NIOSH Healthcare and Social Assistance Program

Expert Panel Evaluation

October 31, 2017

Table of Contents

Evaluation of NIOSH Healthcare and Social Assistance Program

Evaluation Panel Members:

Kerry Eaton, RN, MS, Panel Chairperson
Chief Operating Officer, Gulf Coast Market, Pensacola, FL, Ascension Health

Deborah Cornman, PhD
Associate Director & Associate Research Professor, Institute for Collaboration on Health, Intervention and Policy (InCHIP), University of Connecticut

James Dearing, PhD
Professor & Department Chairperson, Department of Communication, Michigan State University

Dana Palka, RN, MSN, CPHQ
Director of Clinical Operations, Adult Ambulatory Services, Rhode Island Hospital

Jonathan Rosen, MS, CIH, FAHA
Principal Industrial Hygiene, Safety and Health Consultant, AJ Rosen & Associates, LLC

Joann Velardi, OT, MS
Executive Director, Employee Occupational Health, Wellness and Rehabilitation, St. Vincent's Medical Center, Bridgeport, CT

Background

The National Institute for Occupational Health and Safety (NIOSH) is a public health agency within the Federal Government responsible for conducting research to reduce worker illness and injury and advance worker well-being; to promote safe and healthy workers through interventions, recommendations and capacity building; and to enhance international worker safety and health through global collaborations. NIOSH is the steward of the National Occupational Research Agenda (NORA), a partnership program to stimulate innovative research and improved workplace practices. In developing the national agenda, NIOSH and a broad range of stakeholders work together to identify occupational safety and health research priorities for each industry sector ([1]). The work of NORA is carried out by councils, co-chaired by NIOSH and an external partner ([2]). For the Healthcare and Social Assistance Sector (HCSA), the mission is to reduce injuries, illnesses, and fatalities among workers in the healthcare and social assistance sector program ([3]).

A panel (see page 3) was formed and convened to review the relevance and impact of NIOSH's HCSA Sector Program for the period of 2006-2016.

Scoring Model

NIOSH has adopted a slightly modified version of a program evaluation approach known as contribution analysis ([4]). This approach seeks to identify a reasonable association between program activities and observed outcomes to establish the degree to which the program made a difference. Panel members received an orientation and overview of the contribution analysis model prior to conducting the evaluation.

Scoring Process

The evaluation panel chair was engaged to recruit a panel, conduct a review process and produce a report based on the provided scoring methodology. Membership eligibility required participants to have no conflicts of interest with the NIOSH program, and this was confirmed by receipt of a signed conflict-of-interest form from each member. The panel composition required the inclusion of at least one evaluation expert, at least one translation science expert, and two to three subject matter experts in related areas. In addition, panel members were selected to represent a balance of individuals from academia, labor, and industry. Once assembled, the panel members (listed on page 3) participated in a webinar to receive an overview of the evaluation model and project timeline. Thereafter, the panel received a comprehensive *Evidence Package for 2006-2016* that provided detailed and factual information about the program work and results, and clarified that the present review was to exclude the program areas of Veterinary Medicine and Animal Care, and Social Assistance. Lastly, the panel members had a half-day, in-person meeting with NIOSH staff in Atlanta, Georgia, where they were presented with summary overviews of the work and results from each of the program components. Following the presentation, panel members convened in-person, for a full day, to

discuss preliminary observations based on both their review of the provided materials and the NIOSH staff presentations. Panel members then independently studied and appraised all materials and provided individual scores for relevance and impact as well as supportive rationale for their scores. Finally, scores were averaged to issue a single Relevance Score and a single Impact Score (means). In addition, a Total Program Score was calculated, which is the average (mean) of the sum of the scores for both relevance and impact (see Appendix 1).

Score

The mean Relevance Score was 4.5 on a 5-point scale, with "1" indicating the rationale for the activities completed by the program are not justified and "5" indicating the rationale for the activities completed by the program are highly justified.

The mean Impact Score was 3.5 on a 5-point scale, with "1" indicating research activities and outputs do not result in or are not likely to have any application and "5" indicating the research program has made major contribution(s) to worker health and safety on the basis of end outcomes or well-accepted intermediate outcomes.

The Overall Program Score was 8.0. All scores are rounded to the nearest 0.5 increment.

Executive Summary

Expertise

NIOSH consistently assembled noteworthy experts and experienced researchers in all of the included fields of study. The panel would like to acknowledge and commend the work of these talented individuals and thank them for their important contributions to worker safety.

Relevance

The panel concluded that the activities were solidly justified based on cited evidence. The priority areas of safety, healthy workplaces, prevention of musculoskeletal disorders, hazardous drugs, chemicals and infectious disease all demonstrate that priority setting for research and intervention is done with significant congruence to the NORA HCSA Sector Council, HCSA program leadership input, and the *2009 State of the Sector* (5) (which presents a comprehensive review of priorities), and with input from industry, regulatory and other NIOSH partners.

The Evidence Package provided explicit information documenting the risk or presence of worker injury and illness within the sector. The package also documented the existing research and/or interventions in place to adequately address the documented needs. Identified gaps were clearly defined, and the selected interventions were appropriately designed to address those gaps.

It was noted that in some instances, the panel commented that the work plan did not always keep pace with emerging needs. This may be related to the comprehensive long-term planning process that precedes program activities. Examples noted by panel members were workplace violence and safety culture. Although those topics were studied, the breadth and scope, per the assessment of the panel members, was insufficient to address the significance within healthcare settings. It is important to note that there is a process for adapting and updating the long-term plan during an annual review that is conducted to identify the top priorities for resource allocation to new projects. It was suggested that a concurrent review process be considered, instead of an annual review.

Notably, NIOSH did significantly adapt the program in the face of domestic and international disasters, such as the Ebola crisis, significantly contributing to the protection of impacted populations and healthcare providers. This ability to be nimble, in the face of emerging worker risk, is important and may represent an opportunity for specific protocol development to trigger programmatic adaptations concurrently.

Reviewers also noted that in some instances, study parameters did not fully represent the potential range of healthcare populations, particularly in terms of settings and worker types. Hospital workers were the main focus of most studies, which also introduced a bias toward the

study of women. The abundance of studies that evaluated female workers is not surprising, given that they comprise the majority of healthcare workers.

Partnership with commercial product suppliers was evident in some of the areas of study (e.g., personal protective equipment (PPE) such as respirators and protective gowns), but not in others (e.g., software vendors offering healthcare worker training/education). It is not clear what parameters drive commercial partnerships, but the synergies and additional resources to study or address high-risk worker safety issues may be worthy of intentional focus in the future. Healthcare providers are major purchasers of healthcare supplies, thus exploring partnerships that include a provider, a supplier, and NIOSH or a NIOSH-sponsored partner maybe fruitful.

While all the work was deemed to be highly relevant, the panel noted potential gaps (see Recommendations for Future Considerations) that were felt to have sufficient merit for inclusion within the sector. It was acknowledged that program resources are limited and that those constraints may have impacted program scope.

Impact

It was noted in the description of the contribution analysis provided to the panel members with the evidence package (page 11 - *Overview of the National Institute for Occupational Safety and Health*) and discussed at length while onsite in Atlanta, that "demonstrating a cause and effect relationship between a NIOSH research program and desired end outcomes is almost impossible to definitively conclude." As such, the research program considers intermediate outcomes to be important indicators of actions taken by stakeholders in response to NIOSH products or efforts (e.g., policy changes; productions of standards or regulations; adoption of NIOSH-developed technologies; use of publications, technologies, methods, or recommendations by workers, industry, and occupational safety and health professionals in the field; citations of NIOSH research by industry and academic scientists) (6).

The panel found that NIOSH research program activities are ongoing and that produced outputs are *likely* to result in improvement in worker safety and health. Evidence of improved and measurable injury and illness reduction outcomes as a direct result of the research is limited at this time. The panel understood the parameters that define impact for the purpose of this evaluation. However, they were unanimous in recommending that NIOSH pursue efforts to more closely link their important work to actual reductions in illness and injury. Proxies, such as education material and research article downloads, knowledge and satisfaction surveys, and environmental design recommendations, while appropriate and useful, may not always translate into harm reduction.

Of note is the fatality data from the Bureau of Labor Statistics (BLS), Census of Fatal Occupational Injuries from 2007-2014, which demonstrates a downward trend beginning in 2011 (rate of 138 in 2011 and rate of 111 in 2014) (7). Likewise, from the BLS, Survey of Occupational Injuries and Illnesses, non-fatal injuries and illnesses declined from a high of 778.8

in 2009 to 710.2 in 2014. At the same time, the employment trends in healthcare and social assistance increased from 18.09 million in 2007 to 19.90 million in 2014 (Bureau of Census, Current Population Survey). In relation to these trends, it may be reasonable to assume that NIOSH activities contributed to the observed declines based on the high relevance of the research conducted during that timeframe; however, direct contribution cannot be determined.

Overall, NIOSH has done a good job fostering and supporting the development of educational resources for stakeholders (training materials, websites, and conferences for education stakeholders. In addition, NIOSH routinely partners with federal and state agencies, industry, professional and trade associations, academic and industry researchers, and labor unions to transfer the information to the various sectors where adopted knowledge has the potential to be translated to practice.

Using the second of two NIH definitions of translational research, "research…aimed at enhancing the adoption of best practices in the community" ([8]), the panel noted that the majority of resources in the program that seek to assess translation are directed toward evaluating whether materials are used, versus whether the use of the materials results in improved adoption of best practices.

Panelists concurred that the focus on education is relevant and important, but cautioned that there may be an overreliance on education as a modality to improve safety outcomes. Funded research to study actual uptake of information; adoption, adaptation, and maintenance of recommended practices, comparisons of effectiveness of various education modalities (in-person vs. online), and sustained use of the generated outputs would be useful.

Panelists noted that research and engineering controls and design improvement are important, and encourage continuing and expanding this area of work (see Recommendations for Future Considerations).

The Evidence Package suggests that NIOSH infrequently recommended any relevant sector-specific occupational health and safety standards to OSHA, per the stated function in the *OSH Act of 1970* ([9]). Further, except for regulations regarding bloodborne pathogens, there are limited OSHA regulations related to the priority areas. It is recognized that NIOSH is not primarily a regulatory agency and that regulation is difficult to achieve in the current environment. One panelist noted that OSHA regulations enjoy significantly better adherence rates than do recommended guidelines.

Major Contributions

During the 2006-2016 decade, the NIOSH HCSA program had a number of important contributions and accomplishments relative to worker injury and illness prevention, which include, but are not limited to the following:

- Participation in the creation of the Joint Commission-published monograph (2012), *Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration and Innovation* ([10](#))*.*

- Creation of an online course for healthcare workers entitled *Workplace Violence Prevention Training for Nurses* (2013) ([11](#)).

- Participation in the development of the American Nurses Association publication, *Safe Patient Handling and Mobility Interprofessional National Standards* (2013).

- Partnership with 21 professional practice organizations to determine the level of adherence to national guidelines and best practices for minimizing exposure to hazardous chemicals in the workplace, which resulted in the publication of more than ten papers describing the online survey findings.

- Financial and technical support for the Organization for Safety, Asepsis and Prevention (OSAP) to examine bloodborne pathogen exposure risks in private dental practices ([12](#)).

- Publication of *State of the Sector I Healthcare and Social Assistance: Identification of Research Opportunities for the Next Decade of NORA* (2009) as part of its role as co-chair and partner to the NORA HCSA Sector Council ([13](#)).

- Creation of the *2009 National HCSA Agenda* (revised in 2013) as part of its role as co-chair and partner to the NORA HCSA Council ([14](#)).

- Initiation of a NORA HCSA Council workgroup that summarized the current knowledge, research gaps and future needs for safe cleaning and disinfection in healthcare settings (*Cleaning and Disinfecting Environmental Surfaces in Healthcare: Toward an Integrated Framework for Infection and Occupation Illness Prevention*, 2015) ([15](#)).

- Publication of *NIOSH Fast Facts for Home Healthcare Workers* (2012) ([16](#)).

- Conducted important research documenting the aerobiology and potential for airborne transmission of influenza.

- Conducted research evaluating surgical smoke in medical facilities.

- Conducted research to understand the basic mechanisms of latex allergy.

- Studied the effectiveness of respiratory protection, protective gowns and covers, and factors associated with the use and tolerance for personal protective technologies.

- Conducted research aimed at characterizing sharps-related exposures (2016) ([17](#)).

- Conducted research aimed toward an improved understanding of asthma in healthcare workers.

- Funding of workplace violence studies in emergency departments and home health/hospice.

- Influence resulting in nine states enacting workplace violence laws for healthcare.

- Publication of *Slip, Trip, and Fall Prevention for Healthcare Workers* (2011) ([18](#)).

- Research demonstrating the effectiveness of lifting devices in reducing low back injuries, including demonstrated reduction of injuries in long-term care following implementation of best practice lifting programs.

- Direct mailing of *Safe Lifting and Movement of Nursing Home Residents* (CDC publication) ([19](#)).

- Publication of *Safe Patient Handling Training for Schools of Nursing* (2009) ([20](#)).

- Publication of *Occupational Hazards on Home Healthcare* (2010) ([21](#)).

- Influenced funding by Veteran's Health Administration for ceiling mounted lifts above all beds ($205 million).

- Reduction in patient lifting injuries with days away from work in nursing facilities from a high of over 45 per 10K FTE to just over 20 per 10K FTE between 2006 and 2015.

- Provision of *NIOSH List of Hazardous Drugs* and *CDC NIOSH Alert on Antineoplastic and Other Hazardous Drugs in Health Care Settings* (2004 and updated in 2010, 2012, 2014, and 2016) ([22](#)).

- Contributions toward development of USP Chapter 800 regulations and The Joint Commission Safe Handling Practices for Hazardous Drugs.

- Publication of NIOSH/CDC Work Place Solutions document, *Medical Surveillance for Healthcare Workers Exposed to Hazardous Drugs* (2007 and updated in 2013) ([23](#)).

- Publication on reproductive risks associated with hazardous drugs (2014) ([24](#)).

- NIOSH response to 2014 Ebola outbreak: international and domestic deployments; development of guidance, information and training; and research, testing and evaluation of PPE.

- Development of Project BREATHE ™ resulting in an interagency report, 20+ manuscripts and a published proposed standard detailing characteristics of a new class of respirator optimized for healthcare settings (B95 respirator).

- Development of REACH (Respirator Evaluation for Acute Care Hospitals) to study adherence to OSHA requirements, resulting in 10 manuscripts, 2 NIOSH documents and

online respiratory protection training, and use by The Joint Commission, Association for Operating Room Nurses and Association for Prevention and Infection Control.

- Development of performance and design criteria for PPE isolation gowns.

- Research to evaluate the effectiveness of glove tensile strength when exposed to alcohol-based hand rub treatments.

Specific Priority Area Commentary

Safe and Healthy Workplaces

The Evidence Package supported the relevance for research and interventions in this area. The Institute of Medicine report *To Err is Human* (1999) discusses the impact of culture on safety outcomes in the healthcare environment (25). While the focus was on patients, it is reasonable to assume that workplace culture will also impact the frequency and severity of healthcare worker safety events.

NIOSH-supported research, relevant to safe and healthy workplaces, included evaluation of physical work environment, work hours, staffing levels, safety climate, short sleep duration, and workload. NIOSH also supported research related to reducing workplace violence, as the HCSA sector led all other industry sectors in the incidence of nonfatal workplace assaults at the beginning of the second decade of NORA. The funded research substantiated the impact of the above listed factors on worker illness and injury.

The panel commented that the scope of the research on culture was relatively narrow and that the need to better understand the correlations was an important future consideration. Areas suggested for more in-depth study included the impact of hierarchal relationships within selected sub-groups of healthcare workers, impact of staff turnover and temporary/agency staffing and the absence or presence of a "Just Culture" (26), and leaders' behaviors associated with improved safety culture.

The study of length of shift and sleep deprivation was of concern to the panel, because despite overwhelming evidence, shifts routinely scheduled to exceed 8 hours are an industry norm. Unfortunately, the findings have not translated into actual changes in practice, suggesting that prevalence research and education interventions are insufficient, at least in this instance, to drive meaningful change in adoption of shorter work shifts.

Workplace violence research by NIOSH demonstrates significant relevance and evidence of risk, knowledge and impact. Panelists commented that workplace violence is chronically underreported and an accurate knowledge of prevalence may be of value - specifically, studies designed to inform a more specific understanding of risk recognition, prevention and mitigation strategies associated with reducing prevalence.

Environmental factor research and interventions were substantial, and the reductions in slips, trips, falls, and other similar injuries may represent a significant impact.

Specific areas of intermediate outcome achievement during this decade included the use of NIOSH research by the Accreditation Council for Graduate Medical Education, the Agency for Healthcare Research and Quality, the American Nurses Association, the Emergency Care Research Institute, the Government Accounting Office, the Institute of Medicine, Occupational

Safety and Health Administration, The Joint Commission, the U.S Veteran's Health Administration, and others.

Following the 2009 Institute of Medicine report that called for reducing the maximum number of hours residents can work without time for sleep, NIOSH launched a well-utilized online training on shift work and long hours (2015) ([27](#)).

Fourteen states have enacted legislation regarding nurse-staffing ratios, and nine states have enacted workplace violence prevention laws for healthcare facilities.

The panel identified the following opportunities and perceived gaps:

- More research to demonstrate intervention effectiveness is suggested. For example, although there are many recommendations related to safety culture and sleep patterns, there is almost no evidence of the effectiveness of implemented interventions. Several described studies that evaluated interventions found an impact on behavior (e.g., Arnetzet al., 2017; Gillespie et al., 2014) ([28](#), [29](#)). Others provided limited outcome data. For example, NIOSH (2015) ([30](#)) reported that they developed a two-part training program for nurses about the health risks associated with long work hours. Although the program had been completed by almost 3000 individuals by December 2016 and received positive feedback, there is no data provided to determine the impact on nurses' behavior with respect to work hours and fatigue. Similarly, over 20,000 participants had completed NIOSH's Workplace Violence Prevention Training for Nurses at the time of this report, but there was no indication that it had resulted in a reduction in violence. Commendably, these trainings have reached a large number of people; it would be of great benefit to also have data supporting their effectiveness.

- In the Transfer/Translation section of the report, multiple organizations are listed as having "used NIOSH research." The availability of the data to national organizations is of value. That value would be substantially enhanced if there was a reliable way to determine how it was used and if the use is contributing to worker safety or if it has been translated into policy, etc.

- Numbers of downloads provide reliable data that can suggest dissemination, but such data cannot be a proxy for validating uptake or impact of content. It may be useful for NIOSH to add a survey component, to be completed upon download of the materials, to gather user demographic information. Citations may also be a relatively weak indicator of impact, as they may be disproportionately used by academic researchers and/or students and may not indicate awareness and use in actual workplace settings. Small numbers of citations (ten or less) noted for some publications are unlikely to represent significant impact.

- It would be helpful to have a better understanding of how NIOSH influences policy development when the detail is not supplied relative to achieving an intermediate outcome.

- The impact of naps on worker safety requires clarification as some research is showing naps to be effective, but sleeping is generally not permitted in the workplace. This could be an opportunity for NIOSH influence.

- It would be of value to understand whether achievement of OSHA Voluntary Protection Program (VPP) designation reliably impacts workplace environment with respect to injury and illness prevention.

- Considerable research has been conducted using valid instruments that assess safety culture and climate. These could likely be applied to the study of worker safety as well as other environmental factors associated with positive worker safety outcomes.

- "Push" notifications of web training to healthcare leaders via state associations or other vehicles may increase utilization and thus translation to practice.

- Many vendors produce high quality worker safety tools and training currently utilized by healthcare facilities. There may be an opportunity for partnership that could extend the reach of NIOSH resources.

Musculoskeletal Disorders and Patient Mobilization

The panel found this NORA priority area to rank strongly both with respect to relevance and impact. NIOSH is to be commended for this work and, in particular, for the effective dissemination of relevant materials.

The relevance of this program area is evident based on the increased prevalence of worker injury in the healthcare sector as compared to other industries. There were 5.5 cases of nonfatal injury in the HCSA sector per 100 full-time workers, compared to 4.0 and 3.9 cases, respectively, in the private sector and service-providing industries at the start of this NORA decade. The incidence of strains and sprains resulting in days away from work in the HCSA sector was 82.3 cases per 10K workers according to a 2005 study. Also in 2005, the incidence of slips, trips and falls was 80% greater in the healthcare sector than it was for private industry.

Outcomes were considered well-reported by the panel. NIOSH successfully demonstrated how their research contributed to guidelines, best practices, position statements, and national standards. Several studies of workers in skilled nursing facilities demonstrated a reduction in injuries associated with employee participation in a prescribed wellness program and other interventions related to improved lifting practices. Research has also examined which interventions are correlated with the most optimal improvements.

Outputs, evaluations and intermediate outcomes in this area included development of a safe patient handling curriculum for schools of nursing and evaluation of the impact of legislation relative to safe patient handling in California, and dissemination of educational materials in a variety of formats (online, journal articles, and fact sheets). Several organizations have used NIOSH research findings in their publications and/or products (American Association for Safe Patient Handling and Movement, American Nurses Association, etc.). In 2010, the Veterans Health Administration issued a directive outlining recommended practices for patient handling and allocated significant funding to support implementation of the program. NIOSH research provided some of the evidence for the directive.

Although there is no definitive way to link improved end outcomes to the influence of NIOSH programs, since 2006, there has been a steady decline in non-fatal occupational injuries requiring time away from work due to lifting.

The panel identified the following opportunities and perceived gaps:

- Research regarding hazards of sitting/sedentary roles and developing best practice recommendations for sit-to-stand working may be an important area of interest.

- Research on repetitive motion injuries, particularly with the proliferation of electronic data entry and mobile computer carts within the healthcare sector, may be of value. While there have been many interventions, there is limited study of which interventions are most effective and most readily adopted by workers. In the field, training is prevalent, but there is no strong evidence that the training improves adherence to guidelines/best practices.

- In this area, as well as the others, there is an opportunity to look beyond education as a means to translate NIOSH research into practice and thus reduce injury. For example, with respect to the use of patient lift equipment, research could build on the work already done by NIOSH regarding engineering controls such as lifting and administrative controls such as requiring the use of lifting equipment, and evaluate how to most effectively increase accurate, consistent, and ongoing use of this equipment by healthcare staff. The State of the Sector document prioritized the need for research to "address barriers to implementation of known interventions." The panel agrees that this is an important addition to the current research. Members of the panel noted that providing CEU credits for "reading and successfully completing a test on the content" about when it is safe to manually lift a patient is an important step, but it does not guarantee behavior change. Knowledge and translation into practice are two separate and discrete outcomes. Similarly, while development of the Safe Patient Handling Curriculum for Schools of Nursing is a commendable step forward, the effectiveness evaluation was limited to changes in knowledge instead of adoption of practices. Such research could be an important next step.

- Information alone rarely results in behavior change, so developing theory-based interventions is critically important. There are numerous theories of behavior change that speak to the factors that are critical for behavior change to occur ([31](#), [32](#)), such as the Information-Motivation-Behavioral Skills (IMB) Model ([33](#), [34](#)), the Health Belief Model (HBM) ([35](#), [36](#), [37](#)), the Theory of Reasoned Action/Theory of Planned Behavior (TRA/TPB) ([38](#), [39](#)), the Transtheoretical Model/Stages of Change (TTM) ([40](#), [41](#)), and Social Cognitive Theory (SCT) ([42](#), [43](#)), among others.

  It will be useful to not only develop theory-based interventions, but also to conduct research to provide evidence-based guidance using theoretical frameworks to evaluate how to best implement the interventions that are found to be effective. There is a growing literature on implementation science that studies how to most effectively ensure adoption, implementation, and sustainability of effective interventions ([44](#), [45](#), [46](#), [47](#), [48](#), [49](#)). There is agreement that the development of guidelines and interventions is a crucial step, but it is also acknowledged that without adoption into practice, there is a lost opportunity to prevent worker harm. The panel notes that the area of musculoskeletal injury prevention seems ripe for this type of research and recommends conducting more studies similar to the study described in the Evidence Package that identified factors that influence the use of patient lift equipment by healthcare staff.

- The study of worker fitness as a resilience strategy, the special needs of aging staff and the impact of self-care incentives, may be important areas of study in this priority area. There may also be benefit from studying the impact of "influencers" or opinion leaders with respect to evaluating adoption and adherence to worker safety modalities.

Hazardous Drugs and Chemicals

According to the Bureau of Labor Statistics (2011) ([50](#)), approximately 8 million workers are potentially exposed to hazardous medications in the course of their work; exposure may be via inhalation or through direct contact with contaminated sources. Workers are also exposed to cleaning substances used for infection control purposes, gases used to deliver anesthesia may scatter and cause worker exposure, and surgical smoke from laser and cautery procedures may cause respiratory exposure to foreign substances. These examples of hazards supply significant evidence of relevance for adverse health outcomes, including the development of exacerbations of asthma. Also validating significant relevance was an online survey that demonstrated a general lack of adherence to exposure prevention practices, despite widespread knowledge of associated hazards (2014) ([51](#)), (2015) ([52](#)). The need for reproductive health studies was also demonstrated based on evidence that exposures to certain antineoplastic drugs caused a significantly higher incidence of spontaneous abortion. NIOSH clearly established the serious nature of workers' risks related to toxic exposures. One

panel member specifically noted the expertise and diverse experience of the NIOSH researchers in this priority area.

In terms of impact, the panel agreed that a significant and meaningful output has been the up-to-date list of hazardous drugs that is regularly produced by NIOSH. This publication is very important, known to be widely used, and likely impactful to healthcare providers. In addition, a notable intermediate outcome is the publication discussing the adverse reproductive effects that may result from exposure to hazardous drugs. This list has also stimulated the development or proposal of state regulation in a number of states across the U.S. The 2016 version was downloaded over 23,000 times.

The panel appreciated that there has been a focus on developing appropriate and evidence-based engineering controls to prevent exposures (thus not solely relying on education and adoption of practices by individual workers). Examples include development of closed system drug-transfer devices for safe handling of antineoplastic drugs and use of anesthetic gas scavenging systems and surgical smoke evacuators in operating suites. The extent of adherence was also studied, and it was noted that shutting down anesthesia gas flow prior to turning off carrier gas to the breathing system was low, thus identifying an opportunity to further improve worker safety.

Another important area that included engineering controls has been the development of the *2016 USP Compounding Compendium* ([53](#)), which provides authoritative guidance on the safe handling of drugs in healthcare settings, including development of standards for receipt, storage, compounding, dispensing, and disposal of hazardous drugs. NIOSH provided guidance for the development of the regulations. These standards will be enforceable in 2018 by State pharmacy practice acts and professional licensing boards.

NIOSH research has studied the relevant protection afforded by various types of respirators and masks used by healthcare workers. This research has led to actively enforced requirements for fit testing and use of specific grades of respirators for high-risk infection prevention needs.

Many agencies, as with the other priority focus areas, have used and/or relied upon NIOSH research, including the American Nurses Association, American Society of Health-System Pharmacists, Oncology Nursing Society, The Joint Commission, and others. Others have used NIOSH research to develop monographs and/or guidance for safe work practices.

The panel identified the following opportunities and perceived gaps:

- The study that demonstrated that chemotherapy medications are present on the outside of vials was of great interest to the panel. It may be low hanging fruit as there is little awareness of this within healthcare provider organizations. Accordingly, there may be simple labeling intervention opportunities that may be a beneficial area of work and consideration.

- Within the area of reproductive health, studies are generally limited to women, but it may also be appropriate to study impact on male healthcare workers.

- The relative infrequency of NIOSH health hazard evaluations may further indicate a need for more awareness (356 requests over 10 years).

- Within all areas of NIOSH publications and guidance documents, the "push" out of materials may improve awareness and thus adoption. Currently NIOSH seems to rely on users to initiate locating the materials.

- Settings outside of hospitals, particularly those with minimal regulatory impact, may be especially risky for workers (e.g., provider offices, ambulatory centers).

- Another potential gap is the study of adequacy of PPE such as chemo gloves. Additional product evaluation may be a valid area of research.

- The Institute for Safe Medication Practices (ISMP) is the expert resource on medication management for the healthcare industry. They may be a strong partner for NIOSH to consider.

- Research on the effect of cleaning materials and supplies on healthcare workers may be useful.

- Important research was conducted demonstrating the lack of universal adherence to safe handling guidelines. These findings, along with safe handling guidelines, were posted on the NIOSH website, but no information was provided on how workers and employers were driven to this website. This is a passive form of dissemination with no data provided on whether this was effective.

- The NIOSH Alert contains very important information and guidance about hazardous drugs and strategies for protecting workers' health. What is lacking is data on how many people have read this information and whether it has had any impact on policies, procedures, and behavior. The panel commented that despite evidence of limited adherence to safe handling guidelines, there has been minimal research conducted on how to increase adherence.

- University of Michigan researchers are conducting an evaluation of a tailored intervention to increase nurses' use of protective equipment when handling hazardous drugs. NIOSH is encouraged to conduct more intervention studies like this one, which address barriers to workers' adherence to guidelines and best practices.

- The NIOSH Health Hazard Evaluation (HHE) Program is an excellent example of research translated into practice and is recommended as a model for future work.

Infectious Disease and Sharps

Numerous well-established risks related to the inadvertent transmission of infectious disease to healthcare workers provide evidence of relevance for research and study by NIOSH. Examples of risk include Human Immunodeficiency Virus (HIV), Hepatitis B, Hepatitis C, tuberculosis and seasonal influenza. Additionally, sudden outbreaks of emerging infectious diseases such as Ebola and Middle Eastern Respiratory Syndrome (MERS) provide ample evidence of relevance for study in the healthcare sector.

NIOSH also engaged in the study of exposures via "sharps" – commonly from inadvertent sticks by contaminated needles used in healthcare procedures. Panel members actively working in healthcare settings acknowledged the high frequency of this type of exposure.

Impacts described in the review process included the excellent and nimble response to the 2014-2106 Ebola virus both internationally and within the U.S. Notably, NIOSH deployed staff to Texas when the first case of Ebola was identified in the U.S. and transmission to healthcare workers was identified. NIOSH focused on appropriate training of staff to prevent transmission and contributed to many outputs made available to healthcare providers, including online resources, the Buddy System fact sheet, and design guidelines for PPE. NIOSH also participated in the testing of PPE developed to reduce heat burden to users caring for infected patients. Particularly noteworthy was the NIOSH research related to the proper donning and doffing of PPE, as well as ensuring the use of gowns that resisted fluid strike-through.

NIOSH also was an effective partner with the CDC, OSHA, and labor stakeholders to coordinate a response to the 2009 H1N1 influenza pandemic. Additionally, NIOSH conducted important work collaboratively on influenza surveillance projects.

Other intermediate outcomes included NIOSH funding for the 2008 Institute of Medicine Report on *Preparing for an Influenza Pandemic* (54). In 2009, the CDC recommended the use of fit-tested N95 respirators for workers in close contact with patients with the flu; NIOSH participated in the development of the recommendation. NIOSH has also funded basic research regarding influenza transmission and has provided guidance regarding recommended training for healthcare personal on proper donning and doffing of PPE.

NIOSH has conducted studies to identify strategies to reduce the transmission of sharps-related infections to healthcare workers. They have identified hospitals as the largest source of sharps exposures, with registered nurses as the most frequently exposed worker type (2007). Notably, one study linked fatigue as a risk factor for exposures among medical students. NIOSH-funded studies found that glove use reduces exposures and that sharps injuries in operating rooms are less frequent when team members are constant over time. NIOSH-funded studies also found limited use of recommended practices and sharp safety products in dental practices.

Other intermediate outcome interventions produced by NIOSH include the "Stop Sticks Campaign" in 2011, which sought to motivate healthcare workers to adopt sharp safety

practices. In collaboration with the World Health Organization, NIOSH also developed a *Needlestick Prevention Toolkit.* In addition, they funded research to evaluate the impact of the OSHA Bloodborne Pathogen Standard and the Needlestick Safety and Prevention Act. The studies demonstrated reduced exposures due to sharps injuries following implementation of the requirements. NIOSH has produced a number of educational materials related to infectious disease transmission, including posters and brochures, and fact sheets.

NIOSH has studied a number of engineering controls, including airflow control engineering solutions to examine the impact on ventilation, toilet flushing contamination, and ultraviolet light impact on infection control and worker exposure.

NIOSH has also been involved in many research evaluations to inform respirator fit related to weight changes, varying face sizes and shapes, and user comfort. Toolkits for hospitals regarding respiratory protection, were developed with OSHA. NIOSH has also produced training modules on respiratory protection for nurses. A campaign for N95 Day was noted in the evidence package, but no panel members were aware of implementation in the healthcare settings where they had been employed.

NIOSH researchers have also been important members of consensus standard committees that develop standards for a wide variety of healthcare PPE. This contribution is to be commended.

The panel identified the following opportunities and perceived gaps:

- As noted, NIOSH did impressive collaborative work in the area of Ebola PPE research and made important findings. It is unclear whether these findings were translated into practice, and if they were, to what extent. Further, while NIOSH worked with the CDC and other organizations to produce a large number of guidance documents, webpages, communication projects, and new technology, data on the usage of these products and the impact on adoption of best practices are absent. It would be useful to know whether healthcare facilities use the developed information to modify current practice. Research demonstrating the effectiveness of the promulgation of these educational resources is an important next step.

- NIOSH indicated that "improving basic knowledge of how influenza is transmitted" was identified as "an important research priority." The panel agrees that it is important to understand influenza transmission, but also believes that adherence to guidelines and best practices needs to be addressed. Behavioral research is underrepresented and is an essential aspect of the efforts to reduce the transmission of preventable infectious diseases to healthcare workers.

- The development of prototype respirators is a great example of a collaborative effort between federal organizations (NIOSH and VA) and private industry (3M and Scott Safety Corporations) to translate research into a practical solution. Likewise, the NIOSH research that evaluated the impact of the Needlestick Safety and Prevention Act of 2000

is an important study for evaluating whether that legislation has translated to practice changes. NIOSH is encouraged to fund translation/implementation research in the future.

- An important discovery during the Ebola crisis was that healthcare workers rarely don and doff PPE gowns correctly and safely. The unexpected nature of this discovery is an important consideration for future research with respect to persuading the industry to consider that other crucial skills and behaviors may incorrectly be assumed to be in place.

- The 2005 *NIOSH Needlestick Prevention Toolkit* and 2011 NIOSH Stop Sticks campaign were widely implemented. EPINet multistate data tracking has provided evidence of reduced (non-suture) bloodborne pathogen injuries. However, operationally, needlesticks continue to be very prevalent in healthcare settings and thus, worthy of further research regarding effective interventions.

Recommendations for Future Considerations

In all priority areas, numerous organizations are identified as having "translated NIOSH research into publications or products." It is unclear as to the specific relevance of that activity as it is not noted how the use of the published findings impacted policies, operations, or adherence to guidelines and best practices. The panel suggests that NIOSH provide more clarity about the nature of the use and its likelihood to have produced meaningful outputs.

Throughout the Evidence Package, it is clear that NIOSH has made major contributions to the body of knowledge regarding worker safety in healthcare settings. Underrepresented is evidence that the knowledge has had widespread uptake by relevant user groups and most importantly, resulted in adherence to best practice recommendations. The panel recommends that NIOSH consider funding research to better understand adherence prevalence and factors associated with adherence. Additionally, there is a growing literature in the area of implementation science that involves the study of methods to promote the adoption and integration of evidence-based interventions, best practices, and policies into healthcare and public health settings. This field of research identifies the facilitators of and barriers to the adoption, implementation, and sustainability of effective interventions and then develops evidence-based innovations that address those factors. A focus on this area in the future may help the Institute better protect worker safety and health in this sector. The panel noted that there can sometimes be a significant difference between enacted regulation and actual practice adoption.

Providing easy access to information is important. However, it may not be reasonable to assume that downloads and literature citations translate into implementation. Journal article citations, in particular, may not mean that providers used the research. Instead, it is possible that a significant number of the citations may be secondary to academic research.

In general, the impact of staffing, both related to actual ratios and team member composition (contract/temporary labor vs. permanent) is a relevant area of study as related to workplace injury and illness and may be worthy of further study.

The Evidence Package made several references to the finding that existing regulations may be either inadequate or not effectively enforced. While NIOSH is not an enforcement agency, there may be opportunities to study factors that enhance the likelihood of adoption of required practices.

While the panel fully appreciated the difficulties in measuring impact beyond intermediate outcomes, there was consensus that further consideration to address this gap (i.e., relative absence of actual reduction in worker injury and illness) be seriously undertaken. For example, measuring participants' satisfaction with a training program is not a reasonable proxy for actual adoption of the recommended procedures. Likewise, web hits and downloads of materials cannot reasonably be translated into adherence to best practices or reductions in injury and

illness (this may particularly be true when one considers the size of the target audience and compares the frequency of web hits or distribution requests for the materials).

Panel members identified the following areas for possible research in the future:

- Evaluation of successful leadership behaviors present during healthy organizational change. Individual workers may not have sufficient influence to change safety culture and workplace policies themselves.

- Better knowledge regarding the nature of occupational exposures to hazardous drugs and chemicals in specific health occupations and tasks.

- Adequacy of training for all categories of staff, especially those potentially at highest risk due to limited education and/or English as a second language.

- Evaluation of the adequacy of surveillance of employee exposures to hazardous materials.

- Evaluation of worker safety in healthcare settings outside of acute and long-term care.

- Effectiveness of existing regulations.

- Implementation studies to determine how best to translate interventions into practice. This should include identifying facilitators of and barriers to workers' adherence to guidelines and best practices, and evidence-based innovations to address those barriers and increase adherence.

- Study of cultural behaviors associated with better-than-benchmark worker injury and illness experience rates.

- Workplace violence is an increasing vulnerability within healthcare. The definition is broad and may include horizontal non-physical violence such as bullying, and serious violence that results in severe or permanent physical disability and/or death. More detailed study of specific interventions related to workplace violence and effectiveness strategies stratified by type of violence, may be helpful.

- There appears to be absence of study about human factors and high reliability science. This area of study has been useful in preventing inadvertent patient harm, and there may be benefit to studying this area of science as it relates to worker safety.

- Much of the past research is focused on nurses. There is an opportunity to study the many other providers in the healthcare environment.

- The effectiveness of "Just Culture" (26) environments as a tool for improving the likelihood of reporting safety risks and failures may be useful.

- Implications of ratios and unintended consequences relative to non-nurse staffing may be important.

- Learned resilience behaviors and potential links to work stress and fatigue.

- Anthropological research regarding observed vs. reported work behaviors and links to worker safety.

- Adequacy of healthcare training programs (RN, pharmacist, etc.) with respect to self-care and hazard awareness in the workplace.

- Evaluation of interactive and digital platforms (e.g., game-based learning) for knowledge acquisition and translation into practice.

- Simulation is not a prevalent area of study with regard to impact and perhaps worthy of further review.

The panel also suggested NIOSH consider the following:

- Partnerships with large healthcare systems to study education and training curriculum adequacy and impact.

- Expanding and acknowledging the partnership of labor unions in future documents. Labor unions have actively participated in HCSA work by providing NIOSH access to at-risk populations; helping frame the "real-world" environment for researchers; advocating for implementation of recommended guidelines with employers; advocating for regulation adoption, including findings as part of collective bargaining; and sharing NIOSH findings at various settings, such as state, local and national labor federation events.

Acknowledgements

Thank you for this opportunity to evaluate the NIOSH Healthcare and Social Assistance Program. The panel was honored to review the program, and all members expressed appreciation for the depth and breadth of the work of NIOSH. The panel was also grateful for the expertise and deep conviction of the NIOSH researchers. We look forward to seeing the results of the next phase of work.

References

(1) National Institute for Occupational Safety and Health. (2016). *NIOSH strategic goals and objectives (2016-2020)*. 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/about/

(2) National Institute for Occupational Safety and Health. *NORA Healthcare and Social Assistance Sector Council* [webpage]. Retrieved October 29, 2017 from https://www.cdc.gov/niosh/nora/councils/hcsa/

(3) Weissman, D. N. (2017, May 2). NIOSH Healthcare and Social Assistance Program. Presentation at NIOSH Program Review Panel Meeting, Atlanta, GA.

(4) Mayne, J. (2011). Contribution Analysis: Addressing cause and effect. In K. Forss, M. Marra, & R. Schwartz (Eds.), *Evaluating the complex: Attribution, contribution, and beyond* (Vol. 18, pp. 53-96). New Brunswick, NJ: Transaction Publishers.

(5) NORA Healthcare and Social Assistance Sector Council (2009). 2009 state of the sector: Healthcare and social assistance report (DHHS (NIOSH) Publication No. 2009–139). 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/2009-139/pdfs/2009-139.pdf

(6) Bureau of Labor Statistics. *Census of fatal occupational injuries (CFOI) - Current and revised data.* Retrieved on October 29, 2017 from https://www.bls.gov/iif/oshcfoi1.htm

(7) National Institute for Occupational Safety and Health. (2017, April). Overview of the National Institute for Occupational Safety and Health (p. 8). In *NIOSH Healthcare and Social Assistance Program: Evidence Package for 2006-2016.*

(8) Rubio, D. M., Schoenbaum, E. E., Lee, L. S., Schteingart, D. E., Marantz, P. R., Anderson, K. E., Platt, L. D., Baez, A., & Esposito, K. (2010). Defining translational research: Implications for training. *Academic Medicine: Journal of the Association of American Medical Colleges, 85*, 470–475.

(9) Occupational Safety and Health Act. *OSH Act of 1970*. Retrieved on October 29, 2017 from https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=OSHACT

(10) The Joint Commission. (2012). *Improving patient and worker safety: Opportunities for synergy, collaboration and innovation. The Joint Commission Monograph*. Oakbrook Terrace, IL: The Joint Commission. Retrieved from http://www.jointcommission.org/assets/1/18/TJC-ImprovingPatientAndWorkerSafety-Monograph.pdf

(11) National Institute for Occupational Safety and Health. (2013). *Workplace violence prevention for nurses* (NIOSH Publication No. 2013-155). Retrieved from https://www.cdc.gov/niosh/topics/violence/training_nurses.html

(12) Laramie, A. K., Bednarsh, H., Isman, B., Boiano, J. M., & McCrone, S. H. (2016). Use of bloodborne pathogens exposure control plans in private dental practices: Results and clinical implications of a national survey. *Compendium of Continuing Education in Dentistry*, *38*(6), 398-407.

(13) NORA Healthcare and Social Assistance Sector Council. (2009). *State of the sector | Healthcare and social assistance: Identification of research opportunities for the next decade of NORA,* (DHHS (NIOSH) Publication No. 2009–139). 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/2009-139/pdfs/2009-139.pdf

(14) NORA Healthcare and Social Assistance Sector Council. (2013). *National occupational research agenda (NORA). National healthcare and social assistance agenda.* Retrieved from https://www.cdc.gov/niosh/nora/comment/agendas/hlthcaresocassist/pdfs/HlthcareSocAssistFeb2013.pdf

(15) Quinn, M. M., & Henneberger, P. K. (2015). Cleaning and disinfecting environmental surfaces in health care: Toward an integrated framework for infection and occupational illness prevention. *American Journal of Infection Control, 43*(5), 424-434.

(16) 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/pdfs/2012-118.pdf

(17) Myers, D. J., Lipscomb, H. J., Epling, C., Hunt, D., Richardson, W., Smith-Lovin, L., & Dement, J. M. (2016). Surgical procedure characteristics and risk of sharps-related blood and body fluid exposure. *Infection Control and Hospital Epidemiology, 37*(1)*,* 80-87.

(18) National Institute for Occupational Safety and Health. (2010). *Slip, trip, and fall prevention for healthcare workers*, (DHHS (NIOSH) Publication No. 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/pdfs/2011-123.pdf

(19) NIOSH, Collins, J. W., Nelson, A., & Sublet, V. (2006). *Safe lifting and movement of nursing home residents*, (DHHS (NIOSH) Publication No. 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

(20) NIOSH, VHA, ANA, Waters, T. R., Nelson, A., Hughes, N., & Menzel, N. (2009). *Safe patient handling training for schools and nursing*, (DHHS (NIOSH) Publication No. 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/pdfs/2009-127.pdf

(21) National Institute for Occupational Safety and Health. (2010). *NIOSH hazard review: Occupational hazards in home healthcare*, (DHHS (NIOSH) Publication No. 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/pdfs/2010-125.pdf

(22) National Institute for Occupational Safety and Health. (2012). *NIOSH list of antineoplastic and other hazardous drugs in healthcare settings 2012*, (DHHS (NIOSH) Publication No. 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 https://www.cdc.gov/niosh/docs/2012-150/pdfs/2012-150.pdf

(23) National Institute for Occupational Safety and Health. (2013). *Workplace solutions – Medical surveillance for healthcare workers exposed to hazardous drugs,* (DHHS (NIOSH) Publication No. 2013-103). 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/wp-solutions/2013-103/pdfs/2013-103.pdf

(24) Conner, T. H., Lawson, C. C., Polovich, M., & McDiarmid, M. A. (2014). Reproductive health risks associated with occupational exposures to antineoplastic drugs in health care settings: A review of the evidence. *Journal of Occupational and Environmental Medicine/American College of Occupational and Environmental Medicine, 56*(9)*, 901-910.*

(25) Kohn, L.T., Corrigan, J. M., & Donaldson, M. S. (Eds). (1999). *To err is human: Building a safer health system.* Washington, DC: National Academy Press, Institute of Medicine. Retrieved from http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/1999/To-Err-is-Human/To%20Err%20is%20Human%201999%20%20report%20brief.pdf

(26) Marx, D. (2001). *Patient safety and the "Just Culture:" A primer for health care executives: Medical Event Reporting System - Transfusion Medicine (MERS-TM)*. New York: Columbia University.

(27) National Institute for Occupational Safety and Health. (2015). *NIOSH training for nurses on shift work and long work hours* [online training]*.* Available from https://www.cdc.gov/niosh/work-hour-training-for-nurses/

(28) Arnetz, J. E., Hamblin, L., Russell, J., Upfal, M. J., Luborsky, M., Jannisse, J., & Essenmacher, L. (2017). Preventing patient-to-worker violence in hospitals: Outcome of a randomized controlled intervention. *Journal of Occupational and Environmental Medicine, 59*(1), 18-27.

(29) Gillepsie, G. L., Gates, D. M., Kowalenko, T., Bresler, S., & Succop, P. (2014). Implementation of a comprehensive intervention to reduce physical assaults and threats in the emergency department. *Journal of Emergency Nursing, 40*(6), 586-591.

(30) NIOSH, Caruso, C. C., Geiger-Brown, J., Takahashi, M., Trinkoff, A., & Nakata, A. (2015). *NIOSH training for nurses on shift work and long work hours*, (DHHS (NIOSH) Publication No. 2015-115). 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/2015-115/

(31) Glanz, K. & Bishop, D. B. (2012). The role of behavioral science theory in the development and implementation of public health interventions. *Annual Review of Public Health, 21*, 299–418.

(32) Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: A scoping review. *Health Psychology Review, 9*(3), 323-344.

(33) Fisher, J. D. & Fisher, W. A. (1992). Changing AIDS-risk behavior. *Psychological Bulletin*, 111(3), 455-474.

(34) Fisher, W. A., Fisher, J. D., & Harman, J. (2003). The information-motivation-behavioral skills model: A general social psychological approach to understanding promoting health behavior. In J. Suls & K.A. Wallston (Eds.), *Social psychological foundation of health and illness* (pp. 82-106)*.* Malden, MA: Blackwell.

(35) Rosenstock, I. M. Historical origins of the health belief model. (1974). *Health Education Monograph*s, 2, 328–335.

(36) Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social learning theory and the health belief model. *Health Education & Behavior, 15*(2), 175–183.

(37) Champion, V. & Skinner, C. S. (2008). The health belief model. In K. Glanz, B. Rimer, & K. Viswanath (Eds.), *Health behavior and health education* (pp. 45-65). San Francisco, CA: Jossey-Bass.

(38) Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50, 179-211.

(39) Ajzen, I. (2002). Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior. *Journal of Applied Social Psychology, 32*, 665-683.

(40) Prochaska, J. O. & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion, 12*(1), 38–48.

(41) Prochaska, J. O. & DiClemente, C. C. (2005). The transtheoretical approach. In J. C. Norcross & M. R. Goldfried (Eds.), *Handbook of psychotherapy integration. Oxford series in clinical psychology* (2nd ed., pp. 147-171). Oxford, New York: Oxford University Press.

(42) Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

(43) Bandura, A. (2001). Social cognitive theory: An agentive perspective. *Annual Review of Psychology, 52*, 1-26.

(44) Kitson, A. L., Harvey, G., & McCormack, B. (1998). Enabling the implementation of evidence-based practice: A conceptual framework. *Quality in Health Care, 7*, 149–158.

(45) Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: The RE-AIM framework. *American Journal of Public Health, 89,* 1322–1327.

(46) Green, L. W. & Kreuter, M. W. (2005). *Health program planning: An educational and ecological approach*. New York: McGraw-Hill.

(47) Wandersman, A., Duffy, J., Flaspohler, P., Noonan, R., Lubell, K., Stillman, L., Blachman, M., Dunville, R., & Saul, J. (2008). Bridging the gap between prevention research and practice: The interactive systems framework for dissemination and implementation. *American Journal of Community Psychology, 41*(3-4), 171-81.

(48) Damschroder, L. J., Aron, D. C., Keith, R. E., Kirsh, S. R., Alexander, J. A., & Lowery, J. C. (2009). Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implementation Science,* 4(1), 50.

(49) Proctor, E., Silmere, H., RaghaVan, R., Hovmand, P., Aarons, G., Bunger, A., et al. (2011). Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Administration and Policy in Mental Health, 38*, 65–76.

(50) National Institute for Occupational Safety and Health. *Medical surveillance for healthcare workers exposed to hazardous drugs*, (DHHS (NIOSH) Publication No. 2013-103). 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/wp-solutions/2013-103/pdfs/2013-103.pdf

(51) Boiano, J. M., Steege, A. L., & Sweeney, H. (2014). Adherence to safe handling guidelines by healthcare workers who administer antineoplastic drugs. *Journal of Occupational and Environmental Hygiene, 11*(11), 728-740.

(52) Boiano, J. M., Steege, A. L., & Sweeney, H. (2015). Adherence to precautionary guidelines for compounding antineoplastic drugs: A survey of nurses and pharmacy practitioners. *Journal of Occupational and Environmental Hygiene, 12*(9), 588-602.

(53) U.S. Pharmacopeia Convention. (2016). *2016 USP compounding compendium.* Available from http://www.iacprx.org/news/273641/2016-USP-Compounding-Compendium-with-General-Chapter-800-Now-Available.htm

(54) Centers for Disease Control and Prevention. (2009). Interim recommendations for facemask and respirator use to reduce 2009 influenza A (H1N1) virus transmission. Retrieved from https://www.cdc.gov/h1n1flu/masks.htm

Appendix 1

NIOSH Healthcare and Social Assistance Program Panel Scoresheet

Relevance

Did the HCSA Program appropriately set priorities based on burden and need?

5 = The rationale for the activities completed by the program are highly justified.

4 = The rationale for the activities completed by the program are justified.

3 = The rationale for the activities completed by the program are moderately justified.

2 = The rationale for the activities completed by the program are minimally justified.

1 = The rationale for the activities completed by the program are not justified.

4.5 = **Average Panel Relevance Score**

Impact

How engaged was the HCSA Program in transferring research into the workplace? Has (or is it likely in the future) that the HCSA Program's activities and outputs will directly or indirectly lead to improvements in workplace safety and health?

5 = Research program has made major contribution(s) to worker health and safety on the basis of end outcomes or well-accepted intermediate outcomes.

4 = Research program has made some contributions and/or demonstrates great potential to contribute to end outcomes or well-accepted intermediate outcomes.

3 = Research program activities are ongoing and outputs are produced that are likely to result in improvements in worker safety and health. Well-accepted outcomes have not been recorded, but potential for well-accepted outcomes has been demonstrated.

2 = Research program activities are ongoing, and outputs are produced that may result in new knowledge or technology, but only limited application is expected. Well-accepted outcomes have not been recorded, and the potential for well-accepted outcomes is limited.

1 = Research activities and outputs do not result in or are not likely to have any application.

3.5 = **Average Panel Impact Score**

Average Panel Relevance Score + Average Panel Impact Score = Total HCSA Program Score

8.0 = **Total HCSA Program Score**