FINAL PERFORMANCE REPORT

Healthier Workforce Center for Excellence
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Sponsor: National Institute for Occupational Safety and Health

Grant number: U19OH008868

Project Starting and Ending Dates: September 1, 2011 – August 31, 2016

Date of Final Report: May 28h, 2017

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Program Area: Total Worker Health®

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LIST OF TERMS AND ABBREVIATIONS

DOJ	Department of Justice
ETP	Education Translation Project
HWCE	Healthier Workforce Center for Excellence
NIH	National Institute for Health
NIOSH	National Institute for Occupational Safety and Health
TRP	Transdisciplinary Research Project
TWH	Total Worker Health

ABSTRACT

The Healthier Workforce Center for Excellence is one of four “Centers of Excellence to Promote a Healthier Workforce” funded through the National Institute for Occupational Safety and Health. Founded in 2006 by Dr. James Merchant, an international expert in occupational health and safety, the Healthier Workforce Center, through its research and outreach initiatives addresses the implementation, evaluation and dissemination of Total Worker Health®. During the first five years of funding, various activities laid the groundwork for current research and outreach. In particular, regional conferences and state-wide surveys (Merchant et al. 2013, 2014) identified the burden of injuries, illnesses and health care costs to employers, particularly small employers, and the need for evidence-based low cost resources. In our second finding cycle, the HWCE has continued efforts to increase the impact of our funding and enhance the Center’s recognition as a valuable resource for researchers and employers in our region. Internal and external leadership brought together a multidisciplinary team actively engaged in addressing Total Worker Health from basic science to translational research. A Transdisciplinary Research Project has generated preliminary results supporting the benefit of integrating health protection with policies, programs and practices to improve worker health and well-being. Through our Education/Translation Project we have developed and disseminated tools and resources that can be applied across industries, workplaces, and populations to develop, implement, and evaluate programs, policies and practices that benefit workers’ safety, health and well-being, increase productivity, and impact the bottom line. At the same time, HWCE pilot projects have expanded the Center’s activities by addressing a broad a variety of topics and industries highly relevant to Total Worker Health. Throughout the funding period, our Outreach program has worked with and through employers and practitioners within the region to identify and disseminate information relevant to Total Worker Health®.

Significant or Key Finding:
During the past project period (2011-2016) the University of Iowa Healthier Workforce Center matured into a regional and national leader in Total Worker Health®. The goal of the Healthier Workforce Center is to improve understanding of effective, integrated employee health and safety programs and to translate this evidence base into practice for the benefit of employed populations, particularly the small businesses that are the vast majority of businesses in Iowa and other states. This was accomplished through outreach and education activities, a transdisciplinary research project (*Comprehensive Evaluation of an Integrated Health Protection/Health Promotion Program*), an education and translation project (*Promoting Best and Promising Practices*), and a pilot grant program, which funded 18 pilot grants to academic and community researchers. Statewide surveys and focus groups of employees and employers were conducted by our Center (Merchant et al., 2013, 2014) to identify the health and safety practices and **needs** of workplaces, examine their **burden** on employers and employees, and the corresponding **impact** on rising healthcare costs, productivity, and most importantly, worker health and well-being (Merchant et al., 2013, 2014). Although most employers were found to offer worker's compensation insurance to address injuries on the job and promote health protection (95%), fewer employers offer additional health promotion initiatives, including chronic disease management, behavioral health or wellness programs, health screenings/health risk assessments or other programs, particularly small employers. These findings were echoed during a series of site visits subsequently conducted with small Midwest employers (Rohlman et al., 2014). Many employers in our region, as throughout the United States (US Census 2007), are small and represent industries that have been underserved by the occupational safety and health profession (e.g., construction, agriculture).

The Outreach Program has become increasingly significant, particularly among small Iowa employers who feel they lack the information and resources to start worksite health promotion and health protection programs. Through our outreach activities, evidence-based information and resources are translated and disseminated to help fill the informational gap and enable employers, particularly small Iowa employers, to implement programs for their employees. By using multiple online communication strategies (bulletin, website, social media), the Healthier Workforce Center is becoming an online resource for employers and is reaching a growing number of stakeholders (1300+).

The Pilot Program has engaged 18 transdisciplinary research teams throughout Federal Region VII, led to the submission of 10 grant applications across multiple funding organizations, impacted workplaces through the implementation of Total Worker Health® programs, practices and policies, and disseminated results through academic conferences and journals, white papers, policy briefs, 100+ media outlets, and through federal testimony. A new generation of occupational safety and health practitioners and researchers addressing Total Worker Health have been supported through the Pilot Grant Program.

The Planning and Evaluation Core of the Midwest Center provides an organizational structure with clearly defined roles and paths of communication. The structure allows for strategic planning, provides assistance for research and outreach activities, as well as opportunities to build collaborations. The Center leadership and advisory committees includes representation from academia, employers, labor and other intermediary organizations. Advisory meetings are designed to provide regular feedback.

Translation of Finding:
Results from our surveys and focus groups have indicated that employers require tools which allow them to tailor Total Worker Health® programs and policies to the needs and available resources of their specific workplace. Research from our Center has recognized that interventions focusing on the process of implementing Total Worker Health® programs and policies, rather than interventions that target a single behavior, are needed.

During this most recent funding cycle a primary focus of our outreach and educational activities has been the translation of research and practice findings from the Total Worker Health® Centers, including ours, into resources targeting small employers (< 250 employees). This includes the *TWH Essentials*

(www.TotalWorkerHealthEssentials.org), a series of short-videos promoting NIOSH's Total Worker Health® Essentials (http://www.cdc.gov/niosh/twh/essentials.html) and *Total Worker Health In Depth* (http://TotalWorkerHealthInDepth.org), which utilizes a peer-to-peer model and health behavior theories to provide exemplars and testimonials from small businesses that have adopted best practices and shown innovation. The goal is to instruct and persuade other small businesses on how to develop and implement a Total Worker Health® program and address specific topics in more depth. Through our participatory research, education, and outreach activities we established partnerships with regional and national researchers and practitioners.

Potential Outcomes
Since 2011, we have awarded $315,565 to 18 pilot project grantees (10 new investigators, 4 student projects and 4 community partners). Eight follow-up applications were submitted to a range of federal agencies, including NIH, NIOSH, Department of Justice, American Heart Association, and Bureau of Justice. The program successfully engaged new researchers, trainees, and community partners, addressing a variety of topics, many which that were not addressed by Center research projects. These projects have helped us to build a regional presence with projects funded from both Missouri and Nebraska.

In addition, we have had a strong research presence. Our Transdisciplinary Research Project has generated preliminary findings that support the benefits of integrating health protection with policies, programs and practices to improve worker health and well-being. Furthermore, the project identified workplace and work organizational factors that impact employee health and well-being which can be used to direct future targeted interventions. Our pilot grant program successfully engaged new researchers, trainees, and community partners, addressing a variety of topics, many which that were not addressed by Center research projects. These projects have helped us to build a regional presence with projects funded from both Missouri and Nebraska. This has led to our development of a regional center in the next funding cycle.

Intermediate Outcomes
The video series, *TWH Essentials and TWH In-Depth have been widely disseminated throughout the region, nationally and internationally.* Since public release in August 2015, the video series has had over 4000 views. Of those views, the majority have been in Iowa (46%) however, they have been viewed in 46 states and DC as well as 43 countries outside of the United States.

The Outreach Program has helped expand the research foundation for the field of Total Worker Health through the coordination of the Total Worker Health Supplement published in JOEM in November 2013. Manuscripts were based on presentations and conversations from the 2012 TWH™ Symposium and TWH™ Coordinating Committee Meeting, both of which provided a timely opportunity for TWH™ experts to share research and ideas for forwarding the TWH™ agenda.

Background

The Healthier Workforce Center for Excellence is one of four "Centers of Excellence to Promote a Healthier Workforce" funded through the National Institute for Occupational Safety and Health. Founded in 2006 by Dr. James Merchant, an international expert in occupational health and safety, the Healthier Workforce Center, through its research and outreach initiatives addresses the implementation, evaluation and dissemination of Total Worker Health®. During the first five years of funding (2006-2011), various activities laid the groundwork for current research and outreach. Regional conferences and state-wide surveys (Merchant et al. 2013, 2014) identified the burden of injuries, illnesses and health care costs to employers, particularly small employers, and the need for evidence-based low cost resources. This was an important finding given that over 90% of all businesses are considered small businesses (US Census 2012). Consequently, we have focused on the development of activities targeted toward small businesses during the second funding cycle in order to impact the largest number of employers.

Overview

The Healthier Workforce Center is designed to improve understanding of effective, integrated employee health programs and to translate this evidence base into practice for the benefit of employed populations, particularly the small businesses which comprise the vast majority of employers in Iowa and other states. The value of creating integrated health protection and health promotion programs has found support in extensive independent reviews (Sorensen et al., 2013; Anger et al., 2015), yet there remain uncertainties regarding how best to implement such programs, particularly among smaller companies (employing under 250) which do not have the personnel and resources that make corporate-integrated employee health programs successful and cost effective. Our current research and outreach activities have targeted this population.

As described below, the Administration, Planning, and Outreach Core (Administrative Core) provided a structure that supported, guided, and evaluated the progress of all research, education, and outreach activities. The Center consists of a strong, multidisciplinary team of researchers, practitioners, and educators with a range of expertise to protect and preserve worker safety and health from knowledge generation to dissemination. The Administrative Core consisted of Planning and Evaluation which provided Center coordination, leadership and evaluation through internal and external advisors; an Outreach Program, that translated science based findings and provided education through regional and national channels; and a Pilot Grant Program which supported new research projects that utilized both basic and applied research.

During the current funding period (2011-2016), the Center has made substantial progress in addressing all three of its goals which is summarized below.

Goal 1: Implement, evaluate and compare health protection and health promotion models

Goal 2: Identify and promote Total Worker Health® best and promising practices

Goal 3: Serve as a state and national resource center for employee health programs, services, and policies

Goal 1: Implement, evaluate and compare health protection and health promotion models

The Transdisciplinary Research Project, *Comprehensive Evaluation of an Integrated Health Protection/Health Promotion Program,* was led by Dr. Nathan Fethke with support from Dr. Fred Gerr. The project goal was to examine the effects of an integrated health protection (participatory ergonomics) and health promotion (wellness coaching) intervention on: 1) indicators of musculoskeletal health, 2) participation in employer-sponsored chronic disease management programs, and 3) indicators of modifiable health risks among window manufacturing workers (a high risk population). Risk factors for musculoskeletal outcomes have both occupational sources (e.g., forceful manual exertions, biomechanically disadvantageous working postures, and repetitive activities) and non-occupational sources (e.g., obesity and tobacco use). Previous efforts to minimize the occurrence and impact of musculoskeletal outcomes have primarily focused on occupational risk factors, and with inconsistent success, so the integrated approach is warranted. Key innovations of the intervention include the use of digital human modeling software to assist in the recognition and control of biomechanical risk factors, and the use of motivational interviewing during on-site health and wellness coaching for workers.

Enrollment into the study began in early 2012 and data collection concluded in December 2015. Total enrollment includes >300 participants across two study arms – the intervention facility and a concurrent referent facility, both operated by the same organization. Measures of effect were obtained at both the individual and facility levels. Individual data sources included 1) a self-reported questionnaire to collect information about demographics and personal health, musculoskeletal symptoms, occupational psychosocial stress, and general health and well-being (SF36v2), and 2) individual responses to an employer-sponsored health risk appraisal and biometric screening results. Facility data sources included exposure to biomechanical risk factors (via video observation), reported musculoskeletal injuries (i.e., OSHA-recordable), workers' compensation claims information, and health insurance claims information.

Early work demonstrated that ergonomics training improved non-experts' ability to recognize the potential for musculoskeletal harm in production tasks at the facility (Fethke et al., 2013), leading to several instances in which digital human modeling was used to rapidly explore alternatives for task redesign (Schall et al., 2016). Repeated video-based observation of production tasks over time suggested 1) a seasonal variation in levels of exposure to biomechanical risk factors and 2) a trend of decreasing exposure levels for certain body areas (e.g., the distal upper extremity) among the tasks in the intervention facility.

The study team conducted nearly 400 in-person health and wellness coaching sessions on topics of the employee's choice among 70 participants in the intervention facility. Preliminary analyses of coaching activities found that physical activity was initially the most frequent topic discussed. However, from Spring 2013 through Fall 2013, stress emerged as the most frequent topic (Figure 1). Consistent with the emergence of stress as the most frequent topic discussed, the mental component score from the SF36v2 also decreased (after three consecutive rounds of increases) (Branch et al., 2014). This trend was not observed among participants in the control facility. Management turnover at the intervention facility one month prior to the Spring 2013 data collection likely contributed to this interesting observation. These results demonstrated the need for stress-related policies and for delivery of stress-related programming. Management at the intervention facility has stated that the project has resulted in their enhanced awareness of the impact of incorporating a continual ergonomic assessment of workstations for reducing musculoskeletal problems.

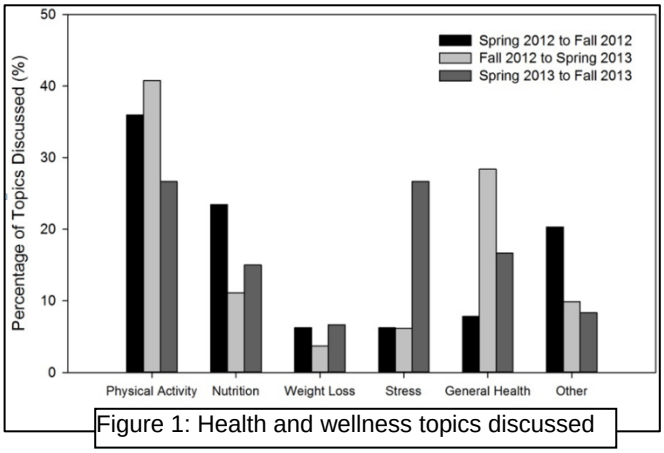

Figure 1: Health and wellness topics discussed

In sum, this Transdisciplinary Research Project has generated preliminary results supporting the benefit of integrating health protection with policies, programs and practices to improve worker health and well-being. Furthermore, workplace and work organizational factors that impact employee health and well-being were identified which can be used to direct targeted interventions. More detail about this project can be found in the final report for the Transdisciplinary Research Project, *Comprehensive Evaluation of an Integrated Health Protection/Health Promotion Program.*

Goal 2: Identify and promote Total Worker Health® best and promising practices

The overall goal of the Education and Translational Project, *Promoting Best and Promising WorkLife Practices*, led by Drs. Rohlman and Campo, is to speed dissemination and translation of evidence-based practices of integrated approaches to health protection and health promotion.

During the first two years of the grant we addressed the needs of members of the Healthier Workforce Learning Network, a consortium of stakeholders cultivated during the first five years of the Center. WorkLife Forums were conducted (September 2011-May 2012) addressing: Wellness Resources in Iowa; Onsite Clinics and Wellness Programming for Public Employers; Comprehensive Tobacco Cessation Programs; Integrated Workplace Health Promotion and Health Protection Programs; and Safe Patient Lifting Program. In addition, the Center offered tutorials through the Patient Education Institute addressing WorkLife/Total Worker Health®

topics, with a reach of over 250,000 viewers. However, viewers were primarily healthcare providers and not employers, our target audience. Therefore, due to new technology, changes in leadership, and feedback from the External Advisory Committee, it was decided to change formats to address a broader audience, specifically targeting employers of small-and medium-sized businesses. The Healthier Workforce Learning Network continues to expand and to regularly receive resources from the Center.

The majority of employers in the US and in Iowa consist of small businesses, defined as less than 500 employees, with limited resources for programs addressing safety and health promotion (Merchant et al., 2013). Although integrated programs have been shown to benefit employee safety, health, and well-being (Anger et al., 2015), small employers often lack these programs. Conveying information to managers, particularly in small businesses, about evidence-based programs is an important component of the NIOSH Total Worker Health® Program. Unfortunately, information products intended for managers are often merely abbreviated versions of scientific reports that leave the targeted audience at a loss as to how to improve their day-to-day operations. Additionally, managers in small businesses are often inundated with information from wellness program vendors who claim to have the programs and expertise to improve employee health and well-being but lack evidence-based findings. This need led us to develop resources targeting small employers that provide practical, and in some cases, low-cost solutions that can be easily implemented, and an approach to track progress and program evaluation.

To reach employers, we engaged a variety of online resources: eBulletins, websites, memorable domain names, search engine optimization, social media and online videos. The online video series, *Total Worker Health Essentials* (http://TotalWorkerHealthEssentials.org) and *Total Worker Health In Depth* (http://TotalWorkerHealthInDepth.org), used a peer-to-peer model and health behavior theories to provide exemplars and testimonials from small businesses that have adopted best practices and shown innovation. The goal was to instruct and persuade other small businesses on how to develop and implement a Total Worker Health® program and address specific topics in more depth. More than 28 site visits to small employers (< 250 employees) in Federal Region VII were conducted. In addition, we conducted interviews with more than 60 experts from organizations providing safety and health resources to small employers, as well as academic and government experts. These interviews were independently reviewed and coded by study investigators (Campo, Rohlman) using the NIOSH *Essential Elements* in combination with health behavior theories to identify elements that illustrate the change process, the benefits to employers and employees, how they overcame obstacles, and lessons learned and recommendations for other small employers. These were used to develop the video series. The videos include a cross-section of workplace sectors (Rohlman et al., 2014) and provide guidance for employers on implementing Total Worker Health programs, practices and policies. The video series was reviewed by the Healthier Workforce Center Internal and External Advisory Committees, employers and practitioners in Federal Region VII, and federal government employees. Videos were disseminated through the Healthier Workforce Learning Network, the College of Public Health Business Leadership Network, social media, NIOSH eNews, American Public Health Association, other media outlets, and national meetings.

Goal 3: Serve as a state and national resource center for employee health programs, services and policies

The Outreach Program worked closely with the Education and Translational Project and aimed to promote Total Worker Health®, translate research into practice, and disseminate evidence-based practices and resources through multiple communication channels. Modalities for communicating information were designed to provide employers and stakeholders with evidence-based programs, practices, and policies, presented in lay language via appropriate channels. This was accomplished through the distribution of eBulletins, website, social media channels, presentations, conferences, manuscripts, service on committees, partnerships and collaborations, and consultations with employers. In the last five years we have:

- Distributed over 30 eBulletins.
- Redesigned the website to provide easy access to research, resources and low-cost solutions related to Total Worker Health®. The new site includes 150+ pages, with new pages and content added monthly. Audience traffic has continually increased, particularly with the launch of the video series.

- Promoted regional and national Total Worker Health® events and activities, new research findings, and resources for employers through social media.
- Presented research and promoted Total Worker Health® through invited and peer-reviewed presentations at local to international venues.
- Cultivated and engaged regional and national partners through committees, meetings, and conferences

The Healthier Workforce Center is recognized as a state and national resource for Total Worker Health®, particularly for employers and intermediary organizations (providers of services) such as public health departments, wellness vendors, safety councils, insurance companies, and municipalities. These organizations are already providing services to small employers, so Total Worker Health® information and resources from the Center can be added or integrated into their current programming and viewed as a value-added service.

Leadership Transitions
The Healthier Workforce Center was founded and directed by Dr. James Merchant from 2006 to 2014. In 2013, in anticipation of his planned retirement, Dr. Merchant initiated a transition plan for the leadership of the Center in which Dr. Diane Rohlman assumed the role of Associate Director in 2013, and became the Center Director in December 2014. In 2013, with the retirement of Dr. Tom Cook from the department of Occupational and Environmental Health, a second leadership transition also took place. Dr. Shelly Campo and Dr. Rohlman assumed leadership of the Education and Translation Project. Their complementary expertise in intervention research addressing workplace safety and health promotion and health communication enabled the utilization of the most up-to-date technology, social media, and health behavior change theories to develop resources to address the needs of small employers, a need previously identified by the Center.

The remainder of this report will present methods and results for the three components of the Administrative Core: Planning and Evaluation, Outreach and Pilot Grants.

Methods

Planning and Evaluation
The Planning and Evaluation activities of the Healthier Workforce Center in the past project period were carried out through weekly meetings of members of the Administrative Core, monthly meetings with the Internal Advisory Committee, and annual meetings with the External Advisory committee who are also consulted on an as-needed basis.

Administrative Core: Members of the Administrative Core met weekly to plan and maintain daily operations of the Center (Director: Merchant 2011-2014, Rohlman 2014-2015; Associate Director: Rohlman 2013-2014; Deputy Director: Fethke; Center Coordinator: Kelly; Outreach Coordinