded that comprehensive SPH programs involving use of equipment to minimize manual handling of patients have proven successful in reducing the frequency and severity of worker injuries and associated costs.

The Task Force developed recommendations for next steps to be taken by hospitals, MDPH, and other stakeholders to address patient handling in the hospital setting. These recommendations were included in the final report of the Hospital Ergonomics Task Force, *Moving into the Future: Promoting safe patient handling for worker and patient safety in Massachusetts Hospitals* (Massachusetts DPH, 2014).

Safe Patient Handling Programs

Pilot "Best Practices" Program

In 2007, NIOSH expanded work in safe patient handling in nursing homes to include acute care hospitals. NIOSH researchers evaluated the effectiveness of a program in acute care hospitals, similar to that of the program they implemented in several long-term care facilities in their previous study (Collins et al., 2004). Northwestern Memorial Hospital in Chicago, IL, and the University of Pennsylvania Medical Center in Philadelphia, PA, implemented a pilot "best practices" program consisting of: 1) state-of-the art patient lifts and repositioning equipment; 2) a safe-lifting policy that described the roles and responsibilities of all affected staff; 3) training on how to use safe patient and repositioning equipment; and 4) training to change the culture of patient lifting and promote compliance with the program. Researchers used Occupational Safety and Health Administration (OSHA) 300 logs, workers' compensation data, occupational health nurse data, and human resources data to measure outcomes from pre-intervention to post-intervention. Data analysis from this project is on-going with results expected in summer 2017.

Evaluation of Minimal Manual Lift Program with Introduction of Lifting Devices

While intramural researchers were conducting a prospective intervention study, NIOSH-funded extramural researchers at Duke University were conducting a retrospective evaluation of a less rigorous intervention program consisting of a "minimal" manual lift policy that eliminates manual handling whenever possible, and the introduction of patient lifting devices. Workers' compensation and human resources data over a 13 year period (which included both pre-intervention and post-intervention time) were examined at a medical center and a community hospital (Schoenfisch, Lipscomb, Pompeii, Myers, & Dement, 2013). While the community hospital experienced a significant decrease (44%) in musculoskeletal injuries during this period, the medical center observed no change. However, researchers suggested that these findings were confounded by institutional level changes that were occurring simultaneously. In another study of the same medical center population, researchers examined the records for the seven year pre-intervention period to determine the

number of reported musculoskeletal injuries caused by patient lifting, the number of these reported injuries by provider subgroup, and the activity the provider was performing when the reported injury occurred. Based on their review, one third of reported musculoskeletal injuries were due to patient handling, with nurses' aides reporting the highest injury rates. Researchers determined that 40% of these reported injuries could have been prevented with the use of mechanical lifting devices (Pompeii, Lipscomb, Schoenfisch, & Dement, 2009).

Comparing Three Program Types in Nursing Homes

NIOSH-funded researchers at the University of Massachusetts-Lowell examined several combinations of a no-lift program, a wellness program, and an employee participation program as preventive measures to reduce MSDs. This 2006-2012 study took place within a large chain of nursing home facilities belonging to a single corporation, which had already committed substantial resources to implementing a safe resident handling program in all of its skilled nursing facilities. An optional "Wellness" program had also been adopted in some facilities. In three other centers without prior wellness programming, a participatory health promotion program (defined broadly to include work organization issues) was implemented. This provided three arms of the study to evaluate: the safe resident handling program (before/after); the wellness program plus safe resident handling program, versus safe resident handling program alone; and the participatory health promotion program plus safe resident handling program, versus safe resident handling program alone. The safe resident handling program provided a greater use of resident handling equipment, which resulted in a short work time and less awkward postures that affected the lower back. Biomechanical modeling confirmed an overall decrease in physical workload, particularly for nursing assistants (Kurowski, Buchholz, & Punnett, 2014).

Business Case

To explore the business case for safe patient handling programs, NIOSH-funded researchers from the University of Wisconsin-Milwaukee evaluated the long-term efficacy of an ergonomics program that included patient-handling devices. Six long-term care facilities and one chronic care hospital were selected for the study. Comprehensive ergonomics programs were implemented in each of the facilities with pre and post intervention injury data collected. The researchers found that post-intervention patient-handling injuries decreased by 59.8%, lost workdays by 86.7%, modified-duty days by 78.8%, and workers' compensation costs by 90.6% (Garg & Kapellusch, 2012).

Worker's Compensation

Workers' compensation system is used to provide a scope and evaluate occupational injuries. Low back pain is the most common musculoskeletal disorder within the healthcare field. A study was conducted by surveying 18 nursing facilities regarding the working environment and related behaviors. The participants who noted down to have low back pain was considered in the study and a statistical analysis was done with the data. Results determines that workers' compensation claims decreased post- vs. pre-intervention with an overall benefit-to-cost ratio of 1.68; savings were higher where there was also a wellness program, despite no direct evidence of effectiveness (Qin, Kurowski, Gore, & Punnett, 2014). There was high variability among centers in these outcomes (Kurowski, Gore, Buchholz, & Punnett, 2012).

Safe Patient Handling Practices

Comparison of Floor-Based and Overhead-Mounted Patient Lifting Devices

Shortly after the publication of *Safe Lifting and Movement of Nursing Home Residents*, NIOSH researchers took a closer look at the differences between available patient lift device designs. Researchers were specifically

measuring the forces needed to operate a floor-based lift compared to a ceiling-mounted lift. 18 participants were used for the study that were pushed and pulled through various tests while measuring the force. Although most of the lift devices tested were below published force limits, results suggested that ceiling lifts are much more beneficial sine they require less force compared to floor-based lifts. Furthermore, if the floor surface was not optimal (e.g., carpeted, wooded, or inclined), the force required for a floor-based lift device has a chance of exceeding the maximum force limit (Rice, Woolley & Waters, 2009).

Case Crossover Study of Factors Associated with Patient Lift Equipment Use

Recently, NIOSH-funded researchers at the University of North Carolina-Chapel Hill conducted a study to identify and understand factors (or triggers) proximal to patient lifts and transfers that influence use of patient lift equipment. Using a case-crossover design, the study quantified the frequency and association between identified factors and lift equipment use among 100 nursing staff engaged in patient care in the acute care hospital setting. This study began in September 2014 and was funded through August 2016 with a final report due to NIOSH in August 2017. Researchers anticipate the study will result in a lift assessment tool.

Best Practices for Bariatric Patient Handling

In 2013, a memoranda of understanding was signed by NIOSH and five Veterans Health Administration (VHA) hospitals for a NIOSH-funded, collaborative study to examine safety hazards and interventions related to patient handling and mobility, with added focus on bariatric SPH. Results will be used to identify associations between program factors (e.g., equipment, algorithms, etc.) and outcome factors (perceived exertion, musculoskeletal injuries and symptoms, assaults by patients, etc.). Data collection concluded in 2016, and dissemination of results is expected to begin in late 2017.

Revised Lifting Equation: When is it safe to manually lift a patient?

In 1981 NIOSH published *Work Practices Guide for Manual Lifting*, which provided a lifting equation to calculate recommended weight limits for two-handed, manual lifting tasks. This lifting equation was revised so it could be used to calculate a weight limit for any manual-lifting task over a substantial period of time without increasing the risk of low-back pain. *The Revised NIOSH Lifting Equation* (NIOSH, 1994) was published in 1994. However, the following limitation was noted: the equation should not be used for assessing manual lifting of patients because it did not account for unpredictable conditions such as a combative or resistant patient; i.e., a patient that is heavier than they appear and that a patient's movements could create loads in the lifter's spine that are greater than lifting a stable object.

The Revised NIOSH Lifting Equation provides a multiplier for six variables which reduces the maximum weight to be lifted under ideal conditions, which is 51 lbs. The recommended weight limit (RWL) is calculated using the following equation:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

where

LC = load constant: maximum weight anyone should lift under ideal conditions (51 lbs.)

HM = horizontal multiplier: horizontal distance of the object from a point between the ankles of the person performing the lift, if measured along the floor

VM = vertical multiplier: vertical height of the lift

DM = distance multiplier: distance the object is lifted or lowered vertically

AM = asymmetric multiplier: distance the object is displaced, in degrees from the front of the body

FM = frequency multiplier: how often the lifts are made in a 15-minute period, and

CM = coupling multiplier: quality of hand-to-object connection (for lifting legs and arms, the coupling would in most cases be rated "good," since you can get your hand around them; for other body parts or for the entire body, however, the coupling would likely be rated "poor")

After the RWL is calculated, the lifting index (LI) can be calculated. The LI is an estimate of the physical stress associated with a particular manual-lifting task. Tasks with an LI greater than 1.0 pose an increased risk of low-back pain for some fraction of the workforce and LI greater than 3.0 indicates that many workers will be at elevated risk for low-back pain. LI is calculated using the following equation:

$$LI = \frac{\text{Load Weight}}{\text{Recommended Weight Limit}} = \frac{L}{RWL}$$

In August 2007, Dr. Thomas Waters of NIOSH, published an article in the *American Journal of Nursing* titled: "When it is safe to manually lift a patient?" (Waters, 2007). Nurses can earn continuing education credits for reading and successfully completing a test on the content. Using easy-to-understand terminology, this article explains how the Revised NIOSH Lifting Equation can be applied to patient lifting when the following four conditions are met:

1. Patient can follow directions and is not combative,
2. Amount of weight the caregiver handles can be estimated,
3. Lifting is smooth and slow, and
4. "Geometry" of the lift—the body and hand positions in relation to the object being lifted— and the amount of weight lifted are not subject to change.

The RWL for overall patient lifetime tasks is 35 pounds. Lifting under certain circumstances such as while kneeling or when near the floor, the RWL is even less. While 'no manual lifting' policies are the best option for patient and healthcare worker safety, the Revised NIOSH Lifting Equation provided healthcare workers and employers a tool to assess safe lifting practices.

Safe Patient Handling Curriculum for Schools of Nursing

Despite research indicating that manual patient handling is unsafe and that assistive equipment is effective in reducing the incidence of MSDs related to patient handling (Nelson, Motaki, & Menzel, 2009), many schools of nursing continued to teach outdated methods for patient handling. The two-person lift and the hook-and-toss methods remained the primary methods of manual patient lifting, which many experts consider unsafe (Nelson et al., 2009).

To address this need in nursing education, NIOSH, the VHA, and the American Nurses Association (ANA) developed a *Safe Patient Handling Curriculum for Schools of Nursing* in November 2009 (NIOSH, 2009b). Designed to be implemented over 1 or 2 days, the curriculum helps nursing instructors design training programs for the use of safe patient handling techniques, contributing to the prevention of MSDs. The training program has four main objectives:

1. Provide evidence-based training on SPH to instructors at schools of nursing so that they can teach SPH methods to students.

2. Ensure that the training is sound and that the curriculum is effective in improving the knowledge, attitudes, and beliefs of the students about SPH.
3. Provide a full range of educational tools nursing educators can use to increase effectiveness of the training program.
4. Encourage all nursing educators at schools of nursing to use the evidence-based, safe-patient-handling curriculum module and recommended laboratory activities for nurse training.

The curricular materials include the *Tool Kit for Safe Patient Handling and Movement Training Program*. The tool kit contains a slide presentation, didactic and clinical laboratory content, and decision support tools to help nurses decide which lifting equipment to use. A quiz is used after the material to evaluate student knowledge. After completing the training, students should be able to:

- Define healthcare ergonomics,
- Recognize high-risk, patient-care activities,
- Identify risks in patient-care environments,
- State why mechanical aids are needed when moving and handling patients,
- Use algorithms to identify safe patient-handling and movement strategies,
- Assess patients to select the right combination of equipment and personnel needed to handle or move them safely, and
- Apply positioning and mobility techniques that are safe for patient and caregiver.

The curriculum was evaluated in a field study of 29 schools of nursing, using 26 schools as an intervention group and three nursing schools as a control group. Using questionnaires, researchers assessed knowledge, attitudes, and beliefs about safe patient handling for both nurse educators and students, before and after the training. Mean pre- and post-test knowledge scores were used to assess training effectiveness. Post-training scores of nurse educators (7.9; SD=0.9) were significantly higher than baseline (4.7; SD=2.0) ($p<0.0001$). Students at the intervention sites also scored significantly higher in the knowledge test (6.7; SD=2.1) than those at control sites (3.7; SD=2.0) ($p<0.0001$) (Nelson et al., 2007).

Safe Patient Handling Legislation

NIOSH Congressional Testimony

In 2010, NIOSH researcher James Collins testified before the U.S. Congressional Subcommittee on Employment and Workplace Safety of the Committee on Health, Education, Labor and Pensions (Collins, 2010). The purpose of the hearing was to examine safe patient handling and lifting standards and to recommend the Secretary of Labor to issue a safe patient handling standard.

> *"NIOSH has shown that manual handling of patients is a serious risk to healthcare workers. Programs that rely on the use of mechanical lifting devices, and worker training in using these devices, offer practical solutions to prevent healthcare worker injuries. These effective alternatives to manual patient handling are safe, and can be cost-effective to implement."*
>
> CAPT. James W. Collins, PhD, MSME during Congressional Testimony, May 11, 2010

Musculoskeletal Disorders in California Healthcare Workers

NIOSH-funded researchers at the University of California-San Francisco recently began evaluating the impact of California's Assembly Bill 1136, safe patient handling legislation enacted in October 2011. The evaluation will

focus on both health and cost outcomes among healthcare workers in California. For such an evaluation effort, understanding the current status of MSDs among California healthcare workers was the first step.

To establish a baseline for future evaluation of the impact, 396 registered nurses were randomly chosen to participate in an epidemiological assessment of organizational SPH practices concentrating on musculoskeletal symptoms and perceptions of hospital policies and resources. Results showed that 22% of the hospital nurses reported a no-lift policy while 37% of the nurses reported that their hospitals had lift teams, and 61% reported access to mechanical lifts. It was found that compared to nurses with no access to lifts, nurses whose units were provided with ceiling lifts had fewer issues with shoulder pain. After the SPH law had gone into effect, 33% reported that hospitals started implementing and bringing a change to the safe patient handling policies/programs whereas 60% were still unaware of the law (S. Lee, J. Lee & Gershon, 2015).

National Evaluation of State Safe Patient Handling Legislation on Nursing Home Worker Injury Rates

In order to assess the national impact of SPH legislation, NIOSH-funded researchers at the University of Massachusetts Medical School are conducting a study to evaluate the effects of state-level patient handling legislation on reducing worker injuries in nursing homes, and to characterize the market and organizational characteristics associated with nursing homes whose worker injury rates declined in the wake of legislation. As part of this project, researchers are cross-linking information from the OSHA Data Initiative with resident level information from the Centers for Medicare and Medicaid Services Minimum Data Set, and facility level information captured by the Certification and Survey Provider Enhanced Reporting system (Lapane, Dubé, & Jesdale, 2016). This project is in the midst of its two-year study period and results are expected soon.

NIOSH Dissemination Materials and Activities

NIOSH has worked to disseminate evidence-based recommendations through several channels, Including:

- *NIOSH Science Blog* post *"*Preventing Back Injuries in Health Care Settings*"* - This blog post addresses patient-handling related hazards and interventions in healthcare settings (Bell, Collins, Galinsky, & Waters, 2008). Drs. Galinsky and Collins respond to questions, and as can be seen on the blog, the numerous visitor comments have been consistently positive.
- *NIOSH Topic Page:* "Safe Patient Handling and Movement (SPHM)" - This web page, first published in 2011, is the most comprehensive source of information on SPHM provided by NIOSH (NIOSH, 2011). In addition to background information and topical and legislative updates, this site contains links to NIOSH publications and related websites, education and training resources, professional associations, etc.
- *NIOSH SPHM for Home Healthcare Workers* - NIOSH researchers published a two-part series of articles in the journal *Home Health Care Nurse* describing safe patient handling equipment and devices for use with both partially weight-bearing and non-weight-bearing patients in home settings (Parsons, Galinsky, & Waters, 2006). The journal selected these articles for inclusion in their Continuing Education Unit (CEU) curriculum.
- "Musculoskeletal Disorders and Ergonomic Interventions" – This chapter was published in the 2010 NIOSH Hazard Review *Occupational Hazards in Home Healthcare* (NIOSH, 2010). Written to answer a series of FAQs, it covers the impact of MSDs, risk factors and prevention.
- *NIOSH Science Blog* post *"*Strains, Sprains, and Pains in Home Healthcare: Working in an Uncontrolled Environment" - This blog post includes information about types of assistive devices available to make

patient handling and movement safer. It also includes recommendations for employers and workers. Galinsky & Burnett, 2010).

- *Fast Facts for Home Healthcare Workers: How to Prevent Musculoskeletal Disorders* – This two page fact sheet describes MSDs and provides recommendations for employers and employees (NIOSH, 2012).

Transfer/translation

Professional practice organizations and federal agencies have used NIOSH research to take actions to address the various needs of their constituents. Below are a few of the key organizations that translated NIOSH research into publications or products:

- **American Association for Safe Patient Handling & Movement (AASPHM) –** An organization of national safe patient handling and movement experts seeking to advance the practice of safe patient handling and movement in order to improve the safety and function of patients and residents, as well as enhance the safety of those who provide their care. (AASPHM, 2017)
- **American Nurses Association (ANA)** – Representing approximately 3.6 million registered nurses, ANA is an advocate for "the nursing profession by fostering high standards of nursing practice, promoting a safe and ethical work environment, bolstering the health and wellness of nurses, and advocating on healthcare issues that affect nurses and the public" (ANA, 2017, para 1).
- **Association of Occupational Health Professionals in Healthcare (AOHP)** - Over 1,000 occupational health nurses, nurse practitioners, physicians, and physician assistants belong to AOHP. This organization is a leading advocate for occupational health, safety, and well-being in healthcare (AOHP, 2017).
- **Food and Drug Administration (FDA) –** As part of the U.S. Department of Health and Human Services, FDA is responsible for ensuring the safety and effectiveness of medical devices (FDA, 2017).
- **Occupational Safety and Health Administration (OSHA)** - OSHA is the federal agency in the Department of Labor charged with the enforcement of safety and health legislation. OSHA assures safe and healthful working conditions for workers by "setting and enforcing standards and by providing training, outreach, education and assistance" (OSHA, 2017, para 1).
- **The Veterans Health Administration (VHA)** – As the largest healthcare system in the world, VHA provides training for a majority of America's medical, nursing, and allied health professionals. The VHA healthcare system includes 152 hospitals, 800 community-based outpatient clinics, 126 nursing home care units, and 35 domiciliaries (VHA, 2017).

Intermediate Outcomes

NIOSH has been diligent in its efforts to inform and partner with individuals and organizations who are in a position to use Institute findings to make impact. The following are examples of instances when NIOSH research has contributed to impact in this area:

Safe Patient Handling Programs

Veterans Health Administration Directive

On June 28, 2010, the VHA issued Directive 2010-032, outlining policies for implementation of a Safe Patient Handling Program (VHA, 2010). The directive outlines the roles and responsibilities for implementing and maintaining a safe patient handling program at all levels of the VHA. Notably, the Directive requires a Safe Patient Handling Champion or Coordinator at each VHA facility. This individual is responsible for:

1. Implementing and maintaining the facility SPH Program,
2. Providing leadership, education, and training for Unit Peer Leaders,
3. Investigating as appropriate, reviewing, and tracking patient handling injuries in order to make suitable recommendations to decrease caregiver risk of injury,
4. Making patient handling equipment recommendations based on the ergonomic process and facilitating purchase of recommended equipment, and
5. Ensuring oversight of patient handling equipment.

In addition, VHA leadership allocated $205 million in funding to support the implementation and maintenance of these programs.

NIOSH research served as one piece of the evidence base for this directive. The following NIOSH publications were cited:

- Collins, J. W., Wolf, L., Bell, J., & Evanoff, B. (2004). An evaluation of a “best practices” musculoskeletal injury prevention program in nursing homes. *Injury Prevention*, *10*(4), 206-211.
- Evanoff, B., Wolf, L., Aton, E., Canos, J., & Collins, J. (2003). Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the workplace. *American journal of industrial medicine*, *44*(5), 451-457.

Beyond Getting Started: A Resource Guide for Implementing a Safe Patient Handling Program in the Acute Care Setting

AOHP collaborated with OSHA to develop a resource guide that provides the necessary tools for the occupational health professional to implement a safe patient handling program. In 2006, *Beyond Getting Started: A Resource Guide for Implementing a Safe Patient Handling Program in the Acute Care Setting* was published (AOHP, 2006). Since that time, this resource guide has been updated twice (2011 and 2014) and includes information regarding:

- The history of the safe patient handling movement in the United States,
- The importance of safe patient handling in acute and long-term care settings,
- Steps on how to successfully develop, implement, and evaluate an effective safe patient handling program,
- AOHP's current position statement on safe patient handling, and
- Sample forms, policies, and worksheets to aid in program implementation.

Additionally, this guide also referred to the Safe Patient Handling Curriculum for Schools of Nursing NIOSH co-developed (see pgs.63-64) as contributing “to a necessary paradigm change for truly creating a safe patient handling culture” (AOHP, 2014, pg.4). Several other NIOSH documents were instrumental in the development of this resource guide and were cited in the text:

- National Institute for Occupational Safety and Health. (1997). *A Primer Based on Workplace Evaluations of Musculoskeletal Disorders*. (DHHS (NIOSH) Publication Number 97-117). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/97-117/pdfs/97-117.pdf
- National Institute for Occupational Safety and Health. (2006). *Safe Lifting and Movement of Nursing Home Residents*. (DHHS (NIOSH) Publication Number 2006-117). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2006-117/pdfs/2006-117.pdf (Discussed on pgs.58-59)

OSHA Factsheet: Safe Patient Handling Programs Effectiveness and Cost Savings

In 2013, OSHA released *Safe Patient Handling Programs: Effectiveness and Cost Savings* (OSHA, 2013). This document lays out the business case for safe patient handling programs by outlining the costs and benefits. Citing several different case studies, the document also outlines the frequency of MSDs and pain in healthcare workers, the cost of patient handling injuries, calculated return on investment from safe patient handling programs, and equipment and instructions for facilities to create their own business case for safe patient handling.

Several NIOSH publications were cited in the factsheet including:

- Garg, A. (1999). Long-term Effectiveness of 'Zero-Lift Program' in Seven Nursing Homes and One Hospital. Contract Report No. U60/CCU512089-02.
- Nelson, A., Matz, M., Chen, F., Siddharthan, K., Lloyd, J., & Fragala, G. (2006). Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *International Journal of Nursing Studies*, *43*(6), 717-733.
- Nelson, A. L., Collins, J., Knibbe, H., Cookson, K., De Castro, A. B., & Whipple, K. L. (2007). Safer patient handling. *Nursing Management*, *38*(3), 26-32.
- Siddharthan, K., Nelson, A., Tiesman, H., & Chen, F. (2005). Cost effectiveness of a multifaceted program for safe patient handling. *Advances in Patient Safety, 3*, 347-358.

Safe Patient Handling Practices

ANA's Safe Patient Handling and Mobility Interprofessional National Standards

One of the goals established by the HCSA Sector Council was for organizations to establish national standards to guide a reduction in MSDs in healthcare workers. ANA facilitated this effort with several Council members and other national subject matter experts, reaching across the continuum of care (NIOSH, 2011a). On June 26, 2013, ANA released *Safe Patient Handling and Mobility (SPHM) Interprofessional National Standards* (ANA, 2013a). The standards establish a national foundation for SPHM to prevent injuries to the healthcare worker and patient. The SPHM standards outline the role of both the employer and healthcare workers in SPHM focusing on eight key concepts (ANA, 2013b):

1. Culture of Safety: a collective and sustained commitment to emphasize safety over competing goals.
2. Sustainable SPHM Program: a formal, systematized SPHM program for reducing the risk of injury for healthcare recipients and healthcare workers.

3. Ergonomic Design Principles: a systemized proactive approach that includes prevention considerations in all designs that affect individuals in the occupational environment.
4. SPHM Technology: assistive tools available at the point of care to facilitate SPHM. Technology can include equipment, devices, accessories, software, and multi-media resources.
5. Education, Training, and Maintaining Competence: an effective system of training and education to maintain SPHM competence of healthcare workers who provide direct care.
6. Patient-Centered Assessment: the plan of care adapted to meet the SPHM needs of individual healthcare recipients and specify appropriate SPHM technology and methods.
7. Reasonable Accommodation and Post-Injury Return to Work: a comprehensive SPHM program that can help employer provide reasonable accommodations to healthcare workers who were injured.
8. Comprehensive Evaluation System: a system to evaluate SPHM program status, using staff performance, staff injury incidence and severity, and healthcare recipient outcome metrics.

NIOSH significantly contributed to the development of the ANA SPHM Standards. Dr. James Collins of NIOSH served as one of the major contributors. In addition, several NIOSH publications and papers written by Dr. Collins and other NIOSH-funded researchers are cited in the ANA Standards:

- Collins, J. W., Wolf, L., Bell, J., & Evanoff, B. (2004). An evaluation of a "best practices" musculoskeletal injury prevention program in nursing homes. *Injury Prevention, 10*(4), 206-211.
- National Institute for Occupational Safety and Health. (2006). *Safe Lifting and Movement of Nursing Home Residents*. (DHHS (NIOSH) Publication Number 2006-117). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2006-117/default.html (Discussed on pgs.58-59)
- Nelson, A., Collins, J., Siddharthan, K., Matz, M., & Waters, T. (2008). Link Between Safe Patient Handling and Patient Outcomes in Long‐Term Care. *Rehabilitation Nursing, 33*(1), 33-43.
- National Institute for Occupational Safety and Health. (2009). *Safe Patient Handling Training for Schools of Nursing*. (DHHS (NIOSH) Publication Number 2009-127). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2009-127/default.html (As discussed on pgs.63-64)
- National Institute for Occupational Safety and Health. (2010). *NIOSH Hazard Review: Occupational Hazards in Home Healthcare*. (DHHS (NIOSH) Publication Number 2010-125). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2010-125/default.html
- National Institute for Occupational Safety and Health. (2010). *Prevention through Design: Plan for the National Initiative*. (DHHS (NIOSH) Publication Number 2011-121). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2011-121/default.html

- Waters, T. R. (2007). When is it safe to manually lift a patient? *AJN The American Journal of Nursing, 107*(8), 53-58. (Discussed on pgs.62-63)
- National Institute for Occupational Safety and Health. (1994). *Applications Manual for the Revised NIOSH Lifting Equation*. (DHHS (NIOSH) Publication Number 94-110). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/94-110/default.html

In addition, the *State of the Sector* (NIOSH, 2009a) written by the NORA HCSA Sector Council was also cited.

OSHA Inspections

On June 25, 2015, OSHA issued a memorandum to regional administrators and state designees titled *Inspection Guidance for Inpatient Healthcare Settings* (OSHA, 2015). This memorandum established guidance on inspections for assessing MSD risk factors associated with patient/resident handling. Specifically, OSHA inspections for MSD risk factors include:

- An assessment of establishment incidence and severity rates and whether the establishment has implemented a process to address these hazards in an effective manner,
- Reporting of maximum census of patients/residents permitted and the current census during the inspection,
- Reporting of the degree of ambulation of the patients/residents, as this information may provide some indication of the level of assistance given to patients/residents or the degree of hazards that may be present,
- Assessment of Safe Patient Handling programs including program administration, employee input/feedback, compliance monitoring, and program implementation,
- Evaluation of the number and adequacy of appropriate lift, transfer, or reposition assistive devices available and operational. This includes slings, batteries, charging stations for lifting devices, slip sheets, mechanical lifts, sit-to-stand assists, walk assists, and air-hover transfer pads,
- An assessment of whether lift, transfer, or reposition assistive devices are available within close proximity and maintained in a usable and sanitary condition,
- Review of training programs that include the recognition of ergonomic hazards associated with manual patient/resident lifting, transferring, or repositioning, the early reporting of injuries, and the establishment's process for abating those hazards,
- Review of training programs that include proper techniques and procedures to avoid exposure to ergonomic risk factors, and
- Demonstration of competency in performing lift, transfer, or repositioning task using assistive devices

NIOSH research on safe patient handling and musculoskeletal injuries significantly contributed to this policy change. The following NIOSH publications were cited in the OSHA memorandum:

- Centers for Disease Control and Prevention, Occupational Traumatic Injuries Among Workers in Health Care Facilities — United States, 2012–2014, *MMWR 64*(15), 405-410.
- National Institute for Occupational Safety and Health. (2010a). *Slip, Trip, and Fall Prevention for Healthcare Workers.* (DHHS (NIOSH) Publication Number 2011-123). Cincinnati, OH: U.S. Department of

Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2011-123/default.html

FDA Statement

As the regulatory body for medical devices, the FDA conducted a survey from nine MedSun facilities to learn about the use of patient lifts from the clinical perspective. Survey respondents included staff who are nurses, nurse managers, nurse educators, physical therapists, patient safety staff, risk managers, and biomedical engineers. Based on this survey and citing the NIOSH topic page on Safe Patient Handling (NIOSH, 2011a), the FDA compiled a list of best practices that can help mitigate the risks associated with patient lifts (FDA, 2016).

AASPHM Guidelines

In 2013, Dr. Traci Galinsky of NIOSH began participating as a member of an AASPHM committee to develop safety guidelines related to the compatibility between patient lift hangar bars and slings. This effort resulted in the 2016 publication of *Healthcare Recipient Sling and Lift Hanger Bar Compatibility Guidelines* (AASPHM, 2016).

State Legislation

While state legislation does not include references to evidence used to draft or pass patient handling legislation, there is evidence to suggest nursing advocacy groups, labor unions, and professional organizations were able to use NIOSH research findings to advocate for safe patient handling legislation.

> *"The Texas Nurses Association would like to commend NIOSH for its research in the area of healthcare and in particular in resulting guidance in the areas of violence prevention and recent guidelines for lifting in long-term care settings. This work has enabled Texas Nurses Association to advocate for and get enacted legislation that requires nurses and healthcare organizations to work together to produce -- policies and procedures that increase safety in these areas."*
>
> Stephanie Tabone, Registered Nurse and Director of Practice at Texas Nurses Association, during the 2006 NORA Town Hall Meeting, Houston, TX (NIOSH, 2006a).

Since 2005, 11 states have enacted "safe patient handling" laws or promulgated rules or regulations. Among these 11 states, ten require a comprehensive program in healthcare facilities in which there are safe patient handling policies and guidelines for obtaining equipment and training, data collection and program evaluation. These state laws are described in Appendix C.

Reach of NIOSH publications

NIOSH tracks the page views of its topic pages and Science Blog posts, as well as the number of downloads of pdf guidance documents. Table 1 below shows the total number of views and downloads of key web resources as of March 2017.

Table 1. Web reach of select NIOSH online resources

Document/Website	Year	Downloads/Page Views
NIOSH Science Blog: Preventing Back Injuries in Health Care Settings	2008	29,143 page views #7 all-time blog post
Occupational Hazards in Home Healthcare	2010	12,629 downloads (Note: Since 2010 an average of 5000 hard copies per year were requested by and disseminated to members of the public in the U.S. and other countries until it was out of stock in 2015.)
NIOSH Science Blog "Strains, Sprains, and Pains in Home Healthcare: Working in an Uncontrolled Environment	2010	6,012 page views (Note: Due to a technical issue, page views only go back to June 2013).
Fast Facts for Home Healthcare Workers: How to Prevent Musculoskeletal Disorders	2012	6,796 downloads
NIOSH Topic Page: Safe Patient Handling and Movement	2016	30,480 page views

Many other publications by NIOSH scientists and extramural researchers have been cited extensively in the literature. Table 2 lists the number of citations for journal articles by NIOSH and extramural researchers from Google Scholar as of March 2017.

Table 2. Citations of select journal articles

Article Name	Author(s)	Number of Citations
Musculoskeletal injuries among hospital patient care staff before and after implementation of patient lift and transfer equipment	Schoenfisch et al 2013	24
Musculoskeletal resulting from patient handling tasks among hospital workers	Pompeii et al 2009	88
The impact of workplace factors on filing of workers' compensation claims among nursing home workers	Qin et al 2014	13
Long-Term efficacy of an ergonomics program that Includes Patient-Handling Devices on Reducing Musculoskeletal Injuries to Nursing Personnel	Garg et al 2012	37
Comparison of required operating forces between floor-based and overhead-mounted patient lifting devices	Rice et al 2009	25
NIOSH research efforts to prevent musculoskeletal disorders in the healthcare industry	Waters et al 2006	135
When it is safe to manually lift a patient?	Waters 2007	132

Article Name	Author(s)	Number of Citations
Effectiveness of an evidence-based curriculum module in nursing schools targeting safe patient handling and movement	Nelson et al 2007	17
Suggestions for preventing musculoskeletal disorders in home healthcare workers. Part 1: lift and transfer assistance for partially weight-bearing home care patients	Parsons et al 2006	11

End outcomes

Although no cause and effect relationship between NIOSH research and occupational safety and health outcomes can be definitively proven, as evidenced above, the use of HCSA Program safe patient handling research and technical expertise illustrates the influence NIOSH has had in preventing non-fatal occupational injuries. Non-fatal occupational injuries, involving days away from work due to lifting, has steadily dropped across in ambulatory healthcare services, hospitals, and nursing homes and residential care facilities since 2006 (Figure 2).

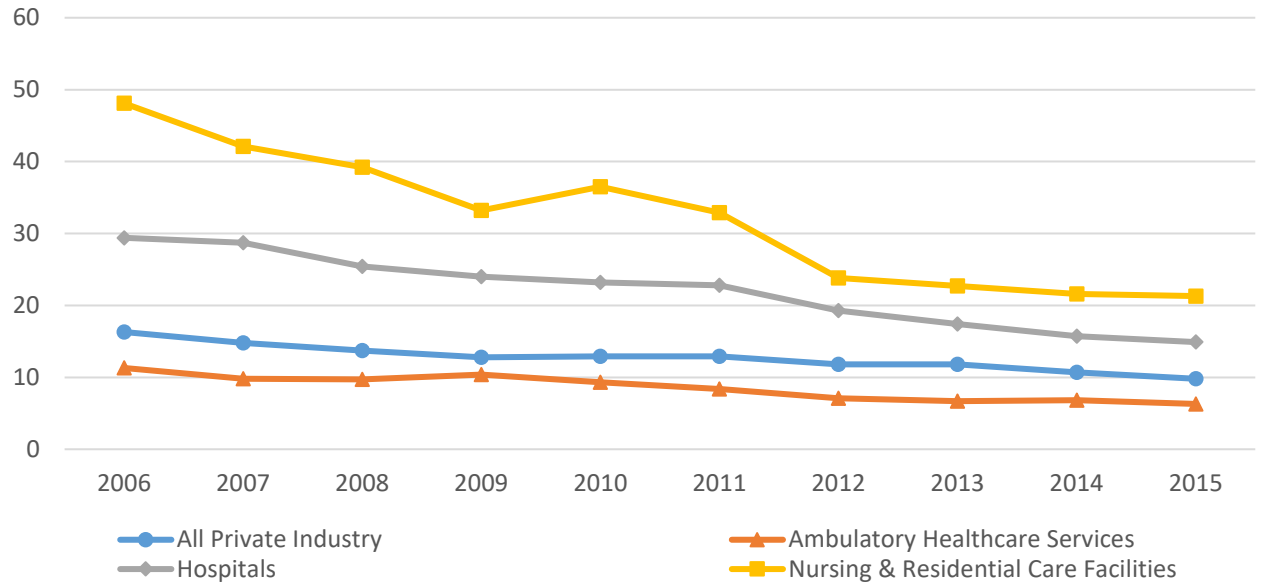

Figure 2. Injuries rates from patient lifting. Incidence rates for non-fatal occupational injuries involving days away from work due to lifting per 10,000 FTE, by industry

Alternative Explanations

While the use of NIOSH research in this area has been documented, there are potential alternative explanations, which in part may explain the decrease in injuries due to lifting. While many organizations have developed and distributed reports, publications, and other products to bring attention to safe patient handling issues, many of these organizations were dependent upon NIOSH research to support their efforts.

Media Attention from National Public Radio's "All Things Considered"

In February 2015, National Public Radio investigative reporter Daniel Zwerdling brought national media attention to safe patient handling issues. Zwerdling's five-part series described the injuries and personal

struggles of healthcare workers who were injured while lifting and moving patients. This series was broadcasted on National Public Radio's "All Things Considered" (Zwerdling, 2015a), which reaches 13.3 million people on 814 radio stations. It brought national attention to safe patient handling issues and highlighted the work of many organizations advocating for safer work conditions for healthcare workers. Dr. James Collins of NIOSH was featured as an expert in the February 11, 2015, story titled: "Even 'Proper' Technique Exposes Nurses' Spines to Dangerous Forces" (Zwerdling, 2015b).

ANA "Handle with Care" Campaign

ANA's "Handle with Care" campaign to promote safe patient handing and the prevention of MSDs among nursing staff has been active from 2003 to the present (De Castro, 2004). Coordinating and mobilizing partners such as nursing organizations, researchers, academic centers, and healthcare systems, the "Handle with Care" campaign seeks to educate, advocate, and facilitate safe patient handling practices and policies. In addition to position statements and brochures, the Campaign's awareness and advocacy efforts have helped influence state legislation such as Hawaii's House Concurrent Resolution No. 16. The campaign's brochure, *Safe Patient Handling and Mobility* (ANA, 2016) cites NIOSH research:

- Waters, T. R. (2007). When is it safe to manually lift a patient? *AJN The American Journal of Nursing*, *107*(8), 53-58. (As discussed on pgs.62-63)

OSHA's "Guidelines for Nursing Homes"

OSHA issued an ergonomics guideline for the nursing home industry in 2003 (OSHA, 2003). The guidelines are advisory in nature and were based on a review of existing safe patient handling programs, state OSHA programs, available scientific information, and stakeholder input. Although published before the second decade of NORA began, these guidelines continue to be relevant. NIOSH research is cited in this publication:

- Garg, A. (1999). Long-term Effectiveness of 'Zero-Lift Program' in Seven Nursing Homes and One Hospital. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.217.7023&rep=rep1&type=pdf

AOHP Position Statement

The Association of Occupational Health Professionals in Healthcare (AOHP) issued a position statement on safe patient handling in 2004 (AOHP, 2004). The position statement advocates for actions and policies that create a safer environment for nurses, other direct patient care providers, and patients. AOHP still supports this position currently. NIOSH research is cited in this statement:

- National Institute for Occupational Safety and Health. (1997). *Elements of Ergonomics Programs*. (DHHS (NIOSH) Publication Number 97-117). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/97-117/pdfs/97-117.pdf

Association of Rehabilitative Nurses "Safe Patient Handling Toolkit"

The Association of Rehabilitation Nurses (ARN) partnered with the American Physical Therapy Association, the American Occupational Therapy Association, and the VHA to produce a web-based *Safe Patient Handling Toolkit* (ARN, 2004). The toolkit provides a business case for safe patient handling, instructions on how to conduct a risk assessment, myths and facts about safe patient handling, tips on equipment selection, and the safe use of lifting equipment. It is still available on the ARN website today. NIOSH research was cited in the toolkit:

- Collins J, Wolf L, Bell J, Evanoff B. (2004). An evaluation of a "best practices" musculoskeletal injury prevention program in nursing homes. *Injury Prevention, 10*(4), 206–211.
- Evanoff, B., Wolf, L., Aton, E., Canos, J., & Collins, J. (2003). Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the workplace. *American Journal of Industrial Medicine*, *44*(5), 451-457.
- Tiesman, H., Nelson, A., Charney, W., Siddharthan, K., & Fragala, G. (2003). Effectiveness of a ceiling-mounted patient lift system in reducing occupational injuries in long term care. *Journal of Healthcare Safety*, *1*(1), 34-40.

Veterans Health Administration "Patient Handling (Lifting) Equipment Coverage & Space Recommendations"

Some patient lifting equipment requires significant storage space and careful installation. The VHA developed a guide to provide information regarding design, installation and storage requirements for patient handling equipment (VHA, 2016). NIOSH research was citied in this document:

- National Institute for Occupational Safety and Health. (2006). *Safe Lifting and Movement of Nursing Home Residents*. (DHHS (NIOSH) Publication Number 2006-117). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2006-117/default.html (As discussed on pgs.58-59)

Minnesota Hospital Association "Road Map to a Comprehensive Safe Patient Handling Program"

In 2012, the Minnesota Hospital Association released a document outlining the necessary components of a safe patient handling program, the specific actions to be taken by the facility, and how to evaluate their program (MHA, 2012).

Ohio Bureau of Workers Compensation "Ergonomics Best Practices for Extended-Care Facilities"

The Ohio Bureau of Workers Compensation (OBWC) conducted an ergonomics intervention study among nursing home workers in 111 Ohio facilities. OBWC provided the nursing homes with devices such as adjustable beds, patient lifts, and transfer devices and followed injury rates for two years using OSHA logs. There was significant evidence that ergonomic interventions in healthcare facilities led not only to reduced musculoskeletal injury rates but also to fewer lost work days and lower turnover (Hamrick, Fujishiro, Weaver, Marras, & Heaney, 2005). Recognizing the high rates of injury in extended-care facilities, the OBWC issued a set of *Ergonomics Best Practices* (OBWC, 2016).

Future plans

NIOSH has planned several areas of research for SPH. Analyses of data from home healthcare workers study revealed that patient handling was a significant risk factor for being physically assaulted (hit, kicked, pinched, shoved, or bitten) by patients. Patient handling remained a significant predictor of assaults by patients after statistically adjusting for worker age, gender, race, job title, hours of work, and use of needles during patient care (Waters et al., 2006). Considering this along with an earlier NIOSH study showing 30%-72% reductions in assaults by patients after introducing patient lifts in nursing homes (Collins et al., 2004), evaluation of patient assaults as well as overexertion injuries in SPH research is advisable.

The NIOSH Center for Worker Compensation began working with representatives of the AASPHM to develop a standardized system for coding worker injuries related to patient handling. In addition to improving claims processes, a standardized set of codes would provide a faster, more accurate, and efficient resource for use by researchers and practitioners to identify injury causes and specific intervention needs. The group has developed

a set of draft codes and recently described their efforts in a white paper and a NIOSH webinar. They are working toward implementing and evaluating these draft codes.

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American Association for Safe Patient Handling and Movement. (2016). *Healthcare Recipient Sling and Lift Hanger Bar: Compatibility Guidelines.* Retrieved from http://aasphm.org/wp-content/uploads/AASPHM-Sling-Hanger-Bar-Guidelines-2016.pdf

American Association for Safe Patient Handling and Movement. (2017). About us. http://aasphm.org/about-us/

American Nurses Association. (2013a). *Safe Patient Handling and Mobility*: *Interprofessional National Standards*. Silver Spring, MD. http://www.nursesbooks.org/ebooks/download/SPHM-Standards.pdf.

American Nurses Association. (2013b). *Safe Patient Handling and Mobility*. Retrieved from http://www.nursingworld.org/MainMenuCategories/WorkplaceSafety/Healthy-Work-Environment/SafePatient/SPHM-Trifold-Brochure.pdf

American Nurses Association. (2017). About ANA. Retrieved from http://www.nursingworld.org/FunctionalMenuCategories/AboutANA

Andersen, T. B., Schibye, B., & Skotte, J. (2001). Sudden movements of the spinal column during health-care work. *International Journal of Industrial Ergonomics*, *28*(1), 47-53.

Association of Occupational Health Professionals in Healthcare. (2004). *Position Statements*. Retrieved from https://www.aohp.org/aohp/Portals/0/Documents/ToolsForYourWork/Position%20Statements/PositionStatementsAug%202015.pdf

Association of Occupational Health Professionals in Healthcare. (2006). *Beyond Getting Started: A resource guide for implementing a safe patient handling program in the acute care setting*. Retrieved from http://www.aohp.org/aohp/TOOLSFORYOURWORK/PublicationsforYourPractice/BeyondGettingStarted.aspx

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Chapter 4: Reducing Health Impacts of Hazardous Drugs and Other Chemicals

Introduction

Health care workers who prepare or administer hazardous drugs or who work in areas where these drugs are used may be exposed to these agents in the air or on work surfaces, contaminated clothing, medical equipment, patient excreta, and other surfaces. Hazardous drugs are defined as exhibiting one or more of the following six characteristics: carcinogenicity, teratogenicity or other developmental toxicity, reproductive toxicity, organ toxicity at low doses, genotoxicity, or possess structure and toxicity profiles of new drugs that mimic existing drugs determined hazardous (NIOSH, 2004). Most antineoplastic (or chemotherapy) drugs and some antiviral drugs, hormone agents, and bioengineered drugs meet the criteria for hazardous drugs. About eight million U.S. healthcare workers are potentially exposed to hazardous drugs, including pharmacists, pharmacy technicians, nurses, physicians, veterinarians, veterinary technicians, environmental services workers, and shipping and receiving personnel (Bureau of Labor Statistics [BLS], 2011). Exposure may occur while preparing or administering hazardous drugs, during cleanup of spills, or when disposing waste (e.g., urine, feces) from patients receiving these drugs. Exposure may occur by breathing liquid aerosols or dusts or by contact with contaminated surfaces. Chemotherapy drugs help provide life-giving treatment to ill patients, but may also cause highly toxic side effects. Workers exposed to these drugs risk experiencing similar health effects, ranging from skin rashes and asthma to adverse reproductive outcomes (including infertility, spontaneous abortions, and congenital malformations), and possibly leukemia and other cancers, when not properly protected (NIOSH, 2004; Connor & McDiarmid, 2006).

Healthcare workers may also be exposed to chemicals such as those used for infection control purposes (e.g., chemical sterilants and high level disinfectants) (Weber & Rutala, 1998), anesthetics and medications administered to patients via inhalation (e.g., sevoflurane and aerosolized pentamidine) (McDiarmid et al., 1993; Occupational Safety and Health Administration [OSHA], 2016), cleaning products (e.g., quaternary ammonium compounds) (Bello, Quinn, Perry, & Milton, 2009) and by-products of surgical procedures employing lasers or electrosurgical devices (e.g., surgical smoke) (OSHA, 2017a). Examples of potentially exposed occupations include sterile supply technicians, medical supply technicians, nurses, anesthesiologists, dentists, respiratory therapists, diagnostic-related technologists and technicians, environmental services workers, among others (NIOSH, 2009a). When not properly controlled, these chemicals can cause adverse health effects like asthma, dermatitis, cancer, and reproductive problems (NIOSH, 2009a). In many cases, the means to eliminate or reduce exposures to hazardous drugs and other chemicals are well recognized and efforts have primarily focused on promoting safe handling guidelines, overcoming barriers to implementation of best practices, and evaluating effectiveness of interventions.

Logic Model

Figure 1 is a logic model illustrating the theory of change by which the Healthcare and Social Assistance (HCSA) Program has moved its hazardous drugs and chemicals activities into practice. The box border with a dotted line indicates an anticipated pathway for change, while solid lines show established pathways. Elements of the logic model – Inputs, Activities, Outputs, Transfer/Translation, Intermediate Outcomes, and End Outcomes – are described in further detail in the following subsections. The dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

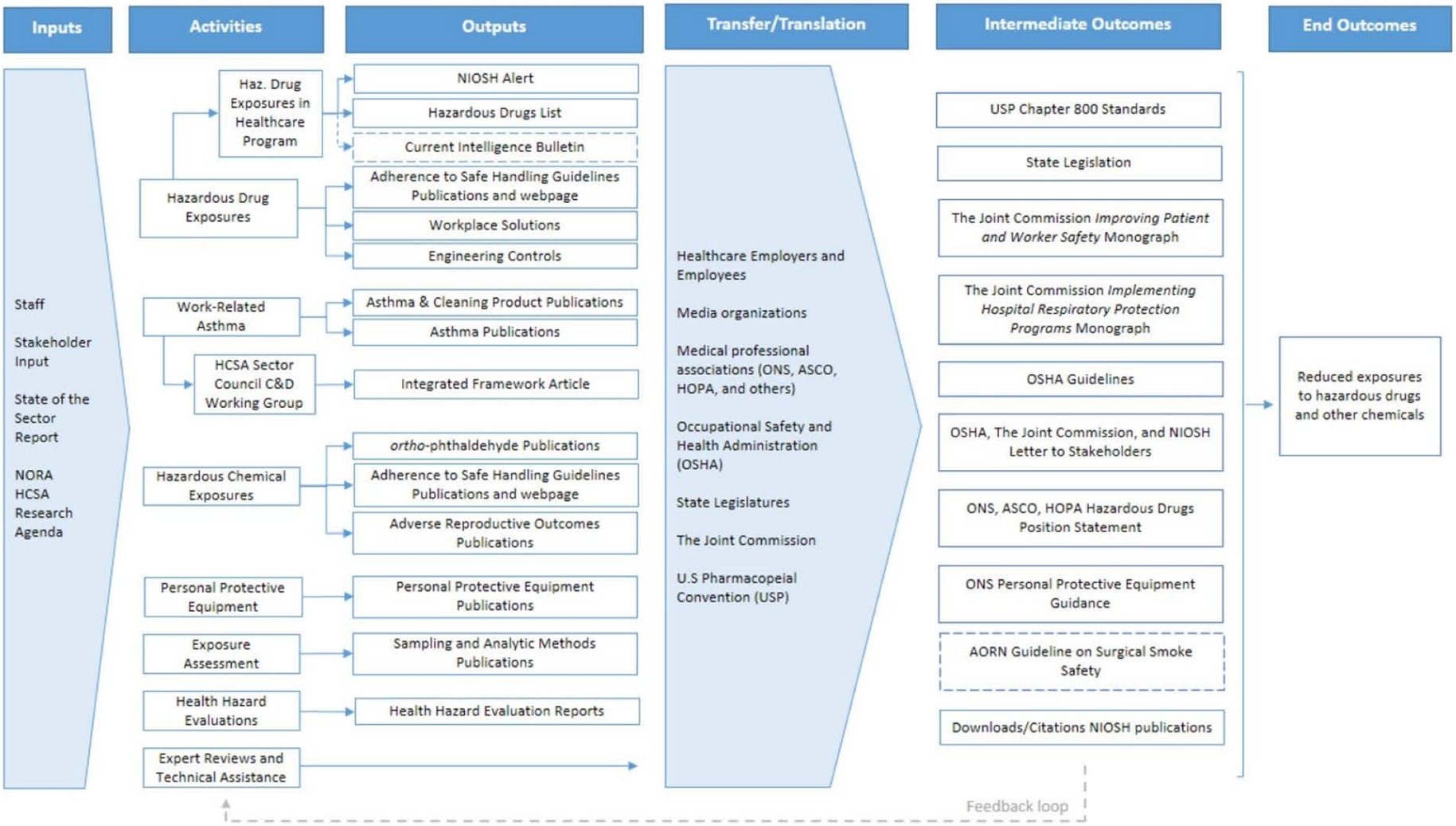

Figure 1. Reducing Health Impacts of Hazardous Drugs and Other Chemicals Logic Model. The box border with a dotted line indicates an anticipated pathway for change, while solid lines show established pathways. The grey dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

Inputs

Staff Input

NIOSH researchers have extensive expertise in this area having contributed to the body of knowledge and the application of that knowledge. The following individuals have been particularly instrumental in these efforts:

- **Thomas H. Connor, PhD** is a research biologist in the Division of Applied Research and Technology (DART) in Cincinnati, OH. He is a nationally and internationally recognized researcher on occupational exposure to antineoplastic drugs and leads the NIOSH Hazardous Drug Exposures in Healthcare Program. Dr. Connor has published numerous papers and presented at various professional meetings on a wide range of topics including workplace surface contamination assessments, biomarkers of exposure, effectiveness of closed system drug-transfer devices, environmental and personal monitoring methodologies, permeability testing of gloves, and scientific evidence of reproductive health risks.
- **Kenneth Mead, PhD, PE,** a senior research engineer in DART, has studied the application of engineering controls to reduce exposure risk to hazardous drugs and infectious agents
- **Christina C. Lawson, PhD** is a team leader and reproductive epidemiologist in the Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) in Cincinnati, OH. She, is collaborating with the Nurses' Health Study team to assess reproductive health risks associated with occupational exposure to antineoplastic drugs and other chemical agents.
- **Deborah V.L. Hirst, PhD, PE,** an engineer in DART, is a principal investigator of several projects addressing engineering controls for hazardous drugs.
- **Paul K. Henneberger, PhD** is a research epidemiologist in RHD, has conducted several studies evaluating asthma and other respiratory diseases in healthcare workers who work with cleaning and disinfecting agents. He is co-chair of the Cleaning and Disinfecting Work Group of the HCSA Sector Council.
- **M. Abbas Virji, MSc, ScD, CIH,** a research industrial hygienist in the Respiratory Health Division (RHD) in Morgantown, WV. He has assessed occupational exposures to cleaning and disinfecting agents in healthcare settings and use of an asthma-specific task based exposure matrix.
- **Jacek M. Mazurek, MS, MD, PhD,** a research epidemiologist in RHD, has conducted surveillance studies to better understand the prevalence of work-related asthma in the U.S. workforce and causative agents and allergic occupational respiratory diseases in healthcare workers.
- **James M. Boiano, MS, CIH**, a senior industrial hygienist in DSHEFS, was principal investigator of a survey of healthcare workers which examined extent of, barriers to, and factors affecting adherence to safe handling guidelines and best practices for handling hazardous drugs and other chemicals.

Stakeholder Input

One of the major activities of the HCSA Program was to facilitate the work of the HCSA Sector Council. During the second decade of NORA, the Sector Council had two major outputs, both of which helped drive research on hazardous drugs and other chemicals in the HCSA industry sector:

State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA

he *State of the Sector* report (NIOSH, 2009a) provided information on the magnitude and consequences of known and emerging health and safety problems, critical research gaps, and research needs that should be addressed over the second decade of NORA. Chapters 14 and 15 of the report provided a concise summary of the issues, health risks, impediments to reducing hazards, and research gaps relating to hazardous drugs and other chemicals. These issues included lack of awareness among healthcare employers and workers of the potential hazards and precautions for preventing exposure, and lack of information on extent of, barriers to, and factors influencing adherence to safe handling guidelines.

National Healthcare and Social Assistance Agenda

The 2009 *National HCSA Agenda* (NORA, 2009) was developed based on evidence provided in the *State of the Sector* report and identified a group of high priority occupational safety and health issues facing the HCSA industry sector. The need to protect healthcare workers from exposure to hazardous drugs and other chemicals found in HCSA work settings was reflected in the Council's third strategic goal: "Reduce or eliminate exposures and adverse health effects caused by hazardous drugs and other chemicals." (NORA, 2009, pg.13) This goal remained the same when the agenda was updated in 2013 (NORA, 2013).

Activities and Outputs

Hazardous Drug Exposures

Hazardous Drug Exposures in Healthcare Program

The NIOSH Hazardous Drug Exposures in Healthcare Program falls under the umbrella of the HSCA program and focuses on reducing occupational exposures to antineoplastic and other hazardous drugs in healthcare workers (NIOSH, 2016b). Working in collaboration with external partners, the Hazardous Drug Exposures in Healthcare Settings Program updates NIOSH Alert and list of hazardous drugs every two years and develops guidance documents. It identifies future research directions in collaboration with the HCSA Program, other NIOSH programs, and external partners.

In 2004, NIOSH first published safe handling guidelines and a list of hazardous drugs in the Alert entitled *Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Healthcare Settings* (NIOSH, 2004). The purpose of this Alert was to increase awareness among healthcare workers and their employers about the health risks posed by working with hazardous drugs and to provide them with measures for protecting their health. Appendix A of the Alert identified a sample list of major hazardous drugs. The list was compiled from information provided by four institutions (including NIOSH) that had generated lists of hazardous drugs for their respective institutions, as well as a list from the Pharmaceutical Research and Manufacturers of America (PhRMA). The Alert also included precautionary guidelines for controlling occupational exposures to hazardous drugs, including: engineering controls, administrative controls and warnings, safe work practices, proper use of personal protective equipment (PPE), personnel training, environmental monitoring, and medical surveillance.

The U.S. Food and Drug Administration continually approves new drugs and issues new warnings for existing drugs. Since the initial list of hazardous drugs was published in 2004, NIOSH has updated the list of hazardous drugs in 2010, 2012, 2014, and 2016 (NIOSH, 2010, 2012, 2014a, 2016a). NIOSH uses a transparent review

process for adding and reclassifying drugs. The process includes peer review and public comment consistent with Office of Management and Budget's Information Quality Guidelines (OMB, 2004, 2007)

A new NIOSH Current Intelligence Bulletin on reproductive risks associated with hazardous drug exposures and recommendations for reducing exposures in healthcare workers is underway (NIOSH, 2015). This document will help raise awareness among healthcare workers and employers about the adverse reproductive outcomes (e.g., infertility, miscarriage, and congenital malformations) and other serious health effects associated with exposure to hazardous drugs. Recommendations involve adhering to the established hierarchy of controls, providing education and training for employees and employers on the safe handling of hazardous drugs, and consideration of a voluntary alternative duty program for those who are at reproductive risk when working with hazardous drugs.

Adherence to Safe Handling Guidelines for Hazardous Drugs

Lack of current information on adherence to safe handling practices for hazardous drugs was one of the research gaps identified in the *State of the Sector* report (NIOSH, 2009a). This report also acknowledged the need for assessing organizational safety climate with respect to safety compliance behavior. To address these and other needs, NIOSH partnered with 21 professional practice organizations and conducted the Health and Safety Practices Survey of Healthcare Workers in 2011. This anonymous, multi-module, web-based survey was the largest federally-sponsored survey of healthcare workers focusing on hazardous drugs and other chemicals commonly found in healthcare settings. The survey was conducted to better understand the circumstances surrounding healthcare workers' exposure to hazardous drugs and chemicals, assess whether safe handling guidelines and best practices were being used to minimize exposure, and evaluate impediments to using PPE and other exposure controls. Respondents included professional, technical and support occupations who were exposed to selected chemical hazards in the week prior to the survey. The web survey included separate hazard modules for antineoplastic drugs (compounding), antineoplastic drugs (administering), aerosolized medications, anesthetic gases, chemical sterilants, high level disinfectants, and surgical smoke. Information on demographics, work organization, health and safety perceptions, and other topics were collected in a core module. The number of respondents ranged from 428 for the chemical sterilants module to 4,752 for the surgical smoke module, with almost 11,000 completing the core module (Steege, Boiano & Sweeney, 2014).

With respect to antineoplastic drugs, survey findings showed a lack of universal adherence to precautionary guidelines and other best practices by healthcare workers during compounding and administration of these drugs despite the longstanding availability of national safe handling guidelines (Boiano et al., 2014, 2015). This finding was highly noteworthy since there is no safe level of exposure to these cancer-causing drugs. When survey responses from a subset of nurses (i.e., employed by hospitals) who administered antineoplastic drugs were analyzed, training, familiarity with safe handling guidelines, and availability of engineering controls and PPE were associated with better adherence to safe handling practices and fewer reported spills (Silver, Steege & Boiano, 2016). When survey responses from another subset of nurses (i.e., those who administered liquid antineoplastic drugs) were analyzed, use of exposure controls was better when nurses were more familiar with safe handling guidelines and when perceived management commitment was higher (Dejoy et al., 2017). The odds of exposure were significantly lower when the use of exposure controls was greater and when more precautionary measures were in place. Apart from antineoplastic drugs, two other hazardous drugs were evaluated in this survey, pentamidine and ribavirin, administered as an aerosol to patients. Similar to the findings for antineoplastic drugs, NIOSH found a lack of universal adherence to safe handling guidelines for aerosolized pentamidine (Tsai, Boiano, Steege & Sweeney, 2015).

A topic page on the survey was posted to the NIOSH website (https://www.cdc.gov/niosh/topics/healthcareHSPS/) in March 2017 to provide users a one-stop resource for concise information on the survey findings including access to published articles. This webpage is expected to raise awareness of the importance of healthcare employers and workers to adhere to safe handling guidelines and other best practices when working with hazardous drugs and other chemicals in healthcare settings.

Workplace Solutions for Safe Handling of Hazardous Drugs

NIOSH "Workplace Solutions" documents provide easy-to-understand, easy-to-access, and easy-to-use recommendations that translate results of NIOSH research into occupational safety and health practice. Since 2006, NIOSH researchers and external subject matter experts have developed three of these NIOSH numbered documents to help protect healthcare workers from exposure to hazardous drugs. Two of the documents recommended medical surveillance of healthcare workers potentially exposed to hazardous drugs, first issued in 2007 (NIOSH, 2007) and later updated in 2013 (NIOSH, 2013). The third document recommended the use of appropriate personal protective equipment for healthcare workers who handle hazardous drugs in the workplace (NIOSH, 2009b).

Engineering Controls for Safe Handling of Hazardous Drugs

A closed system drug-transfer device (CSTD) is used to facilitate the transfer of drug from one reservoir to another, and may be used throughout the drug-handling chain from pharmaceutical compounding to patient dose administration. CSTDs limit the potential for aerosolizing drug contamination and can reduce worker exposure to sharps, thus reducing the likelihood of occupational exposure to hazardous drugs (NIOSH, 2004). While CSTD performance standards exist in regards to sterile practice for patient protection, no CSTD performance standards currently apply to drug containment (Douglass, Kastango, & Cantor, 2012). In the absence of such worker protection standards, the consumers (e.g., healthcare facilities and pharmacies) have no worker-protection performance basis upon which to make their selection of a CSTD, and they may be inclined to select a product based solely upon acquisition costs and uncertain claims of protective performance.

Because information was lacking on the effectiveness of CSTDs, NIOSH researchers, in collaboration with healthcare industry stakeholders, developed a performance test protocol for CSTDs of the physical barrier type and made it available for public comment (NIOSH, 2016c). Following public comment and a meeting with stakeholders, NIOSH was asked to expand the protocol to also include air-cleaning CSTDs. The revised universal test protocol is currently under development. Future plans include inviting CSTD manufacturers to participate in a study where their device is independently tested using the universal protocol at the NIOSH DART Research lab in Cincinnati. The test protocol may have multiple applications; it could be used by manufacturers to evaluate prototype CSTDs, by consumers to compare CSTD products, or by jurisdictions wishing to adopt the protocol for a CSTD performance certification procedure.

Work-Related Asthma in Healthcare

At the beginning of the second decade of NORA, surveillance data suggested that there was an increased risk of work-related asthma (WRA) among healthcare workers; however, limited information was available regarding occupational risk factors. To better understand exposure determinants associated with WRA, a number of studies were conducted by NIOSH and external researchers during the second decade. These included cross-sectional surveys of healthcare worker populations, exposure characterization studies in healthcare settings, analysis of a national surveillance system, and a literature review.

Surveillance

Findings from a NIOSH-funded cross-sectional survey conducted by researchers at the University of Texas contributed valuable information to the scientific community regarding occupational risk factors and exposures associated with asthma in healthcare workers. A survey questionnaire was mailed to a random sample of 5,600 physicians, nurses, respiratory therapists, and occupational therapists in Texas. The researchers found increased risk of WRA among respondents (n=3,650) who cleaned medical instruments, conducted general cleaning, used powdered latex gloves, or administered aerosolized medications. They concluded that occupational exposures are important contributors to asthma and future research is needed to more fully understand determinants of exposure (Delclos et al., 2007). Findings indicated that healthcare workers were at risk of developing WRA from exposure to cleaning-related chemicals including common cleaning products (e.g., bleach, ammonia) and disinfectants (e.g., aldehydes, chloramines) (Arif & Delclos, 2012). The risk of new-onset asthma in nurses from the same cohort of respondents was significantly greater among those involved in medical instrument cleaning and exposed to general cleaning products and disinfectants (Arif, Delclos & Serra, 2009).

NIOSH researchers also analyzed data from the Behavioral Risk Factor Surveillance System (BRFSS) to estimate the prevalence of current asthma among employed adults in the U.S. BRFSS is a state-based, random-digit-dialed telephone survey of the noninstitutionalized U.S. population aged $\geq$18 years that collects information on health risk factors, preventive health practices, and disease status. NIOSH researchers used the data to estimate the proportion of asthma that is work-related among healthcare and non-healthcare workers, and to assess the industry-specific and occupation-specific proportions of adults with current asthma by state. The 2008 and 2010 BRFSS Healthcare Worker Module and Asthma Call-Back Survey data collected in 35 states showed that significantly more healthcare workers/volunteers than non-healthcare workers/volunteers with current asthma, had asthma attacks (White et al., 2013). Data from the 2006-2007 BRFSS Asthma Call-Back Survey collected from 21 states identified healthcare support occupations (e.g., physical therapy assistants and aides, home health aides, medical assistants, orderlies) within HCSA as having the highest asthma prevalence (Dodd & Mazurek, 2016).

Exposure Characterization

Subsequently, NIOSH began more comprehensive efforts to identify agents that cause WRA and what healthcare occupations are exposed to these agents. One such effort by NIOSH researchers involved a study to identify and characterize cleaning/disinfecting tasks, products used, and volatile organic compound (VOC) exposure profiles of 14 healthcare occupations in five hospitals (Saito et al., 2015; LeBouf et al., 2014). They found that cleaning and disinfecting tasks were performed with a high frequency at least once per shift by medical equipment preparers, housekeepers, floor strippers/waxers, and endoscopy technicians. Many of the occupations used products containing amines and quaternary ammonium compounds and many of the products used contained potential irritants and sensitizers (Saito et al., 2015). VOC exposure profiles differed among occupations; the highest total VOC exposures were among nursing assistants, licensed practical nurses, and medical equipment preparers. The authors concluded that the VOC profiles would be useful for estimating exposures for occupational hazard ranking for industrial hygienists as well as epidemiological studies (LeBouf et al., 2014). Another effort included a recent literature review by NIOSH researchers which produced a list of agents causing occupational asthma in healthcare workers (Mazurek & Weissman, 2016). Examples include ingredients in disinfecting and cleaning products, drugs, biocides, quaternary amines, mold, diisocyanates, and proteolytic enzymes. Nearly a hundred relevant papers were included in the review. This paper represents a valuable resource for researchers interested in determinants of allergic occupational respiratory diseases in healthcare

workers. It also brings attention to the need for occupational health physicians to recognize that allergic symptoms such as asthma and rhinitis may be associated with the work environment.

Recommendations for Use of Cleaning and Disinfection Chemicals

Based largely upon the knowledge gained during these efforts, the HCSA Program recognized the need to identify knowledge gaps and future needs for research and practice relating to the use of cleaning and disinfecting chemicals in healthcare settings. To address this need, a working group within the NORA HCSA Sector Council was formed (e.g., Cleaning and Disinfecting in Healthcare Working Group), co-chaired by an external member of the Council and a NIOSH subject matter expert. This working group, representing over 40 infection prevention and occupational health researchers and practitioners, collectively developed an integrated approach to effective environmental surface cleaning and disinfection while protecting the respiratory health of healthcare personnel. This integrated framework was published as a major article in the *American Journal of Infection Control* in 2015 (Quinn & Henneberger, 2015).

Work Underway

Two NIOSH extramural research studies are currently underway that will be completed in 2017 or 2018. Researchers at the UMass Lowell Center for Sustainable Production are evaluating infectious agents found in the homecare environment that can be reduced by using different cleaning and disinfecting options (Quinn et al., 2016). In this four year study, researchers are assessing health effects of respiratory exposure from cleaning practices and identifying safer, and possibly more effective methods of disinfecting patient homes, benefiting both patients and healthcare workers. Researchers at Brigham and Women's Hospital in Boston are evaluating several novel hypotheses about occupational exposures to disinfectant and cleaning agents and their impact on asthma in a cohort of nurses from the Nurses' Health Study 2 (Camargo, 2013). The study results are expected to have a major public health impact on the well-being of healthcare workers, cleaners, and others who are regularly exposed to disinfectant or cleaning agents.

Hazardous Chemical Exposures

High Level Disinfectant: Ortho-Phthaldehyde

The high level disinfectant *ortho*-phthaldehyde (OPA) was marketed as a safer alternative to glutaraldehyde; however, soon thereafter there were reports in the literature of patients experiencing irritation and allergic reactions when evaluated using flexible endoscopes disinfected with OPA (Joshi & Rosenfeld, 2004). Similar reactions were reported by healthcare workers when using OPA to chemically disinfect medical devices (Franchi & France, 2005). These reports and concerns voiced by the American Industrial Hygiene Association (AIHA) Healthcare Working Group prompted NIOSH to develop a research study to determine if healthcare workers are experiencing adverse effects from exposure to OPA. The study encompassed both laboratory and field assessments. Laboratory toxicological testing was conducted using animal models and focused on dermal and respiratory irritation and sensitization. Additionally, sampling and analytical methods for quantitation of OPA in the air and on surfaces was developed by NIOSH chemists (Tucker, 2008; Tucker, 2014). The field assessment was conducted by the NIOSH Health Hazard Evaluation Program at eight healthcare facilities and included personal air samples, surface wipe samples, skin tests to assess allergic reactions, blood tests for OPA antibodies, and evaluation of exposure controls. The animal testing showed that topical application of OPA induced irritancy and allergic responses (Anderson et al., 2010) and inhalation of OPA vapor caused respiratory sensitization (Johnson et al., 2011). In the field evaluations, skin and respiratory symptoms were rare and skin sensitization to OPA was not confirmed (Chen et al., 2015). Recommendations included adherence to

recommended ventilation standards and guidelines for rooms where OPA is used, updating training programs, and having workers wear appropriate personal protective equipment.

Adherence to Recommended Safe Handling Guidelines for Chemicals

The 2011 *Health and Safety Practices Survey of Healthcare Workers (*previously discussed on pages 90-91 above), was also used to better understand current practices for handling selected hazardous chemicals. Lack of adherence to safe handling guidelines and best practices was reported by respondents handling high level disinfectants (Henn et al., 2015), administering aerosolized antibiotics (Tsai et al., 2015), and working in areas where surgical smoke was present (Steege, Boiano & Sweeney, 2016). NIOSH researchers also found that waste anesthetic gas scavenging systems were nearly always used in medical (Boiano & Steege, 2016) and dental settings (Boiano, Steege & Sweeney, 2016), but other best practices to minimize exposure (e.g., stopping anesthetic gas flow before carrier gas to the breathing system is shut off) were not always followed. Findings from the chemical sterilants module revealed that separate ethylene oxide sterilization and aeration units were still being used nearly one year after (EPA) prohibited their use. When separate units are used, healthcare workers can be exposed to ethylene oxide, an occupational carcinogen, when transferring off-gassing loads from the sterilizer to the aerator (Boiano & Steege, 2015).

When evaluating training and availability of employer procedures for minimizing exposure to the targeted chemical hazards, NIOSH researchers found that respiratory therapists who administered aerosolized antibiotics were less likely to have received training on safe handling practices (48% reported they were never trained) (Steege, Boiano & Sweeney, 2014). By comparison, nurses who administered antineoplastic drugs were the most likely to have received training (95%). Those exposed to surgical smoke were less likely to be familiar with employer standard procedures for minimizing exposure (40%). Those administering antineoplastic drugs were the most familiar with employer procedures (97%) (Steege, Boiano & Sweeney, 2014).

Adverse Reproductive Outcomes Associated with Exposure to Chemicals

For more than ten years, NIOSH intramural and extramural researchers have conducted research studies using data from the Nurses' Health Study (NHS) to evaluate occupational exposure to chemical hazards and risk of adverse reproductive outcomes (Lawson et al, 2006). The NHS is an ongoing prospective cohort study of risk factors for major chronic diseases in female nurses. The original study (NHS1) started in 1976, expanded in 1989 (NHS2), and currently it is in its third generation (NHS3). NIOSH began collaborating with the NHS team in 2005. One of the first studies evaluating chemical risk factors assessed risk of spontaneous abortion in 7,482 NHS2 participants exposed to antineoplastic drugs, anesthetic gases, antiviral drugs, chemical sterilants, and high level disinfectants (HLDs) (Lawson et al., 2012). The findings suggested that certain occupational exposures common to nurses are related to risks of spontaneous abortion. For example, antineoplastic drug exposure was associated with a 2-fold increased risk of spontaneous abortion and 3.5-fold increased risk among nulliparous women. Exposure to sterilizing agents was associated with a 2-fold increased risk of late spontaneous abortion, but not with early spontaneous abortion.

In a later study, NHS and NIOSH researchers examined the relationship between occupational use of HLDs among nurses and time to pregnancy. The study included 2,581 women from the NHS3 cohort who were trying to become pregnant or with a recent planned pregnancy. Researchers concluded that occupational use of HLDs, particularly glutaraldehyde, is associated with reduced fertility among women. Nurses using HLDs should be advised to use the recommended protective equipment as these might mitigate the fertility impairments associated with HLD use (Gaskins et al., 2014).

In 2013, NIOSH researchers conducted a structured literature review on occupational exposure to antineoplastic drugs and reproductive outcomes. Based on a review of 18 peer-reviewed, English language papers, the authors found that antineoplastic drug exposure appears to increase the risk of both congenital malformations and miscarriage in healthcare workers. The authors concluded that chronic, low level exposure to these drugs may increase the risk of adverse reproductive outcomes in healthcare workers. Additional precautions to prevent exposure were recommended (Lawson, Polovich & McDiarmid, 2014).

Personal Protective Equipment

Despite the fact that surgical and laser masks are routinely used to protect against surgical smoke in healthcare settings, these types of masks do not provide respiratory protection. A study by NIOSH grantees at the University of Cincinnati evaluated the filtration performance of surgical masks, N95 surgical mask respirators, and N100 filtering facepiece respirators (FFRs) in protecting against surgical smoke. Ten subjects were recruited to perform surgical dissections on animal tissue in a simulated operating room using a standard electrocautery device which generated surgical smoke. Six devices were tested: two surgical masks, two N95 respirators, and two N100 FFRs, including a newly developed faceseal prototype. Fit testing was conducted before the experiment. Each subject was then exposed to the surgical smoke while wearing the devices. Total particulate concentrations inside and outside of the devices were measured by a particle size spectrometer. Researchers found that the surgical masks did not provide measurable protection against surgical smoke. The N95 respirator offered considerably improved protection versus the surgical masks, while the N100 FFRs showed significant improvement over the N95 respirators. The faceseal prototype offered a higher level of protection than the standard N100 FFR, due to a tighter seal. While conventional N100 FFRs (equipped with exhalation valves) are not practical for use in the operating room, the results obtained with the faceseal prototype demonstrate the potential of the new faceseal technology for implementation on various types of respirators (Gao et al., 2016). The results demonstrated that surgical/laser masks are not protective against surgical smoke and thus should not be used for this purpose. Proper use of local exhaust ventilation augmented by the use of properly fitted filtering facepiece respirators and effective controls to reduce surgical smoke are recommended (Novak & Benson, 2010).

Researchers at the University of Michigan are evaluating interventions in a controlled, multi-site trial to increase nurses' use of protective equipment when handling hazardous drugs. The Drug Exposure Feedback and Education for Nurses' Safety (DEFENS) study will compare the efficacy of education (control) versus an audit and feedback intervention (treatment) on nurses' self-reported use of PPE when handling hazardous drugs. The treatment intervention includes tailored messages based on nurses' reported barriers to PPE use (Friese et al., 2015).

Sampling and Analytical Methods to Assess Worker Exposure to Chemicals

Use of validated sampling and analytical methods are essential for accurate assessment of worker exposure to hazardous chemicals in the workplace. When the need for new and improved methods arises, NIOSH chemists have developed sampling and analytical methods for chemical substances in the air, on surfaces, and in blood and urine. Examples of methods which have been developed for hazardous drugs and other chemicals include:

- A liquid chromatography-mass spectrometry/mass spectrometry (LC-MS/MS) method for simultaneous quantification of 4-ketocyclophosphamide, cyclophosphamide, and ifosfamide in human urine (B'Hymer & Cheever, 2010);
- A LC-MS/MS analytical method for measuring five commonly used antineoplastic drugs in field samples (Pretty et al., 2012);

- A drug-detection monitor which measures surface contamination levels on a near real-time basis (Smith et al., 2016a);
- A relatively simple technique which permits relatively low cost simultaneous detection and semi-quantitative measurement of surface contamination from multiple antineoplastic drugs (Smith et al., 2016b);
- A review of current methodology and recent advances in determining surface contamination with hazardous drugs (Connor & Smith, 2016);
- A sampling and analytical method for quantitation of OPA in air and on surfaces (Tucker, 2008, 2014); and
- A field validation of evacuated canisters for sampling VOCs in healthcare settings (LeBouf et al., 2012).

NIOSH is currently field-testing direct-reading devices for measuring hazardous drugs on surfaces in hospitals and other healthcare settings which is expected to be completed in 2017.

NIOSH Health Hazard Evaluations in Healthcare Settings

The NIOSH Health Hazard Evaluation (HHE) Program (https://www.cdc.gov/niosh/hhe/)is a congressionally mandated program that responds to requests from employers, employees and their representatives, and government agencies to assess whether hazardous materials or harmful conditions are adversely affecting worker health. During the second decade of NORA, NIOSH received 356 HHE requests addressing health and safety issues in the HCSA industry sector. Most (n=292) of these requests did not require a field investigation, i.e., information was provided to the requestor. Of the remaining 64 requests which necessitated a field investigation, 21 involved chemical hazards, mostly the high level disinfectant *ortho*-phthaldehyde, 10 involved antineoplastic drugs, and the rest involved non-chemical hazards (e.g., noise, mold, infectious agents). At the conclusion of each HHE, a final determination report was issued which presented methods, findings, conclusions, and practical recommendations to mitigate hazards and exposures. All HHE reports are publicly available at https://www2a.cdc.gov/hhe/search.asp.

NIOSH Subject Matter Experts Contributions to Other Organizations

NIOSH researchers are also actively participating on external committees and work groups and providing expert reviews and technical assistance as requested. As examples:

- Dr. Tom Connor served on the USP Compounding Expert Committee involved in the development of USP *Chapter 800 Hazardous Drugs – Handling in Healthcare Settings* and is co-chair of an American Society of Clinical Oncology (ASCO) working group on safe handling of hazardous drugs.
- Dr. Connor and Dr. Ken Mead were members of a working group that contributed to the development of the 2006 ASHP guidelines on safe handling of hazardous drugs.
- Dr. Paul Henneberger co-chaired the HCSA Program's Cleaning and Disinfecting in Healthcare Work Group which developed an integrated approach to safe and effective use of cleaning and disinfecting products in healthcare settings.
- Mr. Jim Boiano and Dr. Eileen Storey served as expert advisors for TJC on the development of an educational monograph entitled, *Improving Patient and Worker Safety – Opportunities for Synergy, Collaboration and Innovation* (2012).

- Jim Boiano also contributed a sidebar addressing respiratory protection and other exposure controls for surgical smoke in TJC monograph entitled, *Implementing Hospital Respiratory Protection Programs: Strategies from the Field* (The Joint Commission, 2014).

In addition, all NIOSH staff identified earlier have served as peer-reviewers of scientific papers, technical reports, and other documents addressing hazardous drugs and other chemicals developed by NIOSH internal and extramural researchers, as well as other researchers.

Transfer/Translation

A number of organizations have used NIOSH research to address the various needs of their constituents. Below are a few of the key organizations that have translated NIOSH research into publications or products:

- **American Nurses Association (ANA)** – represents approximately 3.6 million registered nurses in advancing the nursing profession by fostering high standards of nursing practice, promoting a safe and ethical work environment, bolstering the health and wellness of nurses, and advocating on healthcare issues that affect nurses and the public. (ANA, 2017).
- **American Society of Clinical Oncology (ASCO)** – a professional organization for physicians and oncology professionals caring for people with cancer (ASCO 2017).
- **American Society of Health-System Pharmacists (ASHP)** – a professional organization with over 43,000 members including pharmacists, pharmacy technicians, and student pharmacists who serve as patient care providers in acute and ambulatory care settings. ASHP has been at the forefront of efforts to improve medication use and enhance patient safety. (ASHP, 2017).
- **Association of periOperative Registered Nurses (AORN)** – a non-profit professional association based in Denver, Colorado, that represents the interests of more than 160,000 perioperative nurses by providing nursing education, standards, and clinical practice more than 160,000 perioperative nurses by providing nursing education, standards, and clinical practice. (AORN 2017b).
- **Hematology/Oncology Pharmacy Association (HOPA)** – a professional organization which supports pharmacy practitioners and seeks to promote and advance hematology/oncology pharmacy to optimize the care of individuals affected by cancer (HOPA, 2017).
- **International Society of Oncology Pharmacy Practitioners (ISOPP)** – a professional organization for pharmacists worldwide practicing in a variety of settings who provide clinical pharmacy and/or cytotoxic preparation services for cancer patients. (ISOPP, 2017).
- **Occupational Safety and Health Administration (OSHA)** – a federal agency in the Department of Labor charged with setting and enforcing safety and health standards and providing training, outreach, education and assistance. OSHA developed new guidelines for controlling occupational exposure to hazardous drugs and other chemicals found in healthcare settings. OSHA has permissible exposure limits for many chemical agents found in healthcare settings such as ethylene oxide, glutaraldehyde, nitrous oxide and other anesthetic gases, and formaldehyde (OSHA 2017c).
- **Oncology Nursing Society (ONS)** – a professional association of more than 39,000 members committed to promoting excellence in oncology nursing and the transformation of cancer care (ONS 2017).
- **The Joint Commission** – An independent, not-for-profit organization which accredits and certifies nearly 21,000 healthcare organizations and programs in the U.S. Accreditation and certification by the

Joint Commission is recognized nationwide as a symbol of quality that reflects an organization's commitment to meeting certain performance standards (The Joint Commission, 2017).

- **U.S. Pharmacopeial Convention (USP)** – A pharmacy-based quality organization that sets standards for protecting the quality of medicines and foods, as well as protecting healthcare personnel who handle hazardous drugs (USP, 2017).

Intermediate outcomes

NIOSH has been highly successful in its efforts to inform healthcare stakeholders and others who are in a position to use our research findings to affect change in practices that can improve the health and safety of healthcare workers. This has occurred through adoption of NIOSH findings, recommendations, and technologies by employers, regulators, consensus standard and accrediting bodies, and professional organizations. The following are examples of these intermediate outcomes.

Chapter 800 Hazardous Drugs – Handling in Healthcare Settings: Standards

In its 2016 Compounding Compendium, USP built upon guidance from NIOSH, ASHP, ONS, and OSHA to develop Chapter 800 Hazardous Drugs – Handling in Healthcare Settings (USP, 2016), the nation's first set of authoritative standards to protect healthcare personnel and the environment when hazardous drugs are handled in healthcare settings. This new chapter identifies requirements for receipt, storage, compounding, dispensing, and administration and disposal of hazardous drugs. It utilizes the NIOSH definition of hazardous drugs and cites the 2004 *NIOSH Alert* along with numerous other NIOSH documents:

- Connor, T. H., MacKenzie, B. A., & DeBord, D. G. (2012). Clarification about hazardous drugs. *American Journal of Health-System Pharmacy*, *69*(22), 1949-1950.
- National Institute for Occupational Safety and Health. (2004). *NIOSH Alert: Preventing occupational exposures to antineoplastic and other hazardous drugs in health care settings* (DHHS (NIOSH) Publication Number 2004-165]. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/2004-165/pdfs/2004-165.pdf (Described on pg.89)
- National Institute for Occupational Safety and Health. (2012). *NIOSH list of antineoplastic and other hazardous drugs in healthcare settings 2012* (DHHS (NIOSH) Publication Number 2012-150). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/2012-150/ (Described on pg.89)
- Couch, J., West, C. (2012). Chemotherapy Drug Exposures at an Oncology Clinic – Florida, Health hazard evaluation report: chemotherapy drug exposures at an oncology clinic - Florida (Health Hazard Evaluation Report No. 2009-0148-3158). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/hhe/reports/pdfs/2009-0148-3158.pdf (Described on pg. 96)
- National Institute for Occupational Safety and Health. (2009). *Workplace Solutions – Personal protective equipment for health care workers who work with hazardous drugs*. (DHHS (NIOSH) Pub. No. 2009-106). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and

Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/wp-solutions/2009-106/pdfs/2009-106.pdf (Described on pg.91)

- National Institute for Occupational Safety and Health. (2013). *Workplace Solutions - Medical Surveillance for Healthcare Workers Exposed to Hazardous Drugs.* (DHHS (NIOSH) Pub. No. 2013-103). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/wp-solutions/2013-103/pdfs/2013-103.pdf (Described on pg.91)
- National Institute for Occupational Safety and Health. (2013). Respirator trusted-source information. Section 3: Ancillary respirator information. Retrieved from http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/RespSource3healthcare.html#e (Described on pg.133)

These standards become effective on July 1, 2018, and will be enforceable by State Boards of Pharmacy. Additional information about Chapter 800 can be found at: http://www.usp.org/frequently-asked-questions/hazardous-drugs-handling-healthcare-settings

State Legislation

NIOSH research findings have also been used to influence state legislation for safe handling of hazardous drugs. Nursing advocacy groups, labor unions, and professional organizations were able to use NIOSH research findings to bring attention to antineoplastic and other hazardous drugs so legislation could be crafted to protect healthcare workers who handle or otherwise come in contact with these highly toxic drugs. To date, seven states have either enacted or are in the process of enacting legislation aimed at protecting workers from the adverse health effects of antineoplastic and other hazardous drugs. Many of these states legislation are based on the 2004 NIOSH Alert and updates of the hazardous drugs list.

- **Washington (2012)** – Senate Bills 5594 and 5149, adopted on January 3, 2012, require standards for the handling of antineoplastic and other hazardous drugs in healthcare facilities to be consistent with but not exceed, those in the 2004 NIOSH Alert: *Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Health Care Settings* (Washington State Legislature, 2011).
- **California (2013)** – Assembly Bill 1202, passed on October 9, 2013, requires standards for the handling of antineoplastic drugs in healthcare facilities to be consistent with, but not exceed, those in the 2004 NIOSH Alert: *Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Health Care Settings* (State of California, 2013).
- **North Carolina (2014)** – House Bill 644, "Prevent Hazardous Drug Exposure," requires standards for the handling of antineoplastic and other hazardous drugs in healthcare facilities to be consistent with, but not exceed, those in the 2004 NIOSH Alert: *Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Health Care Settings* (NCGA, 2014).
- **New Jersey (pending)** – In January 2015, a bill was introduced in State Assembly 4088 establishing the "Hazardous Drug Safe Handling Act" which requires promulgation of standards and regulations concerning safe handling of hazardous drugs (as defined by NIOSH) by healthcare personnel (State of New Jersey, 2015).
- **Massachusetts (pending)** – Proposed House Bill 3995 addresses the safe handling of hazardous drugs. The bill states that the regulations set forth by the State Department of Public Health shall be consistent

with provisions in the 2004 NIOSH Alert and subsequent updates (Commonwealth of Massachusetts, 2016).

- **Maryland (pending)** – This proposed regulation requires employers to develop a hazardous drug-control program, conduct an annual hazard assessment, evaluate and implement appropriate engineering controls (including required use of CSTDs), provide and require PPE, ensure safe storage and transportation of hazardous drugs, provide medical evaluations to employees who directly handle hazardous drugs at no cost, provide training, and maintain training records. (State of Maryland, 2014)
- **Michigan (pending)** – In March 2015, the Michigan legislature introduced Senate Bill 237 which establishes requirements for the safe handling of antineoplastic drugs and other hazardous drugs, as defined by NIOSH. (State of Michigan, 2015).

Medical Guidelines Development and Adoption

Many professional organizations, healthcare institutions, federal agencies, foreign governments, and others have adopted and/or cited NIOSH recommendations, NIOSH research studies and other information in their guidelines addressing hazardous drugs and other chemicals.

The Joint Commission Monographs

The Joint Commission cited the NIOSH Alert, list of hazardous drugs, and other documents in their 2012 educational monograph: *Improving Patient and Worker Safety – Opportunities for Synergy, Collaboration and Innovation* (TJC, 2012). As discussed in previous chapters, NIOSH provided some financial and technical assistance but did not author the document.

- National Institute for Occupational Safety and Health. (2007). *Workplace Solutions - Medical Surveillance for Health Care Workers Exposed to Hazardous Drugs*. (DHHS (NIOSH) Pub. No. 2007-117). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/wp-solutions/2007-117/pdfs/2007-117.pdf (Described on pg.91)
- National Institute for Occupational Safety and Health. (2012). NIOSH List of antineoplastic and other hazardous drugs in healthcare settings 2012. (DHHS (NIOSH) Pub. No. 2012-150). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2012-150/pdfs/2012-150.pdf (Described on pg. 89)
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The Joint Commission developed a second educational monograph *Implementing Hospital Respiratory Protection Programs: Strategies from the Field* (The Joint Commission, 2014). It is intended to stimulate greater awareness and knowledge of the importance of effective respiratory protection in hospitals and to provide examples of strategies for overcoming common implementation challenges. Because of its role in inspecting and approving healthcare facilities, the Joint Commission is extremely influential in healthcare. NIOSH provided

financial support and technical assistance to the Joint Commission because of its potential to raise awareness and assist hospitals in the development and implementation of respiratory protection programs

The monograph provides examples of chemical hazards that may require respiratory protection. Also included was a sidebar on respiratory protection and other exposure control practices for surgical smoke based on findings from the NIOSH Health and Safety Practices Survey of Healthcare Workers. Because many survey respondents who worked in areas where surgical smoke was generated reported that they wore surgical and laser masks (which are not respirators and do not provide respiratory protection), the sidebar highlighted the importance of using appropriate respiratory protection when working in areas where surgical smoke is generated and not adequately controlled.

Since release of the monograph in May 2015, it has over 3,800 downloads. NIOSH is cited several times:

- Beckman, S. Materna, B., Goldmacher, S., Zipprich, J., D'Alessandro, M., Novak, D., Harrison, R. (2013). Evaluation of respiratory protection programs and practices in California hospitals during the 2009-2010 H1N1 influenza pandemic. *American Journal of Infection Control, 41*(11), 1024-1031.
- Institute of Medicine. (2011b). Preventing transmission of pandemic influenza and other viral respiratory diseases: Personal protective equipment for healthcare personnel. Update 2010. Washington, DC: The National Academies Press. Retrieved from https://www.nap.edu/catalog/13027/preventing-transmission-of-pandemic-influenza-and-other-viral-respiratory-diseases
- National Institute for Occupational Safety and Health. (2010). Workplace Safety and Health Topics: Engineering Controls. Retrieved from https://www.cdc.gov/niosh/engcontrols/
- National Institute for Occupational Safety and Health (2013). National Personal Protective Technology Laboratory for Respirator Users Retrieved from https://www.cdc.gov/niosh/npptl/respusers.html
- Novak, D. A. (2013, August 27) *Respiratory Protection: How to best protect from workplace exposures*. Webinar presentation to University of Iowa Heartland Center for Occupational Health and Safety.
- Occupational Safety and Health Administration & National Institute for Occupational Safety and Health. (2015). *Hospital Respiratory Protection Program Toolkit: Resources for Respirator Program Administrators.* May 2015. Retrieved from: https://www.cdc.gov/niosh/docs/2015-117/default.html
- Steege, A. L., Boiano, J. M., & Sweeney, M. H. (2014). NIOSH health and safety practices survey of healthcare workers: training and awareness of employer safety procedures. *American Journal of Industrial Medicine*, *57*(6), 640-652.
- National Institute for Occupational Safety and Health. (2010). A Systematic Review of the Effectiveness of Training and Education for the Protection of Workers (DHHS (NIOSH) 2010-127). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/2010-127/default.html
- National Institute for Occupational Safety and Health. (2013). Respirator-Trusted Source Information. Retrieved from http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/RespSource3training.html

OSHA Guidelines and Communication to Stakeholders

In their 2016 guidelines on controlling occupational exposure to hazardous drugs, OSHA incorporated many references to NIOSH guidance documents and research studies (OSHA, 2016). Ten NIOSH technical reports and 17 peer-reviewed papers authored by NIOSH intramural and extramural researchers were cited in this

document. This online resource replaces previous OSHA guidelines on controlling occupational exposure to hazardous drugs (OSHA, 1993).

OSHA also provides technical review of new NIOSH hazardous drugs lists and, with NIOSH and The Joint Commission, jointly issued a letter in 2011 to hospital employers calling attention to a recent update of the NIOSH hazardous drugs list and safe handling guidelines (OSHA, 2014). As explained by Dr. David Michaels, Assistant Secretary of Labor for OSHA, the letter was intended to "encourage employers to address safe drug handling by committing their management staff to taking a leadership role identifying and remediating hazards, offering employee training, and evaluating workplace injury and illness prevention programs for continuous improvement." (NIOSH, 2011, para 4).

Professional Association Guidance

ONS, in collaboration with ASCO and HOPA issued a joint position statement in 2016, *Ensuring Healthcare Worker Safety When Handling Hazardous Drugs.* It urges evidence-based policy and procedures for safe handling of hazardous drugs; engineering controls; availability of appropriate PPE; and alternative duties for staff who are trying to conceive, pregnant or breastfeeding; among other guidelines.(ONS, 2016b). Of the seven references, four are from NIOSH: a journal article, two guidance documents, and an online repository of NIOSH research on this topic.

- Connor, T. H., & McDiarmid, M. A. (2006). Preventing occupational exposures to antineoplastic drugs in health care settings. *CA Cancer Journal for Clinicians*, *56*(6), 354-365
- National Institute for Occupational Safety and Health. (2004). *NIOSH Alert: Preventing occupational exposures to antineoplastic and other hazardous drugs in health care settings* (DHHS (NIOSH) Publication Number 2004-165). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. http://www.cdc.gov/niosh/docs/2004-165/pdfs/2004-165.pdf (Described on pg. 89)
- National Institute for Occupational Safety and Health. (2014). *NIOSH List of antineoplastic and other hazardous drugs in healthcare settings 2014*. (DHHS (NIOSH) Pub. No. 2014-138). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/2014-138/pdfs/2014-138.pdf (Described on pg.89)
- National Institute for Occupational Safety and Health. (2014) Occupational Exposure to Antineoplastic Agents and Other Hazardous Drugs: Recent Publications, Guidelines, Review Articles and Surveys. Retrieved from https://www.cdc.gov/niosh/topics/antineoplastic/pubs.html

That same year, ONS also produced guidance for PPE, *Personal Protective Equipment Use with Hazardous Drugs*. This brief, seven page guide provides recommendations for gloves, gowns, and respirators while handling hazardous drugs, and touches on other types of PPE like shoe covers and sleeve covers (ONS, 2016a). NIOSH is cited several times:

- Connor, T.H. (1999). Permeability of nitrile, rubber, latex, polyurethane gloves to 18 neoplastic drugs. American Journal of Health-System Pharmacy, 56, 450–453.
- National Institute for Occupational Safety and Health. (2004). *NIOSH Alert: Preventing occupational exposures to antineoplastic and other hazardous drugs in health care settings* (DHHS (NIOSH) Publication Number 2004-165). Cincinnati, OH: U.S. Department of Health and Human Services, Centers

for Disease Control and Prevention, National Institute for Occupational Safety and Health. http://www.cdc.gov/niosh/docs/2004-165/pdfs/2004-165.pdf (Described on pg.89)

- National Institute for Occupational Safety and Health. (2005). NIOSH respirator selection logic (DHHS (NIOSH) Publication No. 2005-100). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/2005-100/pdfs/2005-100.pdf
- National Institute for Occupational Safety and Health. (2009). Personal protective equipment for health care workers who work with hazardous drugs (DHHS (NIOSH) Publication No. 2009-106). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/wp-solutions/2009-106/pdfs/2009-106.pdf (Described on pg.91)
- National Institute for Occupational Safety and Health. (2014). *NIOSH List of antineoplastic and other hazardous drugs in healthcare settings 2014*. (DHHS (NIOSH) Pub. No. 2014-138). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from http://www.cdc.gov/niosh/docs/2014-138/pdfs/2014-138.pdf (Described on pg.89)
- National Institute for Occupational Safety and Health. (2015). Respirator trusted-source information. Retrieved from http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource3healthcare.html (Described on pg.133)

AORN will soon release a new guideline on surgical smoke safety (AORN, in press). In a "First Look" journal article, AORN cites journal articles by NIOSH intramural and extramural researchers, as well as a guidance document:

- Steege, A. L., Boiano, J. M., & Sweeney, M. H. (2016). Secondhand smoke in the operating room? Precautionary practices lacking for surgical smoke. *American journal of industrial medicine*, *59*(11), 1020-1031.
- Gao, S., Koehler, R. H., Yermakov, M., & Grinshpun, S. A. (2016). Performance of facepiece respirators and surgical masks against surgical smoke: simulated workplace protection factor study. *Annals of Occupational Hygiene*, *60*(5), 608-618.
- National Institute for Occupational Safety and Health. (1996). Control of smoke from laser/electric surgical procedures (DHHS (NIOSH) 96-128). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/hazardcontrol/hc11.html

Adoption by Healthcare Institutions

Many healthcare institutions in the U.S. and internationally have cited and/or adopted NIOSH recommendations in their safe handling guidelines. Examples include Veterans Health Administration (VHA, 2006) and Duke University Medical Center (Duke, 2016) in the U.S., and international health agencies in Canada (Institut de Recherche Robert-Sauve en Sante et en Secutite du travail (IRSST), 2008), Malaysia (Ministry of Health Malaysia, 2010), and Spain (Instituto Nacional de Securidad e Hygiene en el Trabajo (INSHT), 2016). The National Institute for Occupational Safety and Hygiene in Spain includes the NIOSH list in their guidance document: *Hazardous Drugs – Preventive Measures for Preparation and Administration* (INSHT, 2016).

Reach of NIOSH Science

Media Attention

NIOSH routinely issues press releases and updates to describe important intramural and extramural research findings, partnerships, conferences, new programs, and other major news events (NIOSH, 2017). With respect to hazardous drugs and other chemicals, examples of NIOSH updates in the past ten years included those issued for newly released hazardous drug lists, summarizing findings of published papers from the healthcare worker survey, and medical surveillance guidelines for workers exposed to hazardous drugs. In many cases media outlets, professional organizations, and others used the information to develop news articles. For example, shortly after the NIOSH Update (NIOSH, 2014b) describing a newly published journal article on antineoplastic drug administration practices from the NIOSH healthcare worker survey, numerous media outlets, professional organizations, and others reported on the findings. These included Oncology Nurse Advisor (Boltz, 2014), Oncology Times (Marcus, 2014), Pharmacy Learning Network (Cook, 2014), European Society for Medical Oncology (ESMO, 2014), American Conference of Governmental Industrial Hygienists (ACGIH, 2014), American Industrial Hygiene Association (AIHA, 2015), Occupational Health and Safety (OH&S, 2014), among others. In some cases, reporters interviewed the NIOSH principal investigators to better understand study findings.

Downloads of NIOSH Guidance Documents

NIOSH has tracked the number of downloads of its guidance documents since 2010. The reach of the Hazardous Drugs List has grown with every new edition. The update in 2016 had more than 23,000 downloads (Figure 1).

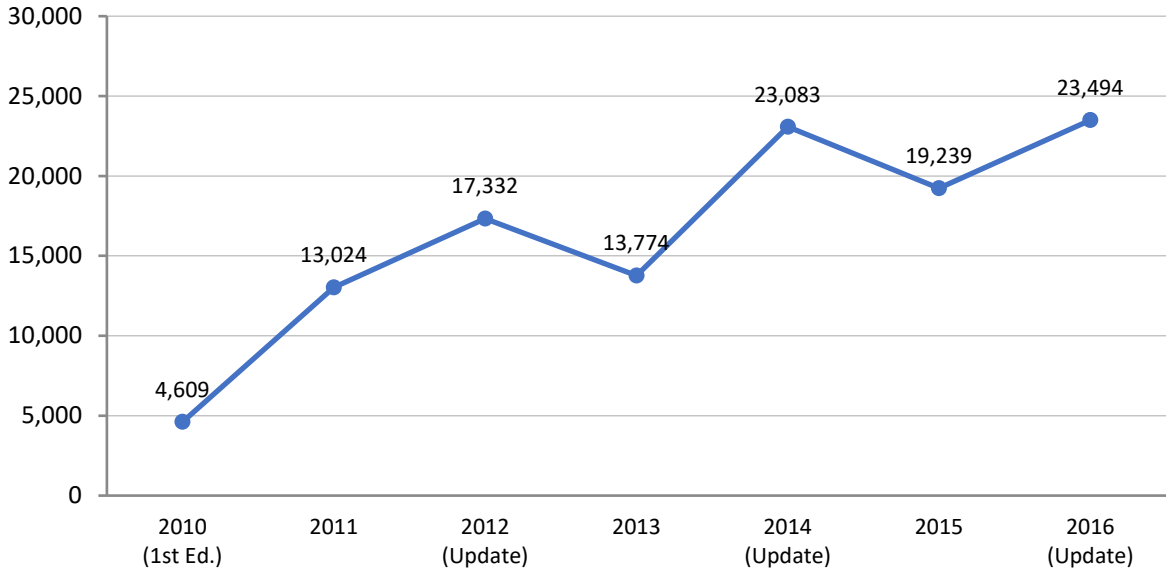

Figure 1. Downloads Number of Downloads of "NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings" document

The reach of documents produced prior to 2010 is almost certainly undercounted, since documents tend to have a high number of downloads in the first few years after publication and taper off over time. Table 1 below shows the number of downloads for three other NIOSH guidance documents related to hazardous drug exposure as of March 2017. With more than 80,000 downloads well after its publication in 2004, the NIOSH Alert continues to be an important and highly-utilized document.

Table 1. Total downloads of select NIOSH guidance documents

Document Name	Year Published	Number of Downloads
NIOSH Alert: Preventing Occupational Antineoplastic and Other Hazardous Drugs in Health Care Settings	2004	80,540
Workplace Solutions: Medical Surveillance for Healthcare Workers Exposed to Hazardous Drugs – 2007 edition	2007	6,702
Workplace Solutions: Medical Surveillance for Healthcare Workers Exposed to Hazardous Drugs – 2013 edition	2013	9,287

Citations

Many publications by NIOSH scientists and/or extramural researchers have been cited extensively in the literature. Table 2 lists the number of citations for journal articles by NIOSH and extramural researchers from Google Scholar as of March 2017.

Table 2. Citations of select journal articles

Publication	Author(s)	Number of Citations
NIOSH Alert: Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Health Care Settings.	Burroughs, Connor, McDiarmid, M.A., Mead, Power, and Reed 2004	53
NIOSH Health and Safety Practices Survey of Healthcare Workers: training and awareness of employer safety procedures	Steege, Boiano, and Sweeney 2014	22
Adherence to safe handling guidelines by health care workers who administer antineoplastic drugs	Boiano, Steege, Sweeney 2014	28
Occupational Risk Factors and Asthma among Health Care Professionals	Delclos, Gimeno, Arif, Burau, Carson, Lusk, Stock, Symanski, Whitehead, Zock , Benavides , and Anto 2007	102
Association between cleaning-related chemicals and work-related asthma and asthma symptoms among healthcare professionals	Arif and Delclos 2012	72
Occupational exposures and asthma among nursing professionals.	Arif, Delclos, and Serra. 2009	59
Characterization of cleaning and disinfecting tasks and product use among hospital occupations	Saito, Virji, Henneberger, Humann, LeBouf, Stanton, Liang, and Stefaniak 2015	10
Cleaning and disinfecting environmental surfaces in health care: toward an integrated framework for infection and occupational illness prevention	Quinn and Henneberger 2015	19

Publication	Author(s)	Number of Citations
Irritancy and allergic responses induced by topical application of orthophthalaldehyde	Anderson, Umbright, Sellamuthu, Fluharty, Kashon, Franko, Jackson, and Joseph 2010	20
Occupational exposures among nurses and risk of spontaneous abortion	Lawson, Rocheleau, Whelan, Lividoti Hibert, Grajewski, Spiegelman and Rich-Edwards 2012	79
Reproductive health risks associated with occupational exposures to antineoplastic drugs in health care settings	Connor, Lawson, Polovich, and McDiarmid 2014.	26
Sampling and mass spectrometric analytical methods for five antineoplastic drugs in the healthcare environment	Pretty, Connor, Kurtz, McLaurin, B'Hymer DeBord 2012.	22

End outcomes

There is no conclusive data to demonstrate NIOSH's direct impact on morbidity outcomes (e.g., cancer, adverse reproductive outcomes, and occupational asthma) among healthcare workers exposed to hazardous drugs and other chemicals. Even if a reduction were observed, linking disease to an exposure would be difficult because of latency between exposure and onset of illness. Nonetheless, with respect to hazardous drugs, the availability of safe handling guidelines has resulted in significant improvements in the way antineoplastic drugs are compounded and administered in healthcare settings. Training and education has been shown to improve compliance with safe handing guidelines including use of engineering controls (e.g., CSTDs) and PPE (Al-Azzam et al., 2015; Keat et al., 2013). Use of these exposure controls has been shown to reduce the likelihood of exposure to hazardous drugs and contamination of the workplace (Vyas, Yiannakis, Turner & Sewell 2014). With respect to other hazardous chemicals, adherence to federal standards and best practice guidelines including training and implementation of the hierarchy of exposure controls are effective in minimizing worker exposures and risk of developing adverse acute and chronic health effects.

Alternative explanations

Although NIOSH has been at the forefront of occupational health and safety research on hazardous drugs and other chemicals in healthcare work settings, many other organizations, institutions, and federal and state government agencies have contributed to efforts to protect and improve worker health in this area. While these organizations added to the body of scientific knowledge, contributed to enacting or influencing legislation and standards, and developed interventions and materials, many of these organizations were dependent upon NIOSH research to support their efforts. Safe handling guidelines for hazardous drugs were updated by ASHP (ASHP, 2006), ONS (ONS, 2014) and OSHA (OSHA, 2016) and, more recently, the USP published the nation's first set of enforceable standards to protect healthcare personnel from exposure to hazardous drugs (USP, 2016).

Best practice guidelines for controlling exposure to hazardous chemicals were developed for a number of chemicals or classes of chemical agents by various organizations and academic institutions. As examples, the Sustainable Hospitals Program in the Lowell Center for Sustainable Production at UMass Lowell conducts research in healthcare settings to identify and implement more environmentally sound, healthy and safe products, and work practices which impact both worker and patient safety (UMassLowell, 2017). Furthermore,

AORN developed precautionary guidelines for minimizing exposure to surgical smoke (AORN, 2017a) and will be publishing new guidelines in early 2017 (AORN, 2017b); the American Society of Anesthesiologists (ASA) and American Association of Nurse Anesthetists (AANA) developed best practice guidelines for anesthetic gases (Berry et al., 1999; AANA, 2013); the Society of Gastroenterology Nurses and Associates (SGNA) and OSHA developed safe handling guidelines for high level disinfectants including glutaraldehyde (SGNA, 2013; OSHA, 2017b); and U.S. Environmental Protection Agency (EPA) mandated use of a single chamber process for ethylene oxide sterilization as a means of lowering ambient workplace levels and reducing long-term non-cancer and potential cancer risks associated with exposure among healthcare workers (EPA, 2010).

Future plans

NIOSH intramural research activities and studies currently underway include field testing direct-reading devices for measuring antineoplastic drugs on surfaces in healthcare settings, evaluating the effects of education and periodic feedback to improve recommended use of PPE among nurses who handle antineoplastic and other hazardous drugs, and developing a universal performance test protocol for CSTDs.

During the third decade of NORA, a number of understudied issues involving hazardous drugs and other chemicals will need to be evaluated. Examples include: use of antineoplastic drugs in medical non-oncology, veterinary, and home healthcare settings; handling of uncoated, pressed-powder forms of chemotherapy drugs; exposure and engineering control assessment of waste anesthetic gases in patient recovery areas and veterinary settings; effectiveness of cleaning and disinfecting products with respect to infection control and occupational illness prevention, and hazardous drugs exposure assessment of personal care assistants, laundry personnel and others caring for patients receiving chemotherapy.

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American Society of Clinical Oncology. (2017). About ACO. Retrieved from https://www.asco.org/about-asco

American Society of Health-System Pharmacists. (2006). ASHP guidelines on handling hazardous drugs. *American Journal of Health-System Pharmacy*, *63*(12), 1172-1191. Retrieved from https://doi.org/10.2146/ajhp050529

American Society of Health-System Pharmacists. (2017). About Us. Retrieved from http://www.ashp.org/menu/AboutUs

Anderson, S. E., Umbright, C., Sellamuthu, R., Fluharty, K., Kashon, M., Franko, J., ... & Joseph, P. (2010). Irritancy and allergic responses induced by topical application of ortho-phthalaldehyde. *Toxicological Sciences*, *115*(2), 435-443. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/20176622.

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Chapter 5: Occupational Infectious Disease Transmission

Introduction

Occupational infectious diseases are an important hazard for workers in the Healthcare and Social Assistance (HCSA) industry sector. Infectious disease transmission in HCSA work settings is also a patient safety issue, since patients and visitors are also at risk from exposure to infectious agents. Many of these infectious disease hazards are long standing and well recognized, yet continued efforts are needed to control them. Examples include bloodborne pathogens such as Hepatitis B virus (HBV), Hepatitis C virus (HCV), and Human Immunodeficiency Virus (HIV); tuberculosis (TB); and seasonal influenza. Other infectious hazards are new and emerging. Responding to them can be very challenging, since mode of transmission, severity of disease, and effectiveness of preventive interventions may initially be unclear. Well-known emerging infectious diseases affecting healthcare workers during the second decade of NORA have included 2009 H1N1 pandemic influenza, Ebola, and Middle Eastern Respiratory Syndrome (MERS).

Infectious agents vary in their routes of transmission, with important implications for prevention. An Institute of Medicine (IOM) report sponsored by NIOSH provides a contemporary description of transmission pathways relevant to many pathogens (IOM, 2011). These include direct contact transmission, indirect contact transmission, droplet spray transmission, and aerosol transmission. Sharps injuries represent another important transmission pathway. Some agents may preferentially transmit infection via one pathway; others may use multiple pathways (Roy & Milton, 2004). Incomplete understanding of the relative contributions of different pathways to disease transmission has led to controversy about optimal approaches to preventing transmission of some occupational infectious diseases. For example, the role of respiratory protection in preventing transmission of influenza continues to be controversial (Jefferson et al., 2011; Radonovich et al., 2016).

Typically, a range of interventions from across the hierarchy of controls are used to protect against transmission of infectious agents. The Center for Disease Control and Prevention's (CDC) recommendations for standard and transmission-based precautions to prevent transmission of infectious agents in healthcare include a multi-pronged approach of engineering controls, administrative and work practice controls and PPE) (Siegel, Rhinehart, Jackson, & Chiarello, 2007). Examples of engineering controls include barriers, directional ventilation, air filtration, airborne infection isolation rooms, and ultraviolet germicidal irradiation (UVGI). Administrative and work practice controls can include rapid identification and isolation of source patients, limiting the number of employees exposed to source patients, hand washing, and vaccination for vaccine-preventable diseases such as Hepatitis B and influenza. A range of PPE may be used by healthcare workers, including barrier protection against contact and droplet spray transmission (e.g. gloves, gowns, eye protection, facemasks, and face shields) and respiratory protection against aerosol transmission.

CDC plays a critical national and international role in issuing guidance to prevent transmission of infectious diseases and in responding to public health emergencies caused by emerging infectious diseases and disease outbreaks, including epidemics and pandemics. NIOSH contributes its unique expertise in areas such as engineering controls, PPE, and other aspects of worker safety and health to these efforts.

This chapter will provide examples of NIOSH efforts and impacts related to protecting healthcare workers from occupational infectious diseases. Areas covered will include responses to the 2014-2016 Ebola virus disease epidemic, influenza, tuberculosis, sharps injuries and bloodborne pathogens, engineering controls, and personal protective equipment.

Logic Model

Figure 1 is a logic mode that illustrates key relationships characterizing how the HCSA Program contributes to infectious disease response and research as it applies to occupational safety and health. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. Elements of the logic model – Inputs, Activities, Outputs, Transfer/Translation, Intermediate Outcomes, and End Outcomes -- are described in further detail in the following sections. The grey dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

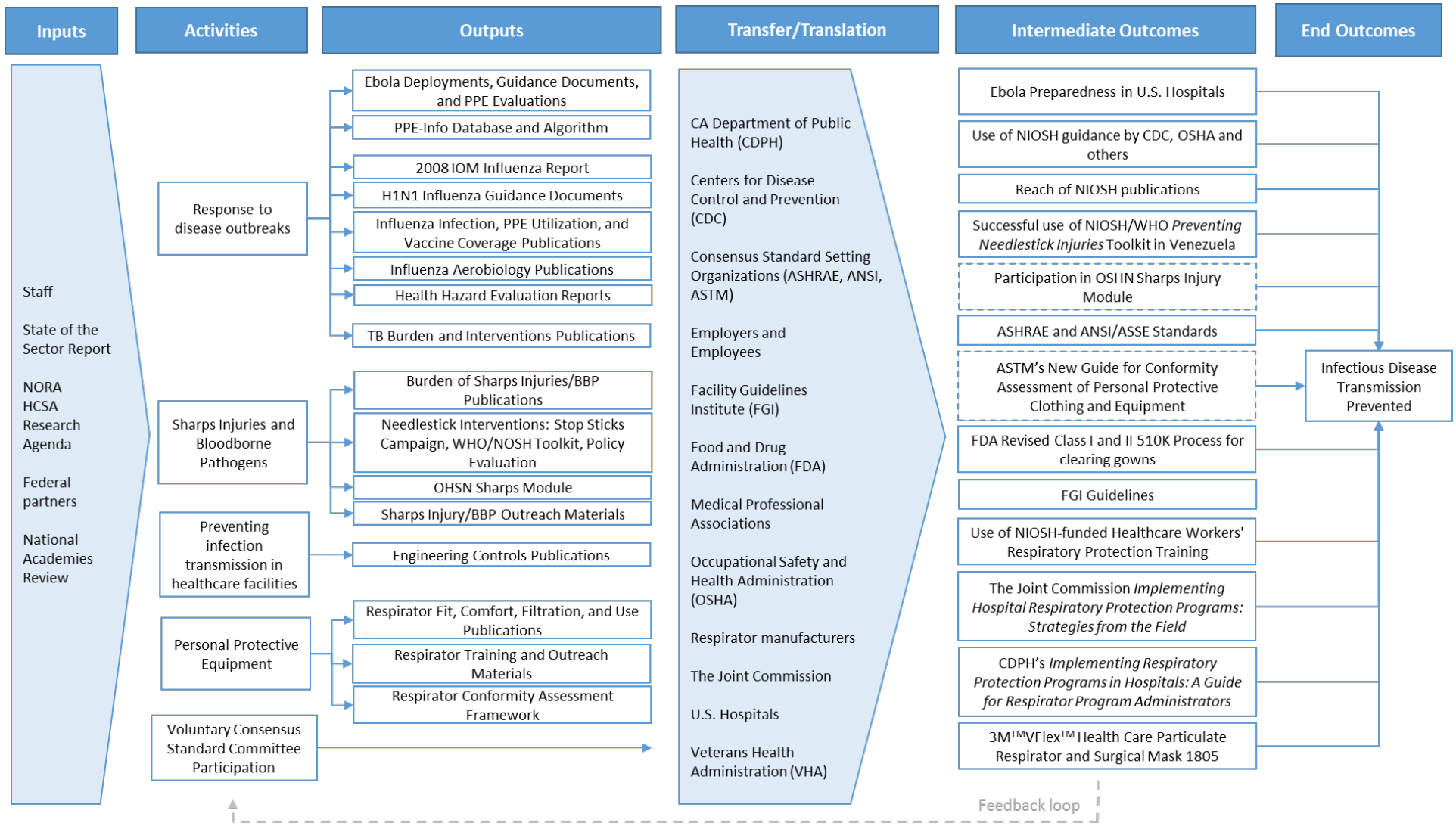

Figure 1. Occupational Infectious Disease Transmission. Dotted lines indicate anticipated pathways for change, while solid lines show established pathways. The grey dotted line at the bottom of the logic model, running from right to left, depicts a feedback loop.

Inputs

Staff Input

Many researchers from across NIOSH have made important contributions in this area. Although there are too many to list them all, a partial list includes the following:

- **Lisa Delaney, MS, CIH** is an industrial hygienist and the NIOSH Associate Director for Emergency Preparedness and Response in Atlanta, GA. She is an expert in biological emergency responses and plays a leadership role in NIOSH responses to disease outbreaks, including during the 2009 H1N1 influenza pandemic and the 2014-2016 Ebola Outbreak.
- **Marie de Perio, MD** is an infectious disease specialist and epidemiologist in the Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) in Cincinnati, OH. She has been engaged in a range of responses to infectious disease outbreaks and published on a variety of issues, including influenza and TB prevention.
- **Ahmed Gomaa, MD, ScD, MSPH** is an occupational medicine specialist and epidemiologist in DSHEFS. He works in the area of sharps injury prevention research and is the lead project officer for the NIOSH Occupational Health Safety Network, a web-based injury and exposure monitoring system for healthcare facilities that recently established a module for monitoring sharps injuries.
- **William Lindsley, PhD** is a research bioengineer in the Health Effects Laboratory Division (HELD) in Morgantown, WV. Dr. Lindsley contributed to NIOSH's efforts to characterize influenza aerobiology and its potential for aerosol transmission.
- **Stephen Martin, PhD, PE,** is a research engineer in the Respiratory Health Division (RHD) in Morgantown, WV. He has played an important role in NIOSH investigations of TB outbreaks and in research on using ultraviolet germicidal radiation (UVGI) as an engineering control.
- **Kenneth Mead, PhD, PE,** a research engineer in the Division of Applied Research and Technology (DART) in Cincinnati, OH. He has studied the application of engineering controls to reduce exposures to infectious agents. Dr. Mead has played a key role in development of expedient isolation units that could be deployed in the event of an outbreak and under-supply of airborne infection isolation rooms.
- **John Noti, PhD**, a microbiologist and molecular biologist in HELD, has conducted research to characterize influenza aerobiology and potential for aerosol transmission.
- **Debra Novak, PhD, RN** is a research nurse in the National Personal Protective Technology Laboratory (NPPTL) in Pittsburgh, PA. She has played an important role in translating PPE research findings into clinical workplaces to better protect healthcare workers.
- **Raymond Roberge, MD, MPH,** an Emergency Medicine and Occupational Medicine specialist and Medical toxicologist in NPPTL, has published extensively on physiological and subjective responses of healthcare workers to the use of PPE.
- **Ronald Shaffer, PhD**, a research chemist in NPPTL, has played a key leadership role in NPPTL efforts to improve PPE for healthcare workers.
- **Ziqing Zhuang, PhD,** an industrial engineer in NPPTL, has played an important role in NPPTL research to understand factors affecting respirator fit and appropriate frequency of fit testing.

Stakeholder Input

NIOSH efforts to prevent transmission of infectious diseases have benefitted from a range of inputs from stakeholders external to NIOSH. The examples of external input provided below are only a sample of NIOSH's engagement with stakeholders:

State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA

Chapter 3 of the *State of the Sector* report produced by the National Occupational Research Agenda (NORA) HCSA Sector Council addresses the burden of injury and illness documented by surveillance systems, including the burden of sharps injuries and infectious disease. Chapters 16 and 17 focus on bloodborne pathogens and sharps injuries; and infectious hazards other than bloodborne pathogens. Issues identified included the persistence of sharps injuries and the need for continued surveillance and intervention efforts. A range of knowledge gaps were identified for a range of infectious hazards, such as needs for surveillance, better characterization of transmission pathways, disseminating known effective interventions and assessing effectiveness of other interventions, and improving the technology and appropriate use of PPE and engineering controls (NIOSH, 2009a).

National Healthcare and Social Assistance Agenda

Subsequently, the NORA HCSA Council developed its 2009 NORA *HCSA Agenda* for the nation. The need to protect healthcare workers from sharps injuries was reflected in the Council's fourth strategic goal, "Reduce sharps injuries and their impacts among all healthcare personnel" (NORA, 2009, pg.15).Preventing infectious disease transmission was the Council's fifth strategic goal, "STOP transmission of infectious diseases in healthcare and social assistance settings among workers, patients and visitors" (NORA, 2009, pg.19). These goals remained in place when the agenda was updated in 2013 (NORA, 2013).

Federal Partners

As already noted, interactions with other parts of CDC are an extremely important aspect of NIOSH efforts to protect healthcare workers from infectious diseases and these interactions inform NIOSH efforts. NIOSH and the Food and Drug Administration (FDA) share responsibilities for certification and approval of respirators and, in efforts to better serve the public, have worked to coordinate efforts as described later in the chapter. Finally, NIOSH obtains important input during emergencies as a result of its interactions with other Federal agencies as a member of the National Response Framework's Worker Safety and Health Support Annex, a group of agencies coordinated by the Occupational Safety and Health Administration (OSHA) to assure response and recovery worker safety and health during incidents requiring a coordinated Federal response (Federal Emergency Management Agency, 2008).

National Academies

During the second decade of NORA, NIOSH sought authoritative program reviews from the National Academies on the relevance and impact of a range of NIOSH programs relevant to infectious disease transmission in healthcare workers, including the Respiratory Disease Research Program and the Personal Protective Technology Research Program. In addition, in 2005, NIOSH funded and established a Committee on PPE for the Workforce with the National Academies' IOM. Throughout the second decade of NORA, a number of National

Academies reports provided important input into NIOSH efforts to improve use of PPE to protect healthcare workers from infectious hazards (IOM, 2006, 2007a, 2007b, 2008, 2009, 2011a, 2011b, 2011c, 2015, 2017).

Activities and Outputs

NIOSH has conducted a range of activities related to occupational infectious diseases transmission, including disaster response to Ebola and H1N1 influenza; surveillance on influenza, Tuberculosis (TB), and sharps injuries; basic and applied research on influenza, TB, sharps, and personal protective equipment (PPE); translation from research to practice; and participation on consensus standard committees. Outputs, the products from these activities include guidance documents, communication products, and new technology like PPE and engineering controls.

Disease Outbreaks

Ebola

NIOSH's responses to the 2014-2016 Ebola virus disease (Ebola) epidemic in West Africa and its efforts to bolster preparedness in the U.S. illustrate its unique contributions and its important role in broader CDC and U.S. Government responses to disease outbreaks. Assuring occupational safety and health for healthcare workers is an important aspect of responses to disease outbreaks. Caring for people infected with Ebola put healthcare workers in countries affected by the epidemic at great risk. For example, a World Health Organization (WHO) report showed that health workers were between 21 and 32 times more likely to be infected than the general population (WHO, 2015). NIOSH contributed to a 2015 report noting that healthcare workers in Guinea had a 42-fold greater cumulative incidence of Ebola infection than the general adult population (Grinnell et al., 2015). Another contemporary report indicates that Ebola has killed about 8% of the healthcare workers in Liberia and about 7% in Sierra Leone (Evans, Goldstein, & Popova, 2015). Thus, improving occupational safety and health for healthcare workers was a critical need.

<u>Ebola Emergency Response</u>

An overview of the CDC response to improving infection control in healthcare settings was published in 2016 (Hageman et al., 2016). NIOSH participated in and contributed to many of the activities described in the article, including: international infection prevention and control; training U.S. healthcare workers traveling to West Africa; developing Ebola Infection Prevention Control guidance for U.S. healthcare facilities; training and educating healthcare workers in U.S. healthcare facilities; onsite technical assistance; and webinars and conference calls. NIOSH's Emergency Preparedness and Response Office led the Worker Safety and Health team as part of the Medical Care Task Force in CDC's response.

NIOSH was intensively engaged in the following response efforts to end the Ebola outbreak:

- 207 NIOSH staff supported the CDC response
- Staff worked 71,312 hours supporting the response
- 104 international deployments to five countries
- 146 domestic deployments.

International deployments supported the International Task Force and Vaccine Task Force, as well as support to the World Health Organization in developing international PPE/Infection Control recommendations. Two NIOSH staff were deployed to the Monrovia Medical Unit as part of a Public Health Service team to provide direct patient care to sick healthcare workers.

Domestic deployments primarily offered technical assistance to hospitals and state health departments. For example, when the first case of Ebola was identified in the U.S. and transmission to healthcare workers was identified, five NIOSH staff deployed to Texas to provide assistance. Staff conducted contact tracings, advised the hospital on setting up the patient care area, and assisted with training staff on PPE donning and doffing and other safe practices for caring for patients. NIOSH also participated in follow-up efforts conducted by multidisciplinary teams of medical officers, epidemiologists, and laboratory experts primarily from the CDC Division of Healthcare Quality Promotion and experts in ventilation, respiratory protection, and worker safety, primarily from NIOSH. These Rapid Ebola Preparedness teams (later known as Infection Control and Response teams) met with upper-level management and caregivers from leading hospitals to review plans in place to care for potential patients with Ebola. In total, the teams visited 81 facilities in 21 states and Washington, DC. The NIOSH staff focused on patient movement throughout the hospital, training and appropriate use of PPE, waste handling and management, and healthcare worker comfort and safety. In addition to work in healthcare facilities, NIOSH deployments were also made to the 5 airports that handled passengers coming from Ebola-affected nations in West Africa. A photobook available on the CDC website illustrates the types of work that NIOSH staff did as part of the Ebola response (CDC, 2015).

Ebola Guidance and Informational Products

NIOSH developed or made contributions to many of the products that are described in the 2016 overview of CDC efforts to improve infection control during the Ebola response (Hageman et al., 2016). The following NIOSH webpages and documents that focused on healthcare workers (additional CDC products to which NOSH made important contributions are listed in the section on intermediate outcomes on pgs.152-153):

- **NIOSH Ebola Topic Page** - Provides access to a range of resources for worker protection (NIOSH, 2014c).
- **Interim NIOSH Training for Emergency Responders: Reducing Risks Associated with Long Work Hours** - Assists response workers in caring for themselves during catastrophic events (NIOSH, 2014d).
- **The Buddy System** - This fact sheet describes the importance of deploying in two-person teams that share the responsibility for each other's safety and well-being (NIOSH, 2014e).
- **Limiting Heat Burden While Wearing Personal Protective Equipment** - This PDF copy of a PowerPoint presentation outlines prevention of heat-related illness when wearing PPE in the hot, humid conditions of the West African Ebola epidemic (NIOSH, 2014f).
- **Prevent heat-related illness** - This poster describes simple steps that healthcare workers wearing PPE for Ebola in Western Africa can take to avoid heat illness (Take time to acclimatize, stay well hydrated, watch for signs of heat-related illnesses, take time to rest and cool down) (NIOSH, 2014g).
- **Fighting Ebola: A Grand Challenge for Development – How NIOSH is Helping Design Improved Personal Protective Equipment for Healthcare Workers** - This NIOSH Science Blog post describes the Ebola Grand Challenge and NIOSH contributions to it (Shaffer, 2015).
- **Considerations for Selecting Protective Clothing used in Healthcare for Protection against Microorganisms in Blood and Body Fluids** - Provides an overview on selecting protective clothing based on their barrier properties (NIOSH 2015a).

NIOSH also partnered with OSHA during the response to develop and co-brand an information document entitled, *Preventing Worker Fatigue Among Ebola Healthcare Workers and Responders* (NIOSH & OSHA, 2014).

The document includes facts about worker fatigue and what employers and employees can do to prevent worker fatigue.

In addition to the documents noted above, various research publications document NIOSH contributions to the Ebola field response. For example, a NIOSH investigator was the first author of a publication describing the CDC response to strengthen infection control at the Texas hospital where two nurses became infected after providing care to a patient who acquired Ebola infection in Africa (Cummings et al., 2016). Another publication first-authored by a NIOSH investigator described leaks in walls separating patient compartments from driver compartments as an important hazard for ambulance workers in Sierra Leone and also described simple steps that could be taken to protect ambulance workers by waterproofing those walls (Casey et al., 2015). NIOSH also provided other prevention services, for example working to ensure that healthcare workers used the appropriate type of gowns.

Ebola Personal Protective Equipment Research

Issues related to PPE were extremely important during the Ebola response. The extreme heat and humidity in West Africa led to concerns about healthcare workers experiencing heat stroke and cognitive issues while wearing their impermeable body-covering PPE ensembles. NIOSH used its unique sweating thermal manikin and conducted tests involving human subjects to evaluate several common PPE ensembles used in West Africa and around the world to better understand factors associated with heat stress and design features that affect comfort and job performance. The evaluation findings were used to refine PPE recommendations. Data on the impact of wearing specific combinations of PPE were nonexistent prior to this work (e.g. how does putting an apron on top of a surgical gown affect heat stress?). Published research findings involving use of sweating thermal manikins confirmed that PPE ensembles utilizing coveralls with moderate to high degrees of impermeability shortened the time to reaching critical core temperatures (Coca, DiLeo, Kim, Roberge, & Shaffer, 2015). Studies involving human subjects showed that P100 filtering facepiece respirators retained better fit than N95 respirators under hot, humid conditions resembling West Africa without additional physiologic or subjective impact (Kim, Wu, Powell, & Roberge, 2016).

Concerns regarding heat and humidity during the Ebola response also led to the initiation of *Fighting Ebola: A Grand Challenge for Development*, by the U.S. Agency for International Development (USAID) in partnership with the White House Office of Science and Technology Policy, CDC, and the U.S. Department of Defense (USAID 2017). The Grand Challenge was a competition to stimulate private sector innovation to address gaps in the Ebola response, including developing fluid-resistant PPE able to protect healthcare workers from Ebola yet still be tolerable to use in hot, humid West African healthcare facilities. NIOSH helped evaluate existing PPE and offered its capabilities to evaluate innovations submitted in response to the Grand Challenge. NIOSH tested innovative PPE prototypes as well as PPE cooling systems proposed in response to the Grand Challenge as part of this evaluation effort.

To further assist the healthcare community in purchase/selection of appropriate PPE for protection from Ebola, NIOSH incorporated a PPE selection algorithm into its PPE-Info Database (NIOSH, 2015b). PPE-Info allows healthcare workers to search for existing standards such as those related to bloodborne pathogens. In addition, it provides a tab for “Medical Response Guidance” (currently only provided for Ebola, but to be updated with future outbreaks). This algorithm allows PPE purchasers/selectors to define the patient’s clinical status and the type of PPE in which they are interested (e.g., gowns). The purchaser/selector then selects from the list of relevant standards (e.g., European, U.S.) and is connected to a listing of products that make claims of conforming to these Ebola-relevant PPE standards. Through the Federal Register, NIOSH solicited feedback from the PPE community regarding the purpose and functions of this tool (NIOSH, 2013).

In addition to PPE-info, NIOSH communication products were developed to assist healthcare facilities with Ebola PPE selection. The first was on powered air-purifying respirators (NIOSH, 2014h) and the second provided guidance on gowns and coveralls (NIOSH, 2015a). NIOSH also identified several difficulties associated with the selection of isolation gowns and published NIOSH Science Blog posts to explain the role of isolation gowns and coveralls (Kilinc-Balci, 2014), the current limitations in existing standards for these PPE and the Ebola Grand Challenge (Shaffer, 2015), and NIOSH's efforts to improve those standards by working directly with standards development organizations (Kilinc-Balci and D'Alessandro, 2015).

NIOSH also performed other research addressing practical problems related to use of PPE for Ebola. For example, donning and doffing PPE were identified as activities when contamination could occur. NIOSH research showed that the simple design change of adding tabs to the straps of filtering facepiece respirators made it easier to doff the respirators without spreading contamination from hands to head (Strauch et al., 2016). In another example, CDC guidance for disinfection of gloved hands during doffing of PPE following care of a patient with Ebola involved multiple applications of alcohol-based hand rub on medical exam gloves, yet it was unknown how this would affect glove properties. NIOSH research showed that the applications reduced the tensile strength of gloves, with nitrile gloves more affected than latex. It was concluded that latex gloves and some nitrile gloves should be safe to use according to the doffing guidance (Gao, Horvatin, Niezgoda, Weible, & Shaffer, 2016). In another study, the ability of five gowns and four coveralls that might be used during management of Ebola patients to resist penetration of body fluid simulants during an Elbow Lean Test were evaluated. Swatches cut from continuous regions of one gown and two coveralls did not have any strike-through. For discontinuous regions, only the same gown consistently resisted fluid strike-through (Jaques et al., 2016). These findings underscore the importance of assessing conformity of PPE to performance standards, referred to as conformity assessment, which is discussed later in the PPE section on pg 145.

Influenza

Influenza is a well-recognized occupational hazard in healthcare and NIOSH has contributed to CDC's comprehensive, multi-faceted recommendations for prevention strategies in healthcare settings (CDC, 2016a). Typical seasonal influenza epidemics in the U.S. caused by influenza A and influenza B viruses occur in the fall and winter (CDC, 2017). Infection is generally thought to be spread when virus-carrying droplets made when people with flu cough, sneeze, or talk land in mouths or noses of people nearby. Another potential route of infection is contact transmission, in which disease is spread when a person touches an infected person (such as by shaking hands) or a surface or object that has become contaminated with virus transfers the virus by touching their own mouth, eyes, or nose. Rarely, the influenza A virus undergoes a major change called "antigenic shift." When this happens, there is little immunity to the new influenza virus in the population and rates of infection can be very high and, in some pandemics, infection can have severe consequences. For example, the 1918 influenza pandemic caused about 675,000 deaths in the U.S. and 50 - 100 million worldwide (CDC 2016b).

The most recent influenza pandemic was the 2009 H1N1 influenza pandemic. Infection with the 2009 H1N1 influenza pandemic virus was first reported in the U.S. in April 2009. It has been estimated that from April 2009 to April 2010, the pandemic caused approximately 60.8 million cases of influenza and about 12,469 deaths (Shrestha et al., 2011). Eighty-seven percent of the deaths occurred in those less than 65 years of age. A recent meta-analysis of the world literature on infection of healthcare personnel during the pandemic found an approximately 2-fold increased risk relative to the general population (Lietz, Westermann, Nienhaus, & Schablon, 2016).

NIOSH Efforts Prior to the 2009 H1N1 Influenza Pandemic

NIOSH anticipated the challenges of an influenza pandemic and funded the IOM to produce a report in 2008 entitled *Preparing for an Influenza Pandemic: Personal Protective Equipment for Healthcare Workers* (IOM, 2008). This report contained recommendations focused in three major areas: understanding influenza transmission; committing to worker safety and appropriate use of PPE; and innovation and strengthening PPE design, testing, and certification. From the standpoint of understanding influenza transmission, the report noted that much of the research on influenza transmission was very old and research was needed to evaluate the potential for airborne transmission and to better understand potential for transmission across the droplet-aerosol continuum.

Influenza Guidance and Informational Products

NIOSH was an important contributor to the overall CDC and national response to the pandemic, in particular contributing its unique expertise related to engineering controls, PPE, and occupational health issues. Direct communication with stakeholders was also an important part of the pandemic response. NIOSH coordinated weekly calls during the pandemic with various parts of CDC, OSHA, and labor stakeholders to keep them up to date on developments and to answer questions.

During the response to the pandemic, whether to recommend respiratory protection as part of the comprehensive set of interventions to protect healthcare workers was a very controversial issue. This was related to uncertainty about the relative contribution of aerosol transmission vs. other pathways of influenza transmission and to uncertainty about the effectiveness of respiratory protection in preventing transmission. Due to differences of opinion on this issue, CDC sought guidance from a committee assembled by the IOM. NIOSH participated in this process. The report issued by the committee recommended that healthcare workers in close contact with infected individuals use fit-tested N95 respirators. It also recommended increased research on influenza transmission (IOM, 2009).

Coordination between FDA and NIOSH

Implementation of the recommendation by IOM on respirator use was not simple. Supply chain shortages for PPE, especially filtering facepiece respirators (FFRs), were a significant concern (U.S. Department of Health and Human Services [DHHS], 2012). NIOSH engaged in a number of efforts during the pandemic and subsequently to address issues related to respirator supply during this type of public health emergency. For example, a key issue was that many respirators certified by NIOSH for use in workplaces are not cleared by the FDA for use in healthcare settings as medical devices. During the pandemic, NIOSH contributed to the issuance of an emergency use authorization from the FDA to allow for the deployment of some respiratory protection devices from the Strategic National Stockpile for use in protecting healthcare workers (FDA, 2009). NIOSH also established its Trusted-Source webpage (NIOSH, 2009b) to assist purchasers in finding respiratory protection approved by NIOSH and cleared by the FDA.

NIOSH is pursuing efforts with FDA to establish a unified process to regulate products used in healthcare, which was identified as desirable during the H1N1 pandemic in 2009. At the current time, in order to be certified by NIOSH and cleared by FDA, a respirator must go through both agencies. NIOSH approval focuses on ability to protect against airborne particles and the FDA clearance process focuses on issues such as flammability, fluid resistance, and biocompatibility. NIOSH funded the IOM to convene a workshop to discuss best approaches to implementing a unified approval process where all necessary testing is done by NIOSH (IOM, 2017). In follow up to the IOM report, NIOSH and the FDA are working together towards implementation.

Influenza Surveillance

NIOSH conducted and collaborated in a number of surveillance projects related to the 2009 H1N1 influenza pandemic. One such study, done collaboratively by CDC, NIOSH, and state and local health officials, evaluated healthcare workers with influenza who had likely become infected at work (Wise et al., 2011). Few reported having worn surgical masks or N95 respirators during all encounters with potentially infected patients, highlighting the need for adherence to comprehensive infection control precautions. Another report assessed the distribution of influenza by occupation and industry early in the pandemic (April to July, 2009). It found that 32% of employed, infected individuals worked in the healthcare sector (Suarthana et al., 2010).

This further supported the need for better data on PPE usage and burn rate and stockpile levels. Starting in 2008, NIOSH initiated a pilot project to gather this type of information, starting with the respirator as the prototype PPE and airborne pathogens as the model hazard. Initial efforts focused on identifying standardized metrics that reflect current hospital policies, standards, and guidelines for respirator use and consider how data from sentinel hospitals can be harmonized to develop a national surveillance system for PPE (Yarbrough et al., 2016). The system was originally pilot tested at Vanderbilt University and later expanded to four locations. NIOSH awarded a three-year contract to Vanderbilt University in August 2015 to expand the current project to incorporate Ebola PPE and evaluate PPE monitoring across 15-20 hospitals (NIOSH, 2016a).

NIOSH also participated with CDC in a series of surveys to estimate influenza vaccine coverage among healthcare personnel. These surveys sampled an opt-in internet panel of healthcare personnel. The most recent survey estimated 79% coverage of healthcare personnel during the 2015-2016 influenza season, similar to the 77% coverage during 2014-2015 (Black et al., 2016) but increased from 63.5% rate reported for the 2010-2011 season (Harris et al., 2011). A 2012 report identified nursing home assistants as an important target for influenza vaccination, with vaccination rates estimated to be about 37% in a survey conducted in 2004 (Groenewold, Baron, Tak, & Allred, 2012).

Basic Research on Influenza

Improving basic knowledge of how influenza is transmitted has repeatedly been identified as an important research priority, even before the 2009 H1N1 influenza pandemic (IOM, 2008). In response to this need, NIOSH has undertaken an extensive body of research to better understand influenza aerobiology and the potential for aerosol transmission. Some of this work is reviewed on the NIOSH *Influenza in the Workplace* Topic Page (NIOSH, 2017). What follows is a brief overview describing examples of the NIOSH work that has been published.

One line of work sought to measure influenza aerosols in clinical settings and generated by adults with active influenza infection. A new methodology for using a novel cyclone-based, 2-stage bioaerosol sampler for collection and size fractionation of influenza-containing aerosols, with subsequent quantification of virus by quantitative reverse transcription polymerase chain reaction was published in 2007 (Blachere et al., 2007). Investigators at West Virginia University who had successfully competed for funding under the NIOSH funding opportunity announcement *Prevention of Airborne Infections in Occupational Settings* (NIOSH, 2006) collaborated with NIOSH researchers to use this methodology to investigate levels of airborne virus in an emergency department and an urgent care clinic operated by West Virginia University (Blachere et al., 2009; Lindsley et al., 2010a). Both studies found that the highest concentrations of influenza RNA were detected in places where, and during times when, the number of influenza patients was highest. The studies also found that 42% to 53% of the influenza viral RNA was contained in airborne particles less than 4 µm in aerodynamic diameter (the respirable size fraction). Another study using this methodology evaluated influenza virus in cough-generated aerosol particles from people with influenza. Thirty-five percent of viral RNA was associated with particles greater than 4 µm in aerodynamic diameter, 23% with particles 1 to 4 µm, and 42% with particles less

than 1 µm (Lindsley et al., 2010b). Because of concerns that viral RNA detected by RT-PCR might not reflect viable virus capable of transmitting infection, methods were developed to assay samples collected with the bioaerosol sampler for viable, infectious influenza (Cao, Blachere, Lindsley, Noti, & Beezhold, 2010; Blachere, Cao, Lindsley, Noti, & Beezhold, 2011). These methods were then applied to measure infectious influenza aerosols generated by subjects with influenza during coughs (Lindsley et al., 2015) or coughs vs. exhalations (Lindsley et al., 2016). These studies showed that coughs and exhalations were both able to generate aerosols containing small potentially inhalable particles containing infectious influenza virus.

Another set of studies used a model system with a coughing manikin and a breathing manikin in an environmental chamber to perform controlled experiments to study the behavior of airborne influenza virus and the performance of various types of PPE to protect the breathing manikin from the coughing manikin (Lindsley et al., 2012; Lindsley, Reynolds, Szalajda, Noti, & Beezhold, 2013). An example of aerobiology research performed using this system includes a study showing that high humidity (40%-45%) inactivates virus aerosolized by the coughing manikin and low humidity (20%-25%) improves survival (Noti et al., 2013). An example of a study used to evaluate protection of the breathing manikin showed that a poorly fitted respirator performed no better than a medical mask (Noti et al., 2012). Another study showed that face shields can substantially reduce exposure to large infectious aerosol droplets, but smaller droplets can flow around the face shield and be inhaled (Lindsley et al. 2014).

Influenza Intervention Research

Even if basic aerobiology studies suggest a role for aerosol transmission as one possible pathway of influenza transmission, there are still reasons why interventions to reduce airborne transmission through use of respiratory protection might not provide incremental benefit over other preventive measures. For example, healthcare workers might not know that a patient, visitor, or co-worker in a healthcare setting is infected and thus might not wear respiratory protection when it is needed. Or perhaps the protection factor of 10 offered by a fitted disposable N95 respirator might not be enough to protect against infection. It is also possible that since PPE are usually used as only one aspect of a comprehensive set of preventive interventions, the incremental benefit to using N95 respirators over face masks might be too small to demonstrate. In addition, influenza can be acquired in the community outside of work settings, making it difficult to demonstrate the impact of workplace interventions. Perhaps for reasons such as these, and because an authoritative study focused on the intervention effectiveness of respiratory protection to prevent workplace transmission of influenza would be difficult to design and execute, a recent Cochrane Review found that only limited, low-quality evidence existed supporting the effectiveness of using N95 respirators to protect against transmission of infectious disease (Jefferson et al., 2011).

In order to critically evaluate whether using N95 FFRs provides substantial incremental benefit over using face masks as part of a comprehensive program to prevent acute respiratory illness (including influenza) in healthcare workers, NIOSH partnered with other parts of CDC, the Veterans Administration and Johns Hopkins University to support the Respiratory Protection Effectiveness Clinical Trial (ResPECT) (Radonovich et al., 2016). The study is a prospective, multi-season, cluster-randomized comparative effectiveness clinical trial conducted at seven study sites, including three university-based medical centers (Johns Hopkins Health System, Denver Health, and Denver Children's' Hospital) and four VA Health Systems (New York, NY; Denver, CO; Houston, TX; and Washington, DC). ResPECT enrolled approximately 5,000 human subjects. Data collection was completed in August of 2015 and publication of the results of this large randomized prospective controlled trial is anticipated in the near future.

Extended use and re-use of disposable N95 respirators have been proposed as a way to extend supplies under conditions of shortage (NIOSH, 2014i). Extended use refers to continuously wearing a respirator across serial patient encounters, without removal or re-donning between encounters. Re-use refers to removing the

respirator and re-donning between encounters. Both of these practices are associated with potential for contamination of the respirator and re-use may have greater risk of self-contamination from touching the respirator for donning and doffing with each encounter. An IOM recommendation in 2006 (IOM, 2006) suggested re-using FFRs in conjunction with medical masks (also known as surgical masks) worn over the FFRs to prevent surface contamination (with the medical masks discarded during each doffing) (Sinkule, Powell, & Goss, 2013).

Implications of potential approaches to extended use and re-use of disposable N95 respirators were critically evaluated in a series of NIOSH studies. NIOSH evaluated the effect of wearing a medical mask over an FFR on breathing quality and resistance and found that it had minimal effect on physical work performance. However, the medical mask did prevent the opening of exhalation valves, and NIOSH recommended against this practice when using FFRs with these valves (Roberge et al., 2010; Sinkule et al., 2013). NIOSH also explored issues related to FFR contamination and decontamination, developed disease transmission models, and compared the effectiveness of the FFR to medical masks for influenza hazards (Fisher, Williams, & Shaffer, 2010; Fisher & Shaffer, 2010; Fisher & Shaffer, 2011; Fisher & Shaffer, 2014; Fisher, Noti, Lindsley, Blachere, & Shaffer, 2014). This analysis suggested that pathogen- or event-specific information must be considered as part of the decision to implement FFR reuse or extended use practices. NIOSH defined the factors that should be considered (e.g., potential for self-inoculation, potential for secondary exposures) and determined that extended use of FFRs should be the *generally* preferred practice due to self-inoculation concerns. NIOSH further concluded that hospital administrators should ensure that all staff are re-trained on proper donning and doffing procedures if a re-use practice is implemented. Finally, NIOSH evaluated whether or not FFR extended use causes a virus to become re-aerosolized, which could infect other patients (Fisher, Richardson, Harpest, Hofacre, & Shaffer, 2012). It was determined that this risk was minimal; however, risk assessment must be updated as new viruses emerge. NIOSH produced a comprehensive review article (Fisher and Shaffer 2014) and web page (NIOSH, 2014i) to outline the scientific basis and to disseminate the new recommendations. NIOSH also developed a detailed web page to cover extensive research and findings from this work that produced over 16 peer-review manuscripts (NIOSH, 2016c).

Field Studies

Health Harzard Evaluations (HHE) are investigations of potential workplace hazards by NIOSH at the request of employers, workers, or their representatives. An HHE carried out by NIOSH during the pandemic was in response to a direct request from the California Occupational Safety and Health Administration regarding fit concerns for a specific respirator model being used to protect healthcare workers from exposure to H1N1. NIOSH evaluation of the stockpiled respirator model included performance testing and human subjects testing of the stockpiled product. The investigation found no issues or concerns of non-compliance (Berry Ann, 2010).

Another HHE report and subsequent journal publication evaluated an outbreak of pandemic 2009 H1N1 influenza in an internal medicine residency program (de Perio, Brueck, & Mueller, 2010; de Perio et al., 2012a). It identified the importance of knowledge and adherence to recommended infection control practices, including use of PPE and work restrictions for ill health care personnel.

Tuberculosis

TB continues to be an important global health issue, killing nearly 2 million people per year (Cummings, 2007). People with active pulmonary TB transmit it to others via small aerosol particles and airborne transmission. After inhaling *Mycobacterium tuberculosis*, most people are able to control but not eliminate the infection. They are asymptomatic and non-infectious and said to have latent TB infection (LTBI). People with LTBI are diagnosed with tests that identify cell-mediated immunity to TB such as the tuberculin skin test and various interferon-

gamma releasing assays. Over time, some people with LTBI are no longer able to control the infection and develop reactivation disease, often presenting as cavitary pulmonary tuberculosis. Identifying people with LTBI and treating their latent infection is an important way to prevent reactivation disease. The emergence of multi-drug resistant TB, extensively drug-resistant TB, and pandrug-resistant TB have been important emerging issues, making primary prevention of disease transmission all the more important.

Burden of Tuberculosis on Healthcare Workers

Healthcare workers are put at risk for TB by coming into contact with people who have active TB. NIOSH funded researchers at the state of Washington's Department of Labor and Industries evaluated tuberculin reactivity in non-hospital healthcare workers based on tuberculin reactivity claims and found that incidence rates were highest for offices and clinics of medical doctors (3.7 per 10K fulltime equivalents [FTE]) followed by medical laboratories (2.6 per 10K FTE)(Shah, Ross, Chotani, Arif, & Neudorf, 2006b). A review of transmission in long-term care facilities suggested that workers in these facilities had a 3-fold increase in TB case rates compared to other jobs (Jackson et al., 2015). In comparison, the risk from TB is much higher for healthcare workers in high-incidence countries such as South Africa. A NIOSH funded study found an LTBI incidence rate of 29 cases per 100 person-years in South African healthcare workers (McCarthy et al., 2015).

Tuberculosis Field Studies

Prevention of occupational TB transmission to healthcare workers is accomplished via comprehensive TB prevention programs that combine administrative controls such as quickly identifying and isolating TB cases, implementing engineering controls such as ventilation and air disinfection with ultraviolet germicidal irradiation (UVGI), PPE use for respiratory protection, and medical screening and surveillance for LTBI with treatment when LTBI is identified. Detailed prevention guidelines were published by CDC in 2005, just before the start of the second decade of NORA (Jensen, Lambert, Lademarco, & Ridzon, 2005). NIOSH was very engaged in developing certain parts of the guidelines, particularly those related to engineering controls and respiratory protection.

During the second decade of NORA, one way NIOSH assisted in implementation of these established prevention guidelines was through HHEs. One evaluated a TB outbreak at a hospital (de Perio & Niemeier, 2012e; de Perio & Niemeier, 2014) and another evaluated ventilation controls at a hospital (Niemeier, 2013). A TB outbreak was also evaluated at a long term care facility (de Perio & Niemeier, 2013). In all three studies, NIOSH found multiple employees with TB and made specific recommendations that reinforced the CDC guidelines, such as ensuring regular screenings and upgrading ventilation systems.

Intervention Research

NIOSH also supported research to improve occupational TB prevention for healthcare workers. A NIOSH-funded investigator at Brigham and Women's Hospital developed a unique research unit at an inpatient TB ward in a South African hospital. Guinea pigs were continuously exposed to air exhaust from a 6-bed multi-drug resistant TB (MDR-TB) ward. Guinea pigs are susceptible to TB and were demonstrated to develop TB disease paralleling human illness when exposed to the contaminated air exhaust (Dharmadhikari et al., 2011). The system was used to demonstrate that effective treatment of MDR-TB patients rapidly made them non-infectious, supporting the importance of rapid identification, isolation, and treatment of such patients (Dharmadhikari et al., 2014). Another study evaluated the impact of deploying upper-room UVGI with air mixing in MDR-TB patients' rooms. Upper room UVGI is a practical and relatively low-cost intervention; several years earlier NIOSH had published guidelines for use of UVGI to protect against TB transmission in healthcare settings (NIOSH, 2009d). However, little research had addressed its ability to prevent MDR-TB transmission from TB patients in actual healthcare settings. Upper-room UVGI with air mixing was found to be highly effective in reducing MDR-TB transmission from patients to guinea pigs receiving air exhaust from their inpatient ward (Mphaphlele et al., 2015).

An important development in medical screening and surveillance for LTBI during the second decade was the emergence of blood tests called interferon-gamma releasing tests as an alternative to tuberculin skin testing. NIOSH published two studies demonstrating use of interferon-gamma releasing tests for LTBI screening of workers (Cummings et al., 2009; de Perio, Niemeier, & Groenewold, 2011).

Sharps Injuries and Bloodborne Pathogens

Medical sharps injuries are an important occupational risk for healthcare workers. Overshadowing the injuries themselves is the risk that they pose for transmission of bloodborne pathogens such as HIV, HBV, and HCV from infected patients to healthcare workers. The magnitude of the issue was described in a chapter of the *State of the Sector* report (NIOSH, 2009c). At the time, there had been 57 documented cases of occupational HIV transmission to U.S. healthcare workers and it was estimated that there were less than 500 HBV cases per year and 50-150 transmissions of HCV per year. It was also noted that the actual number of needlestick and percutaneous injuries sustained by healthcare workers could not be determined due to under-reporting and lack of a national surveillance structure. However, using available data sources, it was estimated that there were about 385,000 percutaneous injuries in U.S. hospital-based healthcare workers alone each year. A NIOSH-funded economic analysis early in the second decade of NORA estimated 644,963 needlestick injuries in the healthcare industry in 2004 with combined medical and work productivity costs of $188.5 million (range $100.7 million to $405.9 million) (Leigh et al., 2007).

Burden of Sharps Injuries and Bloodborne Pathogens on Healthcare Workers

NIOSH conducted a number of studies to better characterize the burden of sharps injuries and transmission of bloodborne pathogens to healthcare workers. Two reports arose from a study evaluating data from the NIOSH National Electronic Injury Surveillance System, which tracks treatment provided by a sample of U.S. hospital emergency departments. The first report found that about 78,000 potential work-related exposures to bloodborne pathogens were treated annually in U.S. hospital emergency departments (Chen & Jenkins, 2007a). Hospitals accounted for 75% of these exposures, with rates of 11.3 per 1,000 FTE, following by nursing homes (2.8) and residential care facilities without nursing (1.9). Registered nurses had the highest exposure rate (15.3 per 1,000 FTE) followed by clinical laboratory technologists and technicians (13.9) and physicians (7). The second report described findings from follow-up phone interviews with treated healthcare workers. It found that sharps injuries were the primary source of bloodborne pathogen exposure in hospitals and non-hospital healthcare settings, while skin and mucous membrane was the primary route of exposure to emergency medical service/firefighting workers (Chen & Jenkins, 2007b). Another NIOSH study involving analysis of mortality data indicated that employment in the healthcare industry was associated with increased risk for death from HIV, HBV, and cirrhosis among men and HCV among men and women (Luckhaupt & Calvert, 2008).

A series of NIOSH-funded surveys conducted by the Massachusetts Department of Public Health in acute care hospitals from 2002-2007 showed a decline in the sharps injury rate of 22% over that time (Laramie, Pun, Fang, Kriebel, & Davis, 2011). A subsequent report from these investigators indicated that in 2010, 53% of Massachusetts sharps injuries were associated with devices without sharps injury prevention features, indicating opportunities for improvements (Laramie et al., 2012).

Another NIOSH-funded study conducted by investigators at the Harvard School of Public Health at two large academic hospitals in Boston linked data from occupational health services and human resources. It found that aides had sharps injury rates matching or greater than nurses (Boden et al., 2012). A follow-up from these same two academic hospitals over a 12 month period found that only 28 of 78 sharps injuries reported by healthcare

workers in a survey appeared in the Occupational Health Services' databases, suggesting marked under-reporting (Boden, Petrofsky, Hopcia, Wagner, & Hashimoto, 2015).

Several NIOSH-funded studies addressed risk factors for sharps injuries in hospitals. In a case-cross over study conducted at five academic medical centers in the U.S. and Canada by researchers at Beth Israel Deaconess Medical Center, fatigue was associated with a 3-fold increase in injury rates among medical trainees (Fisman, Harris, Rubin, Sorock, & Mittleman, 2007). A subsequent study published by this group evaluated healthcare workers from thirteen medical centers in the U.S. and Canada who presented to employee health clinics after sharps injuries. It found a marked reduction in injury risk associated with glove use (incidence rate ratio 0.33, 95% confidence intervals 0.22-0.50) (Kinlin, Mittleman, Harris, Rubin, & Fisman, 2010). A 10-year retrospective cohort study conducted by researchers at Duke University, in a large academic teaching hospital to examine the risk of percutaneous blood and body fluid exposures occurring in operating rooms, found the rate of percutaneous blood and body fluid exposures in surgical procedures to be 6.3 per 1,000 procedures (Myers et al., 2016a). Risk increased with estimated patient blood loss, number of personnel working in the surgical field, and procedure duration. These relationships were stronger for suture needle-related exposures. Researchers found that sharps-related blood and body fluid exposures were lower in surgical teams with greater stability in their members (Myers et al., 2016b).

Sharps Injuries and Bloodborne Pathogens among Home Healthcare Workers

Home care and home healthcare are some of the fastest growing industries in the U.S., but present many challenges likely to increase the risk for sharps injuries (Chalupka, Markkanen, Galligan, & Quinn, 2008). In one large cross-sectional study by NIOSH grantees at Columbia University Health Sciences, lack of compliance with standard precautions, recapping needles, exposure to household stressors or violence, mandatory overtime, and safety climate were all significantly related to percutaneous injuries in home healthcare registered nurses (Gershon et al., 2009). In 2003, NIOSH published a targeted grant announcement to fund research on *Incidence of Needlestick and Sharps Injuries and Medical Safety Device Availability/Use among Non-Hospital Health Care Workers* (NIOSH, 2003). As a result of funding from this announcement, investigators at the University of Massachusetts Lowell (Quinn et al., 2009) used a questionnaire survey and workplace-based surveillance and at the Center for Health Research, Constella Group, Durham NC used mail surveys (Leiss et al., 2009a; Leiss, 2012) to document the substantial problem posed by sharps injuries in home settings. The group at University of Massachusetts Lowell also documented the usefulness of aggregating sharps injuries, blood and body fluid exposures, and near misses to improve the ability to assess risk factors. Using this approach showed increased risk for part-time and temporary home healthcare aides as compared to full-time aides (Kim, Kriebel, Quinn, & Davis, 2010). Another study funded under the grants announcement supported work by researchers at the University of Maryland Baltimore. Examples of their publications included a survey showing increased risk of blood and body fluid exposure among unlicensed personal care assistants as compared to home care registered nurses (Lipscomb et al., 2009). They also reported a cross-sectional survey of home care aides working for two agencies in the Chicagoland area. Performing healthcare-related tasks such as colostomy care, caring for a urinary catheter, or bowel stimulation and caring for clients needing higher levels of assistance were significantly associated with risk for blood and body fluid exposure (Amuwo, Sokas, McPhaul, & Lipscomb, 2011a). They also reported on the impact of interventions. Educational interventions, including an information card for home care aides and sharps safety magnet for clients (Amuwo, Sokas, Nickels, Zanoni, & Lipscomb, 2011b) and an interactive training program (Amuwo, Lipscomb, McPhaul, & Sokas, 2013), were shown to be useful for transmitting information about bloodborne pathogen exposure and sharps safety and improving the use of sharps disposal containers.

Sharps Injuries and Bloodborne Pathogens in Non-hospital Settings

A number of intramural and extramural studies documented sharps injury risk outside of hospitals, including non-hospital based registered nurses (Gershon et al., 2007a), pharmacy employees (de Perio, 2012b), correctional healthcare workers (Gershon et al., 2007b; Lehman, Huy, Viet, & Gomaa, 2012) and dental settings (Shah, Merchant, & Dosman, 2006a). Dental settings were also evaluated through a partnership between NIOSH and the Organization for Safety, Asepsis, and Prevention (OSAP), a non-profit organization focused on improving compliance with science-based dental infection and safety practices. NIOSH and OSAP conducted a national survey of dental practices across the U.S. to identify levels of adherence to recommended to requirements for preventing transmission of bloodborne pathogens. The report is currently in press (Laramie, Bednarsh, Isman, Boiano, & McCrone, in press). Lack of adherence to requirements for preventing transmission of bloodborne pathogens was common. For example, 28% of practices lacked a written site-specific exposure control plan and half of those had no plans to implement one in the next 12 months. Sixty five percent did not use needles with sharps injury prevention features. Fifteen percent did not offer HBV vaccine to employees and another 8% were unsure. Thus, there are many opportunities for improved prevention in dental practices.

Sharps Injury Intervention Research

"Stop Sticks" Campaign

NIOSH made materials available to the public for the *Stop Sticks* campaign in 2011 (NIOSH, 2011b). The "Stop Sticks" campaign seeks to motivate healthcare workers, strengthen safety culture, and encourage use of safe sharps and best prevention practices. The materials were developed and tested with partners, including the Palmetto Health Alliance, Dorn VA Hospital, CM Tucker Nursing Care Center, the South Carolina Department of Health and Environmental Control, PHT Services, Ltd., the Association of Professionals in Infection Control, the University Of South Carolina School Of Public Health, the South Carolina Nurses Association, and health care employers in Columbia, SC. Materials were developed primarily for operating room and emergency department audiences, but other appropriate audiences include clinical and non-clinical health care workers and health care administrators in hospitals, doctor's offices, nursing homes, and home health care agencies.

Preventing Needlestick Injuries Toolkit

NIOSH is also engaged in international efforts to prevent sharps injuries and occupational transmission of bloodborne pathogens (Lioce, Alarcon, & Wilburn, 2009). In 2005, NIOSH and The World Health Organization (WHO) developed a toolkit entitled, *Protecting Healthcare Workers: Preventing Needlestick Injuries Toolkit* (WHO, 2006). In 2007, NIOSH and the World Health Organization (WHO) collaborated with the Pan American Health Organization to adapt and translate the toolkit into Spanish and use it in a project to prevent sharps injuries in Venezuela (NIOSH, 2016b). A survey conducted in Venezuela showed great need for this work, finding that half of healthcare workers had suffered at least one needlestick injury in 2006, mostly when recapping needles after injection. More than 80% of injuries were never reported and about 35% of the healthcare workers were not immunized against HBV (NIOSH, 2016b). The work done by Venezuelan investigators and its impact is described in the section on Intermediate Outcomes on pg.153.

Needlestick Safety and Prevention Act Evaluation

Early in the second decade of NORA, NIOSH funded research to evaluate the impact of the Needlestick Safety and Prevention Act of 2000 and the subsequent update in 2001 of OSHA's Blooodborne Pathogens Standard (OSHA, 2001), which was required by the Act. OSHA's new requirements for employers included updating or creating a bloodborne pathogens exposure control plan; evaluating and implementing "safer medical devices" with engagement of frontline healthcare workers in the evaluation and selection process; continuously

monitoring the effectiveness of engineering controls; and providing bloodborne pathogen training. Evaluators utilized data from the Exposure Prevention Information Network (EPINet), a multi-hospital sharps injury database maintained by the International Healthcare Worker Safety Center at the University of Virginia, Charlottesville. Three reports documented marked reductions in sharps injury rates after implementation of the new requirements (Jagger, Perry, Gomaa, Kornblatt, & Phillips, 2008; Phillips, Conaway, & Jagger, 2012; Phillips, Conaway, Parker, Perry, & Jagger, 2013). Sharps disposal-related injury rates also markedly declined (Perry, Jagger, Parker, Phillips, & Gomaa, 2012). However, analysis of EPINet percutaneous injury surveillance data from 87 U.S. hospitals from 1993 through 2006 found that there was a difference between non-surgical settings and surgical settings. While injury rates in nonsurgical settings dropped by 31.6% after the legislation, rates in surgical settings increased by 6.5%. Most injuries were caused by suture needles (43.4%), scalpel blades (17%), and syringes (12%) (Jagger, Berguer, Phillips, Parker, & Gomaa, 2010). Surgeons and residents were most often the users of the devices and nurses and technicians were most often injured by the devices used by others.

Preventing Sharps Injuries in Surgical Settings

Interventions are available to help reduce risk to surgical personnel associated with intraoperative percutaneous injuries. Researchers at the NIOSH-funded Johns Hopkins Education and Research Center found that they were able to prospectively identify general surgical procedures appropriate for use of sharpless techniques such as tissue adhesive, electrocautery, tissue staplers, and minimally invasive instrumentation and were able to complete those procedures without using sharps in 87% of cases (Makary et al., 2006). NIOSH and OSHA jointly issued a Safety and Health Information Bulletin in 2007 (revised in 2008) to raise awareness that the use of blunt suture needles where appropriate (such as for suturing fascia) can substantially reduce or eliminate sharps injuries from surgical needles (NIOSH, 2008). A follow-up joint communication urging appropriate use of blunt-tip suture needles was issued by FDA, NIOSH, and OSHA in 2012 (FDA, NIOSH, OSHA, 2012).

Occupational Health Safety Network

NIOSH is starting a new effort in 2017 to add sharps injury monitoring capability into its Occupational Health Safety Network (OHSN; NIOSH, 2017b). OHSN is a free, innovative, web-based injury and exposure monitoring system created for healthcare facilities. Occupational health nurses and medical directors helped develop OHSN to ensure the system meets the needs of its users. OHSN enables participating facilities to analyze worker injury and exposure data that they already collect. Trends for injuries and hazardous exposures can be tracked over time and visualized using the OHSN chart function. The system examines three types of injuries (patient handling; slips, trips and falls; and workplace violence) and will now have the newly added capacity to monitor exposures to blood or body fluids (from sharps injuries or other types of exposures to blood/body fluids). Potential benefits to facilities participating in OHSN include: improved ability to identify how injuries and exposures occurred, track injury and exposure trends over time, objectively measure the impact of interventions by monitoring trends over time, gain access to innovative intervention tools developed by NIOSH and other OHSN participating facilities, and generate injury and exposure data reports to meet OSHA regulatory and The Joint Commission accreditation requirements.

Outreach

NIOSH has produced informative, educational materials related to sharps injuries and bloodborne pathogens. These include the following:

- **Protect yourself. Protect your family. Protect the public. Read, wear, and report** - This poster is targeted to healthcare workers in correctional facilities. It is not detailed, and meant to reinforce major

points on how healthcare workers in correctional settings can protect themselves from exposures to bloodborne diseases (NIOSH, 2007a).

- **Protect yourself. Protect your family. Protect the public. Bloodborne pathogen exposure** - This poster is targeted to healthcare works in correctional facilities. It provides more details on how healthcare workers in correctional settings can protect themselves from exposures to bloodborne pathogens (NIOSH, 2007b).
- **Protect your employees with an exposure control plan** - This brochure is targeted to medical service administrators and supervisors in correctional healthcare settings. It provides information for establishing exposure control plans (NIOSH, 2007c).
- **Encourage your workers to report bloodborne pathogen exposures** - This brochure is targeted to medical service administrators and supervisors in correctional healthcare settings. It provides information to help improve reporting of bloodborne pathogen exposures by workers (NIOSH, 2007d).
- **NIOSH fast facts, home healthcare workers: how to prevent needlestick and sharps injuries** - This short fact sheet is targeted to home healthcare workers and employers. It provides information on preventing needlestick and sharps injuries in home healthcare workers (NIOSH, 2012b).

Engineering Controls

NIOSH is unique among the various parts of CDC for its expertise in industrial hygiene and engineering controls relevant to preventing transmission of infectious diseases in healthcare facilities. Ventilation controls are the primary engineering controls used to protect against disease transmission by infectious aerosols. For example, airborne infection isolation rooms (AIIRs) are a critical component of efforts to isolate contagious patients with aerosol-transmissible diseases and having sufficient availability of AIIRs during disease outbreaks is an important need. NIOSH investigators have published a number of studies seeking to improve the technology of AIIRs and to provide other ventilation controls. One NIOSH investigation evaluated 67 AIIRs across the U.S. and used the data collected to develop a simple model based on air flow and pressure differential that can be used to assist in designing AIIRs that perform appropriately (Hayden, Earnest, & Jensen, 2007). NIOSH also modeled airflow patterns in an AIIR and a traditional patient room and evaluated aerosol dispersion from patient coughs. NIOSH researchers documented issues associated with incomplete air mixing in rooms and the importance of considering ventilation arrangement and flow path in design of AIIRs (Ghia et al., 2012).

Computational fluid dynamics were used by NIOSH researchers to model distribution of cough aerosol in an AIIR and showed the ventilation configuration had an important impact on cough aerosol dispersion in the room (Thatiparti, Urmila, & Mead, 2016). A review of experimental studies of AIIRs concluded that the most crucial issue was to minimize escape of contaminated air and that efficient containment could be achieved even with simple and inexpensive construction by considering pressure differential and air flow patterns. It also noted the importance of airflow direction in the AIIR (Hyttinen et al., 2011). Innovative research published in 2012 documented NIOSH efforts to develop expedient airborne isolation units that could be easily be constructed from off-the-shelf materials and high efficiency particulate air (HEPA) filtration systems to provide surge capacity should existing AIIRs in healthcare facilities be overwhelmed by a disease outbreak (Mead, Feng, Hammond, & Shulman, 2012). Another innovative ventilation control solution reported by NIOSH investigators was a portable ventilated hospital bed headboard with a HEPA filter/fan system that could be used a local exhaust ventilation control for potentially contagious patients (Dungi, Ghia, Mead, & Gressel, 2015).

UVGI is another engineering control that can be used to limit transmission of infection. As already described in the section on TB research on pg.136, upper room UVGI can be used as a supplement to ventilation controls to

reduce disease transmission by infectious aerosols. NIOSH intramural investigators developed and published a method to measure UV dose delivered to airborne microorganisms, an important consideration in using upper room UVGI (Schafer, Kujundzic, Moss, & Miller, 2008). However, in addition to delivering adequate dose to inactivate airborne infectious agents, it is important not to over-expose healthcare workers to UV radiation, an issue addressed in a NIOSH HHE (Sylvain & Tapp, 2009). NIOSH funded investigators at the Brigham and Women's Hospital evaluating use of upper room UVGI to prevent transmission of TB (described on pg.137) have also worked to improve UVGI technology. They have published a study seeking to improve the method for measuring UV radiation dose delivered to room occupants (Milnova, Rudnick, McDevitt, & Nardell, 2016) and have developed a modified upper room UVGI system called eggcrate upper room UVGI as a modification to conventional systems for better germicidal efficacy without increased UV exposure to room occupants (Linnes et al., 2014; Rahman, Rudnick, Milonova, McDevitt, & Nardell, 2014).

NIOSH intramural investigators worked with extramural investigators at the University of Oklahoma to assess the potential for contamination of healthcare settings from plumes created by flush toilets. In one study, aerosols generated by toilet flushes were evaluated (Johnson et al. 2013a). High energy toilets such as the direct-connect flush-o-meter models specified in U.S. Hospital Building Guides were found to generate higher amounts of droplet and droplet nuclei contamination than lower-energy toilets. Small droplet nuclei were generated with the potential to remain airborne for prolonged periods. A literature review identified other studies documenting generation of potentially infectious aerosols through toilet flushing (Johnson et al., 2013b). Follow-up studies assessing potential for dissemination of *Clostridium difficile* are in progress.

Personal Protective Equipment

As evidenced in previous sections, issues related to the use of PPE, particularly respiratory protection for prevention of occupational transmission of infectious disease to healthcare workers have played a critical role during disease outbreaks.

Fit

Under the OSHA respiratory protection standard, workers (including healthcare workers) in respiratory protection programs must undergo annual fit testing if the respirators that they use rely upon having a facial seal, as is the case for the N95 filtering facepiece respirators often used in healthcare settings [29 CFR 1910.134(f)(2)]. Insufficient scientific literature evaluating the necessity of fit testing led NIOSH to conduct research to address this knowledge gap. NIOSH followed a cohort of 229 subjects over three years, looking at the relationship between respirator fit over an extensive period of time and the change in facial dimensions, as could be caused by weight gain or loss. The study results supported the utility of annual fit testing and the fit testing of any employee who has undergone an obvious change in body weight. NIOSH found that many of the subjects that experienced >20 pounds of weight loss no longer maintained acceptable fit (Zhuang et al., 2016).

Since this need for fit testing has been demonstrated, it would be useful if respirators fit individuals out of the box without having to fit test each individual with multiple models to find one with good fit. Recognizing this need, NIOSH developed anthropometric databases of face sizes and shapes of workers in the U.S. and China (Zhuang & Bradtmiller, 2005a; Zhuang, Coffey, & Ann, 2005b; Du et al., 2008; Zhuang, Benson, & Viscusi, 2010a; Zhuang, Landsittel, Benson, Roberge, & Shaffer, 2010b; Yu et al., 2012) and human-like headforms (IOM, 2007b; Dai, Yang, & Zhuang, 2011; Lei, Yang, & Zhuang, 2012; Bergman et al., 2014; Lei et al., 2014a; Lei, Yang, & Zhuang, 2014b). These efforts will enable studies to further understand the factors that influence fit and provide a basis for documenting what types of faces a particular respirator will fit.

NIOSH was also the first to publish study findings that demonstrate a positive correlation of respirator fit between a headform and test subjects. In fact, the paper that resulted from this study was recognized with the John White award from the American Industrial Hygiene Association Respiratory Protection Committee for the best respirator paper in 2015 (Bergman et al., 2015). This study was important because it documented the plausibility of testing the fitting characteristics of respirators with headforms instead of human subjects. To further improve required standards for fitting characteristics of respirators, NIOSH has engaged with the American National Standards Institute (ANSI) and the American Society of Safety Engineers (ASSE) to develop a consensus standard for human subjects fit testing to ensure that certified respirators/families of respirators are capable of fitting a specified percentage of their intended user population. The new draft standard, ANSI/ASSE Z88.15, is projected to be submitted for ANSI approval by the end of 2017.

Comfort and Next-Generation Respirators

Issues such as comfort and interference with communication have been raised as important barriers to healthcare workers using respirators. To address these issues, NIOSH partnered with the Department of Veterans Affairs (VA) on Project BREATHE (Better Respirator Equipment using Advanced Technologies for Healthcare Employees). This project sought to develop and shepherd new respirators customized to the needs of healthcare workers into the U.S. healthcare workplace (Department of Veterans Affairs [VA], 2009). During Phase 1 of Project BREATHE, co-leading with the VA, NIOSH convened an interagency working group involving nine Federal agencies and departments that conducted a comprehensive assessment of future respiratory protection needs of U.S. healthcare workers. Twenty-eight desirable performance characteristics for next-generation respirators were identified, falling into four key themes: they should perform their function safely and effectively; they should support, not interfere, with occupational activities; they should be comfortable and tolerable for the duration of wear; and respiratory protective programs should comply with federal/state standards and guidelines and local policies (Gosch et al., 2013).

During Phase 2, NIOSH independently developed methods to evaluate the next generation of respirators for U.S. healthcare (Roberge, Benson, & Kim, 2012a; Roberge, Niezgoda, & Benson, 2012b; Roberge, Kim, & Coca, 2012c; Roberge, Kim, & Benson, 2012d; Roberge, Kim, & Benson, 2012e; Roberge, 2012; Niezgoda, Benson, Eimer, & Roberge, 2013a; Niezgoda, Kim, Roberge, & Benson, 2013b; Roberge et al., 2013), which also included considerations for certain special populations relevant to healthcare, for example pregnant women (80% of U.S. healthcare workers are women) and people with Asian facial characteristics (often difficult to fit with current respirators)(Roberge, Kim, & Powell, 2014; Yu et al., 2014; Roberge, Kim, Palmiero, & Powell, 2015). Shaffer et al. (2014) identified seven of the Project BREATHE characteristics to be tested to quantify performance of a new "B95" respirator, which would better meet the performance characteristics for next-generation respirators described above than current N95 filtering facepiece respirators.

During Phase 3, NIOSH and the VA collaborated with 3M and Scott Safety Corporations (using a Cooperative Research and Development Agreement) to develop prototype respirators designed to meet a prioritized list of the desired characteristics identified in Phase 1. 3M Corporation developed a particulate N95 respirator that can also be used as a surgical mask (described in the intermediate outcomes section). Scott Safety developed an innovative "hybrid elastomeric" respirator that resembles an N95 filtering facepiece respirator. This currently remains a prototype (Quiring et al., 2013). These new respirators, together with other prototypes and commercially-available respirators, were subsequently tested in NIOSH labs for compliance with the project BREATHE respirator test criteria of Shaffer et al. (2014). Findings were recently published (Kim et al., 2017).

Filtration

An issue that has been raised during different infectious disease emergencies has been whether the filters in NIOSH approved N95 FFRs capture different kinds of biological particles. In collaboration with the Biomedical Advanced Research and Development Authority and the Department of Defense (DoD), NIOSH evaluated or funded DoD to evaluate different types of respirators using surrogate viruses (Richardson, Eshbaugh, Hofacre, & Gardner, 2006) and live influenza virus (Harnish et al., 2013; Harnish et al., 2016) and compared commonly used filter test methods (Rengasamy, Shaffer, Williams, & Smit, 2017). These studies consistently find that particle capture by a respirator filter depends on the physical characteristics of the particle – shape, size and, density and not whether the particle is "living" or "infectious." Thus, it is not necessary to test a respirator filter with a biological aerosol, but rather to focus on "worse-case" type test conditions using most penetrating particles as found in the U.S. Code of Federal Regulations, Title 42, Public Health, Part 84, Approval of Respiratory Protective Devices (2015) (42 CFR 84).

Characterize Respirator Use and Practices

To help target outreach efforts, NIOSH sought to determine healthcare stakeholders' approaches to using respiratory protection. In 2008, NIOSH sought to identify sources for data about PPE use and practices (e.g., circumstances in which PPE use is inappropriate, where and how workers are being trained on proper use of PPE). Although numerous potential data sources were explored, none provided the PPE use and practice information needed to assist NIOSH with understanding best approaches to improving PPE user compliance. Because of this information gap, and responding to recommendations provided in the IOM report *Measuring Respirator Use in the Workplace* (IOM, 2007a), NIOSH initiated a series of studies to characterize existing respirator use and respiratory protection practices in healthcare (Beckman et al., 2013; Burgel et al., 2014; Hines, Rees, & Pavelchack, 2014 [NY State Public Health Dept. publication with NIOSH assistance]; Brosseau, Conroy, Sietsema, Cline, & Durski, 2015; Peterson, Novak, Stradtman, Wilson, & Couzens, 2015; Sietsma, Conroy, & Brosseau, 2015; Peterson et al., 2016; Wizner, Stradtman, Novak, & Shaffer, 2016). The studies evaluated a variety of clinical specialties (e.g., emergency room, intensive care unit) and roles including unit managers, respiratory protection administrators, and direct care providers. Observational data was combined with the review of written respiratory protection materials to evaluate the usage of respirators to protect against potentially infectious droplet sprays and aerosols. Salient findings from the studies include (1) respirator shortages can occur, (2) improper use of respirator protective equipment (e.g., not performing seal check, improper strap placement, improper disposal) is prevalent, (3) a reliance on signage for determining when to don PPE, (4) healthcare workers' belief that they are at high risk for contracting influenza, (5) high levels of adherence to many OSHA-required respiratory protection program elements, (6) front-line healthcare workers were less likely to be compliant with respirator use guidance, and 7) HCWs were unclear about when to wear respiratory protection and what type of respiratory protection should be used.

Ensure Appropriate Performance of PPE used by Healthcare Workers

Conformity assessment is an important way to ensure appropriate performance of PPE used by healthcare workers. It involves everything from defining the performance requirements for PPE to designing and executing conformity assessments that assure compliance with technical specifications. In the U.S.A., respiratory protection is unique among the various types of PPE in that a single government entity (NIOSH) provides conformity assessment infrastructure through its regulatory authorities to test and approve respirators used in most U.S. workplaces. This is not the case for other types of PPE relevant to healthcare workers, such as gloves, gowns, masks, and eye protection. Conformity assessment for those types of PPE is managed by a wide variety

of public and private sector entities, resulting in a lack of consistency in approach and strategy. Recognizing the importance of NIOSH's unique expertise and scope of influence within the U.S. PPE community, the IOM's Committee on PPE for the Workforce recommended that NIOSH play a leadership role in conformity assessment for all types of PPE, not just respiratory protection (NIOSH, 2011).

In 2011, NIOSH posted the IOM's report for public comment (NIOSH, 2011) and established a PPE Conformity Assessment Work Group to explore and document foundational information needed to establish an overarching PPE conformity assessment infrastructure framework. The work group included representation from all industry stakeholder groups with subgroups in the areas of surveillance, risk, products and standards, and compliance and enforcement. Subsequently, NIOSH drafted, posted for public comment (NIOSH, 2014a) and has obtained a peer-review of its proposed *Framework for PPE – A Conformity Assessment Infrastructure*. NIOSH expects to publish the final Framework document in 2017.

To further support this framework, NIOSH has conducted research to inform the development of conformity assessment requirements and standards for PPE where a potential for severe health or safety outcomes existed and PPE reliability was not fully understood. In particular, work published by NIOSH has focused on isolation gowns, a type of PPE not regulated by NIOSH but commonly used in healthcare. Reviews of current knowledge have been published (Kilinc, 2015; Balci, 2016). An elbow lean test was used to assess impact of pressure on penetration of body fluid simulants in continuous and discontinuous regions of gowns (Jaques, 2016). Guidance has been published on considerations for selecting protective clothing for protection against microorganisms in blood and body fluids (NIOSH, 2014b).

Outreach

The results of the studies described above informed the development of educational and intervention materials and events.

- **Hospital Respiratory Protection Program Toolkit** - Co-branded with OSHA, this toolkit is designed to help program administrators in hospitals develop and implement effective respiratory protection programs. It is particularly geared towards preventing the transmission of aerosol diseases (NIOSH, 2015c).
- **Training Modules in Respiratory Protection for Nurses** - NIOSH provided a grant to a team from three nursing associations (American Nursing Association, Association of American Occupational Professionals in Healthcare, and American Association of Occupational Health Nurses) to develop training modules in respiratory protection for nurses. In June, 2014 the team posted the online "Healthcare Workers' Respiratory Protection Training" to help healthcare professionals meet OSHA Respiratory Protection Standard's (1910.134 CFR) annual training requirements (AAOHN, 2017). Healthcare workers can also receive continuing education credit for completing the course.
- **N95 Day** - An integrated marketing and social media campaign, known as N95 Day, that is designed for end-users and PPE selectors has been held annually on September 5 since 2012. The campaign centers on a new theme each year to continually grow participation, and includes a webinar, infographics and resources (NIOSH, 2016d).
- **Comprehensive webpage** - Includes web links to all of NIOSH's respiratory protection program resources for hospital respiratory protection program administrators (NIOSH, 2016e).

- **Preparedness through Daily Practice: The Myths of Respiratory Protection in Healthcare**: This five page "Workplace Solutions" document provides easy-to-understand information about common misconceptions around respiratory protection and easy-to-implement recommendations for safer daily practices (NIOSH, 2016f).
- **Journal articles –** Articles detail the differences between medical masks and FFRs and assisting respiratory protection program administrators with reinforcing healthcare workers' proper usage and selection (Benson, Novak, & Ogg, 2013; Burgel et al., 2013; Janssen, Ettinger, Graham, Shaffer, & Zhuang, 2013; Harkavy & Novak, 2014; Shaffer & Janssen, 2015; Kang et al., 2017 [University of Pittsburgh study conducted with NIOSH assistance]).
- **NIOSH Science Blog post** - To help educate respiratory protection program managers on the frequently asked question of whether particulate respirators filter all kinds of viruses, NIOSH created a Science Blog post (Brosseau and Shaffer, 2014), and a video (NIIOSH, 2016g).

NIOSH Service on Consensus Standards Committees

Because of their expertise, NIOSH researchers have served as members and observers on a variety of influential consensus standards committees. For example, NIOSH engineers have served on the Facility Guideline's Institute's (FGI) Healthcare Guidelines Revision Committee that periodically updates/rewrites the Guidelines and on several ASHRAE (formerly known as the American Society of Heating, Refrigerating and Air-Conditioning Engineers) committees related to the use of UVGI. NIOSH researchers have also served on PPE related committees for consensus standard bodies including American Society of Testing and Materials International (ASTM) and American National Standards Institute (ANSI). Tables 1 and 2 provide additional details on NIOSH's role in select consensus standard committees.

Table 1. NIOSH involvement in ASTM standards; F23 on Personal Protective Clothing and Equipment.

Standard (Current Edition)	Personal Protective Equipment	NIOSH Role(s)	Purpose of Engagement
F2815 – 10 Standard Practice for Chemical Permeation through Protective Clothing Materials: Testing Data Analysis by Use of a Computer Program (2010)	Gowns, garments and ensembles materials providing chemical hazard barrier protection	NPPTL Project Officer served as the ASTM Technical Contact	Standard provides computer software program to accurately determine chemical permeation resistance
F903 -10 Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids (2010)	Gowns, garments and ensembles materials providing chemical hazard barrier protection	Voting member providing technical expertise	Closely aligns chemical permeation resistance with hazards experienced in the field
F739 – 12 Standard Test Method for Permeation of Liquids and Gases through Protective Materials under Conditions of Continuous Contact (2012)	Gowns, garments and ensembles materials providing chemical hazard barrier protection	Voting member providing technical expertise	Closely aligns chemical permeation resistance with hazards experienced in the field

Standard (Current Edition)	Personal Protective Equipment	NIOSH Role(s)	Purpose of Engagement
F1671 -13 Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System (2013)	Blood-borne pathogen and bodily fluid protective gowns, garments and ensembles	Voting member providing technical expertise and testing to improve test method reproducibility	Closely aligns liquid penetration resistance with hazards experienced in the field
F1862 – 13 Standard Test Method for Resistance of Medical Face Masks to Penetration by Synthetic Blood (Horizontal Projection to Fixed Volume at a Known Velocity) (2013)	Surgical masks and filtering face-piece respirators (FFR's)	Voting member and provided technical expertise	Closely aligns liquid penetration resistance with hazards experienced in the field
F1670 -14 Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Synthetic Blood (2014)	Blood-borne pathogen and bodily fluid protective gowns, garments and ensembles	Voting member providing technical expertise and testing to improve test method reproducibility	Closely aligns liquid penetration resistance with hazards experienced in the field
F1359 – 16 Standard Test Method for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under Shower Spray While on a Manikin (2016)	Chemical and biological hazard protective ensembles	Voting member providing technical expertise	Closely aligns liquid penetration resistance with hazards experienced in the field
F2407 – 13 Standard Specifications for Surgical Gowns Intended for Use in Healthcare Facilities (2016)	Surgical gowns	Voting member and provided technical expertise	Closely aligns liquid penetration resistance with hazards experienced in the field
F2370 – 16 Standard Test Method for Measuring the Evaporative Resistance of Clothing Using a Sweating Manikin (2016)	All types of protective gowns, garments and ensembles	Voting member and provided technical expertise	Enhances safety by knowing physiological impact on the wearer
F2371 -16 Standard Test Method for Measuring Heat Removal Rate of Personal Cooling Systems Using a Sweating Heated Manikin (2016)	Body-worn personal cooling systems such as cooling vests	Voting member and provided technical expertise and conduced in-house testing	Reduces the heat burden and heat stress to the wearer

Standard (Current Edition)	Personal Protective Equipment	NIOSH Role(s)	Purpose of Engagement
F2668 – 16 Standard Practice for Determining the Physiological Response of the Wearer to Protective Clothing Ensembles WK55144 New Practice for Evaluating the Transfer of Exterior Contaminants from Protective Clothing and Equipment During doffing (2016)	Test method is applicable to all types of PPE	Technical Contact and lead the development of this standard	Reduces the heat burden and heat stress to the wearer
ASTM E2720 Standard Practice for Evaluation of Effectiveness of Decontamination Procedures for Air-Permeable Materials when Challenged with Biological Aerosols Containing Human Pathogenic Viruses (2016)	PPE that is air permeable	Co-lead for the test method working group and conducted the research used in the standard (Fisher, Rengasamy et al. 2009)	Developed laboratory protocol for reproducibly contaminating respirator and facemask samples with viruses and assessing decontamination effectiveness
ASTM E2721 Standard Practice for Evaluation of Effectiveness of Decontamination Procedures for Surfaces When Challenged with Droplets Containing Human Pathogenic Viruses (2016)	Test method is applicable to all types of PPE	Co-lead for the test method working group and conducted the research used in the standard (Vo, Rengasamy et al. 2009)	Laboratory protocol for reproducibly contaminating PPE samples with viruses and assessing decontamination effectiveness were developed

Table 3. NIOSH involvement with other Standards Development Organizations (SDOs) related to PPE

SDO and Committee	Standard (Current Edition)	PPE	NIOSH Role(s)	Purpose of Engagement
National Fire Protection Association (NFPA)	NFPA 1999 Standard on Protective Clothing and Ensembles for Emergency Medical Operations (2013, revision in process)	PPT used in medical operations: protective clothing, helmets, gloves, footwear, face protection devices	Voting member of the Technical Committee on Emergency Medical Services Protective Clothing and equipment and provided technical content to design and performance revisions in the 2013 Edition.	Design, performance, testing, documentation, and certification requirements for new single-use and multiple-use emergency medical operations, including use by emergency medical responders prior to arrive at medical care facilities, and use by medical first receivers at medical care facilities during emergency medical operations; enhances worker safety with design and protective performance criteria expected in the field
American National Standards Institute, American Society of Safety Engineers (ANSI/ASSE); Z88	• Z88.2 American National Standard Practices for Respiratory Protection (2015) • Z88.10 Respirator Fit Testing Methods (2010)	Respirator selection and use	NPPTL serves as Z88 Vice Chair and has numerous researchers and the Associate Director for Science (ADS) as Voting members and providing technical expertise and research and testing data	Committee management and supervision and providing technical expertise in practices for respiratory protection, respirator fit testing methods, and respirator fit capability.

Transfer/translation

A number of organizations have used NIOSH research to generate intermediate outcomes that addressed the various needs of their constituents. Below are a few of the types of organizations that have translated NIOSH research into publications or products:

- **American Association of Occupational Health Nurses (AAOHN)** - A professional association of licensed nurses engaged in the practice of occupation and environmental health nursing serving nearly 5,000 members (AAOHN, 2016).
- **American Nurses Association (ANA)** - Represents approximately 3.6 million registered nurses in advancing the nursing profession by fostering high standards of nursing practice, promoting a safe and ethical work environment, bolstering the health and wellness of nurses, and advocating on health care issues that affect nurses and the public (ANA, 2017).

- **American Society for Testing and Materials (ASTM)** – A standards setting organization that develops and delivers voluntary consensus standards, including standards for personal protective clothing and equipment (ASTM, 2016).
- **ASHRAE –** Formerly known as the American Society of Heating, Refrigerating and Air-Conditioning Engineers, this professional organization has more than 57,000 members. ASHRAE develops voluntary consensus standards related to refrigeration processes and the design and maintenance of indoor environments (ASHRAE, 2017).
- **Association for Advancement of Medical Instrumentation (AAMI)**-a nonprofit organization and primary source of consensus standards, both national and international, for the medical device industry, as well as practical information, support, and guidance for healthcare technology and sterilization professionals (AAMI, 2017).
- **Association of Occupational Health Professionals in Healthcare (AOHP)** - Over 1,000 occupational health nurses, nurse practitioners, physicians and physician assistants belong to AOHP. This organization is a leading advocate for occupational health, safety and well-being in healthcare (AOHP, 2017).
- **Association of periOperative Registered Nurses (AORN)** – a non-profit membership association serving 41,000 registered nurse members by providing nursing education, standards, and clinical practice resources (AORN, 2017).
- **California Department of Public Health (CDPH)** provides a range of services to optimize the health and well- being of people in California (CDPH, 2017).
- **Centers for Disease Control and Prevention (CDC):** The mission of the CDC is to protect America from health, safety and security threats, both foreign and in the U.S. In addition to NIOSH, CDC has a National Center for Emerging, Zoonotic and Infectious Diseases and an Office of Public Health Preparedness and Response (CDC, 2014b)**.**
- **Facility Guidelines Institute (FGI)** - produces consensus-based guidelines using research for the planning, design, and construction of hospitals, outpatient facilities, and residential health, care, and support facilities. FGI is an independent, not-for-profit organization (FGI, 2017).
- **Food and Drug Administration (FDA)** is responsible for regulating a wide range of products to protect the public safety, including its responsibility to assure the safety and effectiveness of drugs and medical devices (FDA, 2017).
- **Occupational Safety and Health Administration (OSHA)** - OSHA is the federal agency In the Department of Labor charged with setting and enforcing standards to implement safety and health legislation (OSHA, 2016).
- **The Joint Commission**: The Joint Commission accredits and certifies nearly 21,000 health care organizations and programs in the United States. Joint Commission accreditation and certification is recognized nationwide as a symbol of meeting or exceeding performance standards (The Joint Commission, 2017a).
- **Veterans Health Administration (VHA)** – As the largest healthcare system in the world, VHA provides training for a majority of America's medical, nursing and allied health professionals. The VHA healthcare system includes 152 hospitals, 800 community-based outpatient clinics, 126 nursing home care units and 35 domiciliaries.

Intermediate outcomes

NIOSH has been diligent in its efforts to inform and partner with individuals and organizations who are in a position to use Institute findings to make impact. The following are examples of instances when NIOSH research has contributed to impact in this area:

Disease Outbreaks

Ebola

NIOSH participation in Rapid Ebola Preparedness Teams helped the U.S. to increase its network of hospitals prepared and certified to treat Ebola patients during the 2014-2016 Ebola epidemic from just 3 facilities in the U.S. to 55 facilities in 17 states and Washington, DC (CDC, 2015). Through its efforts (described on pg.129), NIOSH helped to inform other parts of the CDC including the Strategic National Stockpile, domestic hospitals, and the Monrovia Medical Ebola Treatment Unit on the specific PPE that should be purchased based on meeting technical standards. For example, CDC changed its Ebola guidance in August 2015 (CDC, 2015f) to recommend that purchasers select gowns and coveralls tested by an ISO 17025 certified third party laboratory due, in part, to the NIOSH study showing leakage in AAMI rated isolation gowns evaluated with the elbow lean test (Jaques et al., 2016). In addition, one of the "Frequently Asked Questions" provided in this guidance asks if alcohol-based hand rub treatments affect the integrity of medical exam nitrile/latex gloves. The response cites preliminary NIOSH research which has since been published (Gao et al., 2016), which found minimal degradation.

NIOSH then incorporated this and other information into CDC guidance and training documents for protecting healthcare workers including:

- Interim Guidance for Healthcare Workers Providing Care in West African Countries Affected by the Ebola Outbreak: Limiting Heat Burden While Wearing Personal Protective Equipment (PPE) (CDC, 2015b)
- Guidance for Safe Handling of Human Remains of Ebola Patients in U. S. Hospitals and Mortuaries (CDC, 2015c)
- Guidance on Personal Protective Equipment (PPE) To Be Used By Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola who are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE (CDC, 2015d)
- For U.S. Healthcare Settings: Donning and Doffing Personal Protective Equipment (PPE) for Evaluating Persons Under Investigation (PUIs) for Ebola Who Are Clinically Stable and Do Not Have Bleeding, Vomiting, or Diarrhea (CDC, 2015e)
- Frequently Asked Questions for Guidance on Personal Protective Equipment to Be Used by Healthcare Workers During Management of Patients with Confirmed Ebola or Persons Under Investigation (PUI) for Ebola Who are Clinically Unstable or have Bleeding, Vomiting or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing (CDC, 2015f)

NIOSH and CDC webpages and guidance documents were viewed and/or downloaded over 346,000 times during the epidemic. This is likely an undercount due to URL/document changes over time. Table 3 below shows the page views and guidance document downloads of Ebola information posted specifically by NIOSH as of March 2017.

Table 3. Reach of Select Online Resources Related to the Ebola Response

Webpage/Guidance Document	Page views/downloads
NIOSH Ebola Topic Page	53,515 page views
NIOSH Healthcare Worker Topic Page (Note: provides links to Ebola, but also to other topics)	241,885 total page views (#27 among NIOSH pages)
Interim NIOSH Training for Emergency Responders: Reducing Risks Associated with Long Work Hours	9,981 page views
Considerations for Selecting Protective Clothing used in Healthcare for Protection against Microorganisms in Blood and Body Fluids	30,081 page views
Fighting Ebola: A Grand Challenge for Development – How NIOSH is Helping Design Improved Personal Protective Equipment for Healthcare Workers	1,768 page views
Preventing Worker Fatigue Among Ebola Healthcare Workers and Responders	1,194 downloads
NIOSH Fact Sheet: The Buddy System	3,744 downloads
Prevent Heat-Related Illness	4,732 downloads

Influenza

CDC guidance developed to prevent transmission infectious agents, including the influenza guidance to which NIOSH contributed, are viewed as authoritative by many healthcare stakeholders and thus have real impact on healthcare facilities. For example, they are prominently cited by influential groups such as The Joint Commission (The Joint Commission, 2012) and OSHA (OHSA, 2017).

NIOSH contributed to critical healthcare worker infection control guidance including the following:

- Interim Guidance on Infection Control Measures for 2009 H1N1 Influenza in Healthcare Settings, Including Protection of Healthcare Personnel (CDC, 2010a)
- Questions and Answers about Updating Guidance on Infection Control Measures for Influenza in Healthcare Settings (CDC, 2010
- Interim Recommendations for Facemask and Respirator Use to Reduce 2009 Influenza A (H1N1) Virus Transmission (CDC, 2009)
- Questions and Answers Regarding Respiratory Protection For Preventing 2009 H1N1 Influenza Among Healthcare Personnel (CDC, 2010c)

NIOSH also contributed to CDC guidance on steps that healthcare facilities could take to conserve supplies of disposable N95 respirators. These included minimizing the number of individuals needing to use them through engineering and administrative controls; using alternatives to disposable N95 respirators where feasible; extending use and considering re-use of disposable N95 respirators; and prioritizing use of N95 respirators for those personnel at highest risk of exposure (CDC, 2010a; CDC, 2010b).

Tuberculosis

Published findings by NIOSH funded researchers at Brigham and Women's Hospital (Dharmadhikari et al., 2014; described on pg.137) demonstrating that effective treatment of MDR-TB patients rapidly made them non-infectious were cited to justify recommendations in the clinical practice guidelines for treatment of drug-susceptible tuberculosis jointly developed by the American Thoracic Society, CDC, and Infectious Diseases

Society of America (Nahid et al., 2016). The findings from this study show the importance of rapidly identifying patients and placing them on effective treatment as a way to prevent MDR-TB transmission and that prolonged hospitalization after starting effective therapy should not be needed to prevent transmission. These findings are being used now as part of a new USAID/TB CARE "core" TB infection control campaign called, "F-A-S-T" standing for Find cases Actively (by molecular diagnostics), Separate, and Treat (based on molecular drug susceptibility testing).

Sharps Injuries and Bloodborne Pathogens

The WHO/NIOSH resource *Protecting Healthcare Workers: Preventing Needlestick Injuries* Toolkit (WHO, 2006) was used in Venezuela to great success (first discussed on pg.140). The Institute of Advanced Studies, based in Venezuela, led the effort. Their team conducted training programs at 810 healthcare facilities, training about 37,400 healthcare workers. More than 10,000 copies of the free WHO/NIOSH training program on CD-ROM were distributed. With sustainability in mind, 3920 healthcare workers were trained to become "super-trainers," who went on to train more than 10,500 healthcare workers and serve as advisors to healthcare facilities in their home regions. An additional 5200 graduate and undergraduate students were trained after content was added to public health, occupational health, epidemiology and nursing curricula. (NIOSH, 2016b).

Domestically, OHSN will soon begin to enroll healthcare facilities in its new bloodborne fluid exposures (including sharps injuries) module (first described on pg.141). Although it is too early to say how many facilities will ultimately enroll in the sharps injury module, 125 are currently enrolled in other OHSN modules.

The published findings from the NIOSH funded study conducted by researchers at the University of Virginia, Charlottesville, that found an increase in sharps injuries in surgical settings versus nonsurgical settings after passage of national needlestick legislation (Jagger, Berguer, Phillips, Parker, & Gomaa, 2011; described on pg. 141), were cited by AORN (Ford, 2014; Guglielmi et al., 2010]) and OSHA (Michaels, 2010) to encourage implementation of recommendations.

Consensus Standards

NIOSH researchers participate in and play influential roles in the development of various consensus standards through their involvement in standards committees. These standards do not always cite NIOSH publications. However, below are examples of consensus standards that have cited NIOSH authored publications, with references or comments about cited NIOSH publications listed as bullets.

ANSI/ASSE Standard Z88.2-2015: American National Standard Practices for Respiratory Protection.

- Coffey, C. C., Campbell, D. L., Myers, W. R., & Zhuang, Z. (1998). Comparison of six respirator fit-test methods with an actual measurement of exposure in a simulated health care environment: Part II—Method comparison testing. *American Industrial Hygiene Association*, *59*(12), 862-870.
- Coffey, C. C., Campbell, D. L., & Zhuang, Z. (1999). Simulated workplace performance of N95 respirators. *American Industrial Hygiene Association Journal*, *60*(5), 618-624.
- Coffey, C. C., Lawrence, R. B., Campbell, D. L., Zhuang, Z., Calvert, C. A., & Jensen, P. A. (2004). Fitting characteristics of eighteen N95 filtering-facepiece respirators. *Journal of Occupational and Environmental Hygiene*, *1*(4), 262-271.
- National Institute for Occupational Safety and Health. (1987). *A Guide to Industrial Respiratory Protection*. (DHHS (NIOSH) Publication Number 87-116). Cincinnati, OH: U.S. Department of Health and

Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/87-116/pdfs/87-116.pdf

- National Institute for Occupational Safety and Health. (1996). *NIOSH Guide to the Selection and Use of Particulate Respirators* (DHHS (NIOSH) Publication Number 96-101). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/96-101/
- National Institute for Occupational Safety and Health. (1997). Letter to All Users of P-Series Particulate Respirators - NIOSH Service Time Recommendations for P-Series Particulate. Retrieved from https://www.cdc.gov/niosh/npptl/usernotices/notices/run-050297.html
- National Institute for Occupational Safety and Health. (2005). *NIOSH Pocket Guide to Chemical Hazards* (DHHS (NIOSH) Publication Number 2005-149). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/2005-149/pdfs/2005-149.pdf
- Zhuang, Z., Coffey, C. C., Jensen, P. A., Campbell, D. L., Lawrence, R. B., & Myers, W. R. (2003). Correlation between quantitative fit factors and workplace protection factors measured in actual workplace environments at a steel foundry. *AIHA Journal*, *64*(6), 730-738.

ANSI/ASSE Z88.10-2010: Respirator fit testing methods.

- Myers, W. R., Allender, J., Plummer, R., & Stobbe, T. (1986). Parameters that bias the measurement of airborne concentration within a respirator. *The American Industrial Hygiene Association Journal, 47*(2), 106-114.
- Myers, W. R., Allender, J. R., Isakender, W., & Stanley, C. (1988). Causes of in-facepiece sampling bias—I. Half-facepiece respirators. *Annals of occupational hygiene, 32*(3), 345-359.
- Myers, W. R., & Allender, J. R. (1988). Causes of in-facepiece sampling bias—II. Full-facepiece respirators. *Annals of occupational hygiene, 32*(3), 361-372.
- Myers, W. A., & Hornung, R. W. (1993). Evaluation of new in-facepiece sampling procedures for full and half facepieces. *Annals of Occupational Hygiene, 37*(2), 151-166.

ANSI/AIHA Z88.6–2006

- National Institute for Occupational Safety and Health. (1986). *Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986)* (DHHS (NIOSH) Publication Number 86-113). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/86-113/86-113.pdf

ASTM Standard E2720-16: Standard Practice for Evaluation of Effectiveness of Decontamination Procedures for Air-Permeable Materials when Challenged with Biological Aerosols Containing Human Pathogenic Viruses.

- Fisher, E., Rengasamy, S., Viscusi, D., Vo, E., & Shaffer, R. (2009). Development of a Test System to Apply Virus-Containing Particles to Filtering Facepiece Respirators for the Evaluation of Decontamination Procedures. *Applied and Environmental Microbiology*, *75*(6), 1500-1507.

ASTM Standard E2721-16: Standard Practice for Evaluation of Effectiveness of Decontamination Procedures for Surfaces When Challenged with Droplets Containing Human Pathogenic Viruses.

- Vo, E., Rengasamy, S., & Shaffer, R. (2009). Development of a Test System to Evaluate Procedures for Decontamination of Respirators Containing Viral Droplets. *Applied and Environmental Microbiology, 75*(23), 7303-7309.

In addition, NIOSH's activities and outputs related to the assuring performance of PPE through conformity assessment have led to a draft standard *WK27616 New Guide for Conformity Assessment of Personal Protective Clothing and Equipment* by the American Society for Testing and Materials International (ASTM). NIOSH has been instrumental in the development of this standard.

NIOSH's post-market testing and evaluation of surgical and isolation gowns in support of the U.S. PPE have also resulted in the FDA clarifying its interpretation of its Class I and II 510k process for clearing gowns (FDA, 2015). These studies also significantly influenced the consensus standards that the FDA requires healthcare PPE to meet.

ASTM Standard F2815-10: Standard Practice for Chemical Permeation through Protective Clothing Materials: Testing Data Analysis by Use of a Computer

- NIOSH. (2007). *Permeation Calculator* (DHHS (NIOSH) Publication Number 2007-143c). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Retrieved from https://www.cdc.gov/niosh/docs/2007-143c/

NFPA 1999: Standard on Protective Clothing and Ensembles for Emergency Medical Operations (2008, 2013, and revision in process)

- International Personnel Protection, Inc. (2008).Improved criteria for emergency medical protective clothing (Final Contract Report No. 20080806)

ASHRAE Standard 170 (continuously maintained, most recent published version in 2013): *Ventilation of Health Care Facilities*.

- National Institute for Occupational Safety and Health. (1994). *NIOSH Alert: Controlling Exposures to Nitrous Oxide During Anesthetic Administration*. (DHHS (NIOSH) Publication No. 94-100). Cincinnati, Ohio: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Retrieved from https://www.cdc.gov/niosh/docs/94-100/default.html
- Hayden, C.S., II, O.E. Johnston, R.T. Hughes, & P.A. Jensen. (1998). Air volume migration from negative pressure isolation rooms during entry/exit. *Applied Occupational and Environmental Hygiene, 13*(7), 518–527.

This standard is the primary healthcare facility ventilation design standard in the U.S. and is directly incorporated into The Facility Guideline Institute's (FGI*) Guidelines for Design and Construction of Healthcare Facilities* (formerly published by the American Institute of Architects (AIA)). Some version of the document is used by over 40 states as state-specific code for healthcare facility design. During the 2014 revision cycle, FGI began publishing two separate books: *Guidelines for Design and Construction of Hospitals* and *Outpatient Facilities and Guidelines for Design and Construction of Residential Health, Care, and Support Facilities*. In 2018, it is planned to publish 3 separate books: *Guidelines for Design and Construction of Hospitals*, *Guidelines for Design and Construction of Outpatient Facilities*, and *Guidelines for Design and Construction of Residential Health, Care, and Support Facilities*.

Training

In June 2014, AAOHN posted its online respiratory protection program training and resources that had been developed with NIOSH funding (AAOHN, 2017). By January 2016, 724 participants had completed the training. About 33% were leaders of their organizations' respiratory protection programs, about 15% were going to lead programs in the near future, and about 52% did not lead a program but indicated that the training was relevant to their work. The majority strongly agreed that the training was applicable to their work and enhanced their professional expertise (Pompeii, Byrd, Delclos, & Conway, 2016). The AAOHN Respiratory Protection Modules have been recommended as training resources by the California Department of Public Health, the Florida Department of Health, the American Board of Occupational Health Nursing, and The Joint Commission.

Reach of NIOSH Science

In addition to citations in consensus standards, many publications by NIOSH scientists and extramural researchers have been cited extensively in the literature. Table 4 lists the number of citations for journal articles by NIOSH and extramural researchers from Google Scholar as of March 2017.

Table 4. Citations of select journal articles

Article name	Author(s)	Number of Citations
Respiratory Protection for Healthcare Workers in the Workplace Against Novel H1N1 Influenza A: A Letter Report	IOM 2009	12
Transmission of pandemic (H1N1) 2009 influenza to healthcare personnel in the United States	Wise et al. 2011	36
Influenza vaccination coverage among health-care personnel – United States, 2010-11 influenza season	Harris et al. 2011	67
Low influenza vaccination rates among child care workers in the United States: assessing knowledge, attitudes, and behaviors	de Perio et al. 2012b	17
Bioaerosol sampling for the detection of aerosolized influenza virus	Blachere et al. 2007	39
Measurement of airborne influenza virus in a hospital emergency department	Blachere et al. 2009	215
Distribution of airborne influenza virus and respiratory syncytial virus in an urgent care medical clinic	Lindsley et al. 2010a	101
Measurements of airborne influenza virus in aerosol particles from human coughs	Lindsley et al. 2010b	142
Enhanced detection of infectious airborne influenza virus	Blachere et al. 2011	19
Viable influenza A virus in airborne particles from human coughs	Lindsley et al. 2015	14
Dispersion and exposure to a cough-generated aerosol in a simulated medical examination room	Lindsley et al. 2012	25
High humidity leads to loss of infectious influenza virus from simulated coughs	Noti et al. 2013	29
Detection of infectious influenza virus in cough aerosols generated in a simulated patient examination room	Noti et al. 2012	46
Potential work-related bloodborne pathogen exposures by industry and occupation in the United States Part I: an emergency department-based surveillance study	Chen & Jenkins 2007a	21

Article name	Author(s)	Number of Citations
Potential work-related exposures to bloodborne pathogens by industry and occupation in the United States Part II: a telephone interview study	Chen & Jenkins 2007b	17
Sharps injuries among employees of acute care hospitals in Massachusetts, 2002-2007	Laramie et al. 2011	22
Occupational injuries among nurses and aides in a hospital setting	Boden et al. 2012	28
Deaths due to bloodborne infections and their sequelae among health-care workers	Luckhaupt & Calvert 2008	17
Costs of needlestick injuries and subsequent hepatitis and HIV infection	Leigh et al. 2007	51
Fatigue increases the risk of injury from sharp devices in medical trainees: results from a case-crossover study	Fisman et al. 2007	89
Non-hospital based registered nurses and the risk of bloodborne pathogen exposure	Gershon et al. 2007a	53
Prevalence and risk factors for bloodborne exposure and infection in correctional healthcare workers	Gershon et al. 2007b	41
Percutaneous injuries among dental professionals in Washington State	Shah et al. 2006a	88
The prevalence and risk factors for percutaneous injuries in registered nurses in the home health care sector	Gershon et al. 2009	55
Sharps injuries and other blood and body fluid exposures among home health care nurses and aides	Quinn et al. 2009	49
Blood exposure incidence rates from the North Carolina study of home care and hospice nurses	Leiss et al. 2009a	12
Occupational blood exposure among unlicensed home care workers and home care registered nurses: are they protected?	Lipscomb et al. 2009	19
The impact of U.S. policies to protect healthcare workers from bloodborne pathogens: The critical role of safety-engineered devices	Jagger et al. 2008	111
Percutaneous injuries before and after the Needlestick Safety and Prevention Act	Phillips et al. 2012	39
Issues in understanding the impact of the Needlestick Safety and Prevention Act on hospital sharps injuries	Phillips et al. 2013	21
Disposal of sharps medical waste in the United States: impact of recommendations and regulations, 1987-2007	Perry et al. 2012	25
Increase in sharps injuries in surgical settings versus nonsurgical settings after passage of national needlestick legislation	Jagger et al. 2010	101
Sharpless surgery: a prospective study of the feasibility of performing operations using non-sharp techniques in an urban, university-based surgical practice	Makary et al. 2006	27
Natural infection of guinea pigs exposed to patients with highly drug-resistant tuberculosis	Dharmadhikari et al. 2011	36
Rapid impact of effective treatment on transmission of multidrug-resistant tuberculosis	Dharmadhikari et al. 2014	40
Controlled trial of upper room ultraviolet air disinfection: a basis for new dosing guidelines	Mphaphlele et al. 2015	11

Article name	Author(s)	Number of Citations
Prospective comparison of tuberculin skin test and QuantiFERON-TB Gold In-Tube assay for the detection of latent tuberculosis infection among healthcare workers in a low-incidence setting	Cummings et al. 2009	21
Airborne infection isolation rooms - a review of experimental studies	Hyttinen et al. 2011	13
Method for estimating ultraviolet germicidal fluence rates in a hospital room	Schafer et al. 2008	13
Head-and-Face Anthropometric Survey of U.S. Respirator Users	Zhuang and Bradtmiller 2005a	97
The effect of subject characteristics and respirator features on respirator fit	Zhuang et al. 2005b	43
Head-and-face anthropometric survey of Chinese workers	Du et al. 2008	43
Digital 3-D headforms with facial features representative of the current U.S. workforce	Zhuang et al. 2010a	46
Facial anthropometric differences among gender, ethnicity, and age groups	Zhuang et al. 2010b	55
Digital 3-d headforms representative of Chinese workers	Yu et al. 2012	11
Assessment of the NIOSH head-and-face anthropometric survey of U.S. respirator users	IOM 2007b	17
Sensitivity analysis of important parameters affecting contact pressure between a respirator and a headform	Dai et al. 2011	12
Headform and N95 filtering facepiece respirator interaction: contact pressure simulation and validation	Lei et al. 2012	17
B95: a new respirator for health care personnel	Gosch et al. 2013	12

NIOSH has also provided a web page containing links to the respiratory protection program educational resources described above from The Joint Commission, AAOHN and CDPH as well as other resources directly developed or funded by NIOSH. The total number of downloads for resources accessible from this page, including those provided by NIOSH, The Joint Commission, and OSHA came to a total of 12,614 downloads as of January 11, 2017.

Use of NIOSH Work in Guidance by Other Organizations

The California Department of Public Health (CDPH) published *Implementing Respiratory Protection Programs in Hospitals: A Guide for Respirator Program Administrators* in August, 2015 (CDPH, 2015). NIOSH is acknowledged and NIOSH products are cited extensively in the guide. NIOSH had interacted closely with CDPH from the time of the 2009 HIN1 influenza pandemic to help CDPH identify needs for improving healthcare workers' respiratory protection practices. Development of resources for respirator program administrators was identified as one such need (Beckman et al., 2013). California is unique in its need to provide high quality guidance at the state level because of California's Aerosol Transmissible Diseases Standard, promulgated in 2009 (CDPH, 2017). The California standard mandates appropriate practices, includes an important role for NIOSH-approved respirators and also includes provisions making workplace records available for NIOSH inspection.

The co-branded NIOSH/OSHA Hospital Respiratory Protection Program Toolkit (NIOSH, 2015c) was used and cited by AORN in their 2017 edition of Guidelines for Perioperative Practice. The NIOSH/OSHA toolkit and The Joint Commission monograph (The Joint Commission, 2014) were recommended training for The Joint Commission Surveyors.

PPE

NIOSH work has helped to spur additional action around PPE for healthcare workers. Collaborations with the VA on the issue of respiratory protection for healthcare workers helped motivate the VA to independently fund a substantial amount research to improve the comfort and tolerability of respirators used by healthcare workers as part of Project BREATHE. Project BREATHE, in turn, motivated the development and marketing of a new N95 disposable respirator, the 3M™ VFlex™ Health Care Particulate Respirator and Surgical Mask 1805 (3M, 2017). The number of units sold is proprietary information, but the fact that it remains on the market is a positive sign of its utility.

Finally, NIOSH events such as N95 day reach numerous stakeholders in the healthcare community each year N95 Day began in 2012 and has had steadily increasing stakeholder attendance (NIOSH, 2016d). The 2016 theme—*The Science Behind Respirator Fit Testing in the Workplace: Past, Present, and Future*—produced impressive engagement from healthcare stakeholders: (1) twenty-two organizations partnered with the NIOSH event including N95 respirator manufacturers, academic/government intuitions, industry trade groups, and professional organizations such as the American Industrial Hygiene Association, AAOHN, AOHP, and Society for Healthcare Epidemiology of America, (2) fourteen states proclaimed September 5th, 2016 as "N95 Day," (3) Approximately 400 attendees participated in a Webinar on respirator fit, (4) a NIOSH Science Blog post (NIOSH, 2016i) on the topic had 757 views and (5) NOSH Facebook and Twitter activity (quizzes and resources) produced 33 tweets and 56 retweets, which reached an estimated 312,304 accounts.

End outcomes

While the evidence presented here suggests that NIOSH's unique contributions, extensive collaborations, and focus on healthcare workers has had a positive effect on national and international progress over the last 10 years, other organizations have also developed and distributed reports, publications, and guidelines and taken other actions to protect healthcare workers, patients, visitors, and others from acquiring infections in healthcare settings.. The brief list below comes from the Joint Commission's *Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration and Innovation* (The Joint Commission, 2012), which provides examples of the many organizations that have made contributions to preventing transmission of infectious disease in healthcare settings. It is by no means complete, but provides a sense of the many governmental and non-governmental organizations working in the area.

An important effect on end outcomes was documented by NIOSH during the second decade of NORA for an effort carried out during the first decade of NORA. This was the approximately 38% reduction in sharps injury rates that occurred after passage of the Needlestick Safety and Prevention Act of 2000 and promulgation in 2001 of 29 CFR 1910.1030, OHSA's Blooodborne Pathogens Standard (Phillips et al. 2012). NIOSH contributed to the legislation by publishing the document *Preventing Needlestick Injuries in Health Care Settings* late in 1999 and by working with stakeholders to disseminate interventions similar to those that were included in the law (Hodus et al. 1999). More recently, a WHO/NIOSH pilot program carried out in collaboration with the Venezuelan Dr. Arnoldo Gabaldon Institute of Advanced Studies decreased needlestick injuries by 52% between 2007 and 2012 in the 810 healthcare and occupational health facilities in Venezuela that participated in the program (NIOSH 2016b, page 19).

In other situations, it is more difficult to document prevention of infectious disease transmission that otherwise might have occurred. For example, during the Ebola epidemic of 2014-2016, only two U.S. healthcare workers were infected as a result of occupational transmission in U.S. healthcare settings. Both acquired their infections in 2014 relatively early in the epidemic after caring for a man who became infected in Liberia and travelled to Dallas, TX (CDC, 2014a). Fortunately there were few additional Ebola cases cared for in the U.S. So although

NIOSH made important contributions to helping the original hospital improve its practices, and in helping other healthcare facilities to become prepared to care for Ebola patients, it is unclear if those efforts prevented any additional occupational transmissions.

Alternative explanations

Although this chapter has documented NIOSH contributions, many organizations have developed and distributed reports, publications, and guidelines and taken other actions to protect healthcare workers, patients, visitors, and others from acquiring infections in healthcare settings. Thus, even though the evidence presented here suggests that NIOSH's unique contributions, extensive collaborations, and focus on healthcare workers has had a positive effect on national and international progress over the last 10 years, many others have shared in that progress. The brief list below comes from the Joint Commission's *Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration and Innovation* (The Joint Commission, 2012), which provides examples of the many organizations that have made contributions to preventing transmission of infectious disease in healthcare settings and the products that they have produced. It is by no means complete, but provides a sense of the many governmental and non-governmental organizations working in the area.

Agency for Healthcare Research and Quality (AHRQ) Healthcare-Associated Infections Program

AHRQ's mission is to produce evidence to make health care safer, higher quality, more accessible, equitable, and affordable, and to work within the U.S. Department of Health and Human Services and with other partners to make sure that the evidence is understood and used. AHRQ has provided a range of tools and resources to prevent healthcare-associated infections (HAIs), with a primary focus on patient safety (AHRQ, 2017).

Association for Professionals in Infection Control and Epidemiology (APIC)

APIC is the leading professional association for infection preventionists. Its mission is to create a safer world through the prevention of infection. APIC has provided many resources for preventing transmission of infection in healthcare settings relevant to patient and worker safety (APIC, 2017).

Centers for Disease Control and Prevention (CDC)

The CDC mission is to work 24/7 to protect America from health, safety and security threats, both foreign and in the U.S (CDC, 2014b). NIOSH is part of CDC. Many parts of CDC other than NIOSH are focused on preventing transmission of infection and have published numerous reports and guidelines related to different types of infectious agents. In addition, CDC hosts a federal advisory committee called the Healthcare Infection Control Practices Advisory Committee (HICPAC) that has published guidelines for preventing transmission of infection in healthcare that are relevant to patient and worker safety (CDC, 2017b).

Institute for Healthcare Improvement (IHI)

IHI is an independent, not for profit organization with the mission of improving health and healthcare. The IHI website provides a customized collection of processes to guide improvement efforts in preventing HAIs(IHI, 2017).

National Quality Forum (NQF)

The National Quality Forum is a not for profit, nonpartisan, membership-based organization that works to catalyze improvements in healthcare. It produced a report on 34 practices that have been demonstrated to be

effective in reducing the occurrence of adverse healthcare events (NQF, 2010). Chapter 7 focused on preventing HAIs.

Occupational Safety and Health Administration (OSHA)

OSHA is the federal agency that is primarily responsible for promulgating and enforcing regulations with protection of healthcare workers as the primary focus. OSHA has a topic page providing an overview of standard and directives related to infectious diseases (OSHA, 2017).

Society for Healthcare Epidemiology of America (SHEA)

SHEA is a professional society representing physicians and other healthcare professionals around the world with expertise in healthcare epidemiology, infection prevention, and antimicrobial stewardship. SHEA's mission is to promote the prevention of healthcare-associated infections and antibiotic resistance and to advance the fields of healthcare epidemiology and antibiotic stewardship. One of SHEA's products produced with partner organizations is a Compendium of Strategies to Prevent HAIs that provides a summary of guidelines to prevent HAIs in acute care hospitals (SHEA, 2014).

The Joint Commission

The Joint Commission accredits and certifies health care organizations and is extremely influential in the healthcare industry. It has produced many guidance documents on infection prevention and HAIs (The Joint Commission, 2017b).

Future plans

Occupational transmission of infectious diseases continues to be an important hazard faced by healthcare workers and NIOSH will continue its efforts to improve knowledge and practice for better prevention. NIOSH will continue to be responsive to infectious disease outbreaks with potential for occupational transmission and will work with the rest of CDC and others to address them. NIOSH will also continue to provide assistance to individual workplaces seeking to assess and better control infectious hazards through the HHE program.

An important focus of NIOSH's work related to influenza will be to continue efforts with partners to complete and publish the ResPECT randomized prospective cluster-controlled trial of face mask vs. disposable N95 respirator to prevent respiratory tract infections and influenza in healthcare workers. Depending on the results of this important study, appropriate follow up research and service activities will be pursued.

NIOSH will maintain and expand participation in the newly-available sharps module of OHSN (NIOSH, 2017b). This will provide much-needed surveillance information to track sharps injuries and blood and body fluid exposures and to identify opportunities for improved prevention.

NIOSH will continue to participate in ASHRAE's efforts to update Standard 170-2013, *Ventilation of Healthcare Facilities*, to Standard 170-2018. NIOSH will also participate in FGI's plan to publish the following guidelines: *Guidelines for Design and Construction of Hospitals, Guidelines for Design and Construction of Outpatient Facilities, and Guidelines for Design and Construction of Residential Health, Care, and Support Facilities*. NIOSH will also participate in ASHRAE Guidelines Project Committee 37's efforts to develop Guideline 37: *Guidelines for the Application of Upper-Air (Upper Room) Ultraviolet Germicidal (UV-C) Devices to Control the Transmission of Airborne Pathogens*.

NIOSH's research is actively informing an additional five consensus standards that are not yet completed but pertain to chemical and biological protective clothing and equipment, range of motion test methods for

protective ensembles, isolation gown design and performance requirements, respirator fit capability, and liquid barrier performance of protective apparel. NIOSH will maintain its database to centralize PPE standards information; address complex regulatory, practice, and policy issues with partner professional organizations and agencies; develop and maintain multifaceted educational resources and public health outreach based on evidence based findings; and continue efforts to develop and maintain a National Framework for PPE conformity assessment infrastructure that addresses the full range of PPE used to protect healthcare workers. NIOSH will also continue work under a contract with Vanderbilt Hospital to develop systems for monitoring PPE utilization rates in healthcare. Finally, NIOSH will work to better coordinate regulation of respiratory protection used in healthcare with FDA to ease burden on respirator manufacturers and users (IOM, 2017).

NIOSH will also work to facilitate use of powered air-purifying respirators (PAPRs) in healthcare. NIOSH's existing regulations are most appropriate for PAPRs that are used in industrial applications, as evidenced by the requirement of a silica test. From interactions with stakeholders, NIOSH has determined that the existing, NIOSH-approved loose-fitting PAPR devices are over-designed for use in healthcare (IOM, 2015). Thus, NIOSH is exploring options to develop healthcare-specific PAPRs. To date, NIOSH has evaluated consensus standards that the International Organization for Standardization has published, or is actively developing, to identify a healthcare-appropriate method to test PAPR performance that could be used in lieu of the silica test. Based on its ongoing PAPR research, NIOSH is also looking reduce the size, weight, and noise produced by current PAPRs by matching pressure and gas concentration requirements to the needs of healthcare workers.

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Appendix A: List of Abbreviations

AAMI	Association for Advancement of Medical Instrumentation
AANA	American Association of Nurse Anesthetists
AAOHN	American Association of Occupational Health Nurses
AASPHM	American Association for Safe Patient Handling and Movement
ACGME	Accreditation Council for Graduate Medical Education
AHRQ	Agency for Healthcare Research and Quality
AIIRs	Airborne Infection Isolation Rooms
AIHA	American Industrial Hygiene Association
ANA	American Nurses Association
ANSI	American National Standards Institute
AOHP	Association of Occupational Health Professionals in Healthcare
AORN	Association of perOperative Registered Nurses
APIC	Association for Professionals in Infection Control and Epidemiology
ARN	Association of Rehabilitation Nurses
ASA	American Society of Anesthesiologists
ASCO	American Society of Clinical Oncology
ASHP	American Society of Health-System Pharmacists
ASHRAE	No abbreviation. Organization was formerly known as the American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASSE	American Society of Safety Engineers
ASTM	American Society of Testing and Materials
BBP	Bloodborne Pathogen
BLS	Bureau of Labor Statistics
BREATHE	Project Better Respirator Equipment using Advanced Technologies for Healthcare Employees
BRFSS	Behavioral Risk Factor Surveillance System
C&D	Cleaning and disinfection
CDC	Centers for Disease Control and Prevention
CDPH	California Department of Public Health
CEU	Continuing Education Unit
CSTD	Closed-System Transfer Device
DART	Division of Applied Research Technology, NIOSH

DHHS	U.S. Department of Health and Human Services
DMH	Department of Mental Health
DoD	U.S. Department of Defense
DSHEFS	Division of Surveillance, Hazard Evaluations and Surveillance, NIOSH
DSR	Division of Safety Research, NIOSH
ED	Emergency Department
EID	Education and Information Division, NIOSH
EPA	U.S. Environmental Protection Agency
EPINet	Exposure Prevention Information Network
EPRO	Emergency Preparedness and Response Office, NIOSH
ERCI	Emergency Care Research Institute
ERN	Emergency Nurses Association
FAQ	Frequently Asked Questions
FDA	Food and Drug Administration
FFR	Filtering Facepiece Respirator
FGI	Facility Guidelines Institute
FTE	Full-Time Equivalent
FY	Fiscal Year
GAO	Government Accountability Office
HAI	Hospital Acquired Infection
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HCSA	Healthcare and Social Assistance
HELD	Health Effects Laboratory Division, NIOSH
HEPA	High Efficiency Particulate Air
HHE	Health Hazard Evaluation
HIV	Human Immunodeficiency Virus
HLD	High Level Disinfectant
HOPA	Hematology/Oncology Pharmacy Association
HRO	High Reliability Organizations
IAHSS	International Association for Healthcare Security & Safety
IHI	Institute for Healthcare Improvement
IOM	Institute of Medicine

ISOPP	International Society of Oncology Pharmacy Practitioners
LI	Lifting Index
LTBI	Latent Tuberculosis Infection
MDPH	Massachusetts Department of Public Health
MDR-TB	Multi-Drug Resistant Tuberculosis
MERS	Middle Eastern Respiratory Syndrome
MMWR	Morbidity and Mortality Weekly Report
MSD	Musculoskeletal Disorder
NAICS	North American Industry Classification System
NEISS-Work	National Electronic Injury Surveillance System-Work Supplement
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
NPPTL	National Personal Protective Technology Laboratory, NIOSH
NPR	National Public Radio
NHS	Nurses' Health Study
NQP	National Quality Forum
OBWC	Ohio Bureau of Worker's Compensation
OEP	Office of Extramural Programs, NIOSH
OHSN	Occupational Safety Health Network
OMB	Office of Management and Budget
ONS	Oncology Nursing Society
OPA	*ortho*-phthaldehyde
OSAP	Organization for Safety Asepsis and Prevention
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air-Purifying Respirators
PPE	Personal Protective Equipment
ResPECT	Respiratory Protection Effectiveness Clinical Trial
RFA	Request for Applications
RFI	Request for Information
RHD	Respiratory Health Division, NIOSH
RWJF	Robert Wood Johnson Foundation
RWL	Recommended Weight Limit
SGNA	Society of Gastroenterology Nurses and Associates

SEIU	Service Employees International Union
SHEA	Society for Healthcare Epidemiology of America
SPH	Safe Patient Handling
SPHM	Safe Patient Handling and Mobility, or Safe Patient Handling and Movement
STF	Slips, Trips and Falls
TB	Tuberculosis
USAID	U.S. Agency for International Development
USP	U.S. Pharmacopeial Convention
UV	Ultraviolet
UVGI	Ultraviolet Germicidal Irradiation
VA	U.S Veteran's Administration
VHA	Veteran's Health Administration
VM/AC	Veterinary Medicine and Animal Care
VOC	Volatile Organic Compounds
VPCM	Violence Prevention Community Meeting
VPP	Voluntary Protection Programs
WHO	World Health Organization
WRA	Work-Related Asthma
WSH	Western State Hospital

Appendix B: Summary of State Workplace Violence Legislation

Nine states have enacted some form of workplace violence legislation

- **California (2014) -** California's law requires healthcare facilities to form workplace violence safety committees. Covered facilities include general acute care hospitals, acute psychiatric hospitals and certain other types of hospitals. These committees are responsible for developing a safety plan, which must be updated annually based on a facility assessment. Other aspects of the plan must include staffing, security personnel, training and coordination with local law enforcement (State of California, 1993). In 2014, two healthcare worker unions filed petitions requesting that a new standard be adopted to provide healthcare workers with specific protections against workplace violence. One of these petitions cited NIOSH's 2002 document, *Violence: Occupational Hazards in Hospitals*.

  In September 2014, SB 1299 was approved by the Governor and filed with the Secretary of State. In addition to requiring facilities to develop and maintain a workplace violence prevention plan, hospitals must now retain a written record of any violent incident for five years. Moreover, hospitals must report violent incidents to the Division of Occupational Safety and Health within 72 hours. It also makes specified violations of the law a crime (State of California, 2014). Battery against specified healthcare providers "is punishable by a fine not exceeding two thousand dollars ($2,000), or by imprisonment in the county jail not exceeding one year, or by both the fine and imprisonment." (State of California, 2015a).

  Two NIOSH documents were cited as part of the initial statement of reasons for the law (State of California, 2015b):

  - Ahmed E. Gomaa, MD, Loren C. Tapp, MD, Sara E. Luckhaupt, MD, et al. "Occupational Traumatic Injuries Among Workers in Health Care Facilities - United States, 2012–2014," MMWR Morb Mortal Wkly Rep 2015;64:4051
  - NIOSH, "Workplace Violence Prevention for Nurses," CDC Course No. WB1865 - NIOSH Pub. No. 2013-155.

- **Oregon (2015) -** Oregon's law also requires facilities to have violence prevention plans, periodic facility assessments and record reviews. Covered facilities include hospitals, ambulatory surgical centers and home healthcare services. Employees have the right to refuse to treat a patient who has assaulted them if the employer denies the employee's request to have a second employee present. Home healthcare workers may also refuse to treat a patient if their employer refuses to provide them a two-way communication device. Written records of violent incidents must be kept for five years. However, the law does not specify penalties for non-compliance (State of Oregon, 2015).

- **Washington (2013)-** Washington's law requires hospitals, home healthcare agencies, community mental health programs, and evaluation and treatment facilities to conduct a facility assessment and review records of violent incidents before developing a workplace violence prevention plan. The law also recognizes that home healthcare agencies may have unique circumstances where it is inappropriate and impractical for these agencies to address workplace violence in the same manner as facility-based healthcare settings. Therefore, it provides flexibility to these agencies to implement and maintain compliance with the law (State of Washington, 1999). Washington revised code WA § 9A.36.031 states that "a person is guilty of assault in the third degree if he or she, under circumstances not amounting to assault in the first or second degree assaults a nurse, physician, or healthcare provider who was

performing his or her nursing or healthcare duties at the time of the assault." (State of Washington, 2013).

- **Illinois (2005) -** Illinois workplace violence prevention law is limited to only mental health and developmental disability facilities. Covered facilities must develop a workplace violence prevention plan after a risk assessment and record review. The plan must be reviewed every three years and the results of this review must be provided to the Illinois Department of Human Services (State of Illinois, 2005). Punishment for aggravated assault or battery against a specified healthcare worker can result in a misdemeanor or a Class 4 felony (State of Illinois, 2012).
- **New York (2007)-** This law mandates that employers in public settings or other specified workplace violence risk factors with at least twenty full time permanent employees shall develop and implement a written workplace violence prevention program that addresses all hazards found in a facility risk assessment. Employees who feel that the workplace violence protection program is in violation of the law and their employer does not take action to correct the issue, the employee(s) or representative of employee(s) may request an inspection by giving notice to the commissioner of such violation (State of New York, 2007). New York penal code does specify some penalties for violators of the law, including a charge of assault in the second degree (State of New York, n.d.)
- **Maine (2012) -** Maine's workplace violence protection law, which covers only hospitals and requires that a safety and security plan be implemented annually. Hospitals must also have a way to receive and record incidents or threats of violent behavior (Commonwealth of Main, 2012). No specific penalty is specified for violators of the law.
- **Connecticut (2011) -** Connecticut's workplace violence law requires hospitals, long-term and residential care facilities, behavioral health facilities, outpatient and ambulatory care facilities, home care and any other facility with 50 or more full or part-time employees to convene a workplace safety committee on a quarterly basis and implement a violence prevention plan. Employees may request that another employee accompany them when caring for patient who previously assaulted them or may be asked to be reassigned (State of Connecticut, 2011). CT Revised Statutes § Sec. 53a-167c makes assault of healthcare personnel a Class C Felony (State of Connecticut, 2005). In its *Violence in the Workplace: Policy and Procedures Manual* (State of Connecticut, 2010), the state of Connecticut cites a NIOSH guidance document and uses NIOSH's definition of workplace violence.
    - National Institute for Occupational Safety and Health. (1996). *Current Intelligence Bulletin: Violence in the Workplace* (DHHS (NIOSH) Publication No. 96-100). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and health. Retrieved from https://www.cdc.gov/niosh/docs/96-100/default.html
- **New Jersey (2013) -** New Jersey's "Violence Prevention in Health Care Facilities Act" applies only to hospitals and nursing homes. These facilities are required to conduct annual risk assessments and have a violence prevention plan. Records of violent incidents are required to be kept for five years (Health Professionals and Allied Employees, 2009). New Jersey Code of Criminal Justice declares a violent act against any person engaged in medical services acting in the performance of his duties as an aggravated assault (State of New Jersey, 2013)
- **Maryland (2014) -** The "Nursing Homes and Health Care Facilities Safety Assessment and Safety Program" applies to hospitals, state residential facilities and nursing homes with 45 beds or more. Like other state laws, it requires an annual facility assessment and a workplace safety committee. A written

policy describing how the facility provides for the safety of healthcare workers and a process for reporting, responding to and tracking incidences of workplace violence is required (State of Maryland, 2014). There are no penalties specified for violation of this law.

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Appendix C: Summary of Safe Patient Handling State Legislation

Thirteen states have enacted "safe patient handling" laws or promulgated rules or regulations. Eleven states passed legislation in 2006 or later (the period under review). Among these 11 states, ten require a comprehensive program in healthcare facilities in which there are safe patient handling policies and guidelines for obtaining equipment and training, data collection and program evaluation.

- **New York (2005)** - This legislation established a statewide safe patient handling demonstration project in 2005. In 2011, this program received a 2 year extension. In April 2014, New York passed SB6914 which mandated that healthcare facilities must develop a safe patient handling committee by January 2016 and a safe patient handling program by January 2017. Covered healthcare facilities include all hospitals, nursing homes, diagnostic treatment centers, clinics, state operated group homes, and healthcare units in prisons. Each facility must conduct a patient handling hazard assessment, develop a process to identify the appropriate use of the safe patient handling policy, and provide initial and ongoing training. Annual performance evaluations of the program will be reported to the safe patient handling committee (American Nurses Association [ANA], 2013; State of New York, 2013).
- **Texas (2005)** - Senate Bill 1525 was signed into law on June 17, 2005. This legislation requires hospitals and nursing homes to develop strategies to minimize the risk of injury to patients and nurses associated with patient lifting, transferring, repositioning, or movement. The code stipulates that each facility conduct a risk analysis for both patients and nurses, educate nurses in the identification of risks, evaluate safe patient handling equipment and the environment, and submit an annual report to the nurse staffing committee. The code also states that when developing architectural plans for constructing or remodeling a unit of a hospital or nursing home, a feasibility analysis of incorporating patient handling equipment must be considered (ANA, 2013; State of Texas, 2005).
- **Ohio (2006)** - House Bill 67 was signed into law on March 21, 2006, Section 4121.48. However, it was repealed by 131st General Assembly on June 30, 2015. This legislation created the long term care loan program, where eligible facilities can apply for reimbursement on safe patient handling equipment and improvement projects. Operated by the bureau of workers' compensation, this legislation only applied to long-term nursing care, general, specialty and psychiatric hospitals. Loans could be used for the purpose of purchasing, improving, installing lifts, and to support the cost of staff education and training (ANA, 2013; State of Ohio, 2006).
- **Rhode Island (2006)** - House 7386 and Senate 2760 were passed on July 7, 2006. This law requires licensed healthcare facilities to form a committee to develop a written safe patient handling program. The legislation stipulates that the committee should be chaired by a professional nurse and that at least half of the committee membership should consist of hourly, non-managerial employees who provide direct patient care. By July 1, 2008, facilities have to be prepared to implement a safe patient handling policy to "achieve the maximum reasonable reduction of manual lifting, transferring, and repositioning of all or most of a patient's weight," except in exceptional circumstances. This legislation also requires that each facility calculate the number and rate of patient handling injuries annually so that it may be reviewed by the committee (ANA, 2013; State of Rhode Island, 2006).
- **Washington (2006)** - House Bill 1672 was signed into law on March 22, 2006. This law requires general and specialty hospitals and state psychiatric hospitals to establish a safe patient handling committee by February 2007 and implement a safe patient handling program by December 2007. Facilities must obtain required safe patient handling equipment by January 2010. Hospitals with fully implemented safe patient handling programs were to receive a reduced workers compensation premium and a 100% tax credit for hospital

purchases of safe patient handling equipment up to $1000 per acute-care bed (ANA, 2013; State of Washington, 2006).

- **Hawaii (2006)** - House Concurrent Resolution No. 16 was passed on April 24, 2006. This legislation requested the support of the Legislature of the State of Hawaii to support the policies contained in the American Nurses Association's Handle with Care campaign (ANA, 2013).
- **Maryland (2007)** - SB 879 safe patient handling legislation was signed into law in April 2007. The "Safe Patient Lifting" law, requires hospitals to establish a safe patient lifting committee by December 1, 2007, who would be required to develop a safe patient lifting policy by July 1, 2008. The law applies to hospitals, some specialty hospitals, skilled nursing facilities, and long-term care facilities. The committee was required to consider lifting equipment, lift teams, and training needed to mitigate patient handling risk as part of the development of the policy (ANA, 2013; State of Maryland, 2008).
- **New Jersey (2008)** - S-1758/A-3028, safe patient handling practice act, was signed into law in January 2008. This legislation required general and special hospitals, nursing homes, state or county psychiatric hospitals, and state developmental-disability centers to establish a safe patient handling committee by January 2009. The law does not include private psychiatric hospitals or outpatient or primary care facilities. Each facility is required to maintain a written description of the program and its components and provide a copy to the Department of Health and Senior Services or Department of Human Services by January 2011. At least one-half of the members of each committee must be healthcare workers who provide direct patient, and the committee must meet at least quarterly. The law also specified that a healthcare facility may not retaliate against any healthcare worker because that worker refuses to perform a patient handling task due to a reasonable concern about safety or the lack of appropriate patient handling equipment (ANA, 2013; NJ Senate, 2013).
- **Maryland (2008)** - House Bill 585 extended safe patient handling practices to residents and employees in nursing homes. Each nursing home was to establish a safe patient handling committee with equal membership of management and employees by December 1, 2008. The committee had to develop a safe patient handling policy to reduce employee injuries associated with lifting, improve patient handling risk assessment, increase the use of lifting devices with the incorporation of lift teams and determine the process for evaluating the program (ANA, 2013; MD Senate, 2008a).
- **Missouri (2011)** -The Department of Health and Senior Services published rules (CSR 30-20.20.97) requiring hospitals to have committees responsible for a comprehensive safe patient handling program and policy. This legislation does not include skilled nursing, long-term care, ambulatory, or primary care facilities. While the law does not require a written plan, it does specify that the facility create an assessment process for patient lifting needs. Each hospital must evaluate its safe patient handling program annually by evaluating employee or patient injuries, lost work days, or workers compensation claims. In February 2015, House Bill 963 was introduced which, among a number of provisions, requires facilities to have patient lift teams, provides protections to healthcare workers who refuse to lift patients, and establishes fines against facilities that do not adhere to the safe patient handling legislation (ANA, 2013; State of Missouri, 2011).
- **Minnesota (2011)** - HB 1760 requires all settings that move patients to develop a comprehensive safe patient handling plan. The first version, passed in 2007 only applied to hospitals, nursing facilities and outpatient surgical centers. These facilities had to develop a written policy by July 2008 and implement the policy by January 2011. In 2009, the state expanded the scope of the law to include outpatient clinics and primary care facilities. These facilities had to develop a written plan by July 2010 and implement the plan by January 2012. The state offered each facility matching grants for safe patient handling training and equipment up to $40,000. However, these funds were exhausted by 2008 and additional funding was vetoed (ANA, 2013; State of Minnesota, 2009).

- **Illinois (2011)** - Public Act 97-0122 was signed into law on July 30, 2011. This law amends the Hospital Licensing Act to address safe patient handling policies and includes general, specialty, and psychiatric hospitals, some long-term care facilities, and outpatient psychiatric care facilities. It also includes all childbirth places. The law does not apply to facilities controlled by the state or its agencies, including medical-care facilities associated with a college or university that is funded mainly by taxpayers. Facilities must have trained and available lift teams, but do not have to acquire safe patient handling equipment (ANA, 2013;State of Illinois, 2011).
- **California (2011)** - Assembly Bill 1136 safe patient handling legislation was signed into law in October 2011. California added section 6403.5 to the Labor Code of the existing law, which requires employers to provide safety devices and safeguards reasonably necessary to render employment safe. This includes a safe patient handling policy, replacing manual lifting with lifting devices, and the use of lift teams. This legislation applies to general acute care hospitals, including several types of hospital care and some specialty hospitals. The law does not require safe patient handling committees, leaving the safe patient handling planning to facility managers. Workers who refuse to lift a patient due to concerns about safety are protected from discipline (ANA, 2013; State of California, 2011).

Although, no federal safe patient handling law has been enacted to date, it has been proposed. On December 16, 2015, Representative John Conyers (D-MI) and Senator Al Franken (D-MN) introduced the Nurse and Health Care Worker Protection Act (H.R. 4266/S.2408). This legislation proposed:

- A requirement for employers to purchase, use, and maintain equipment within two years after the establishment of the standard
- That employers provide training to healthcare workers annually on the proper usage of equipment
- OSHA develop and implement a SPHM standard that will eliminate manual lifting of patients by nurses within two years of the legislation's enactment
- SPHM programs provide early mobility therapy which gets patient up and moving, as soon and as often as possible (U.S. Congress, 2015; ANA, 2015).

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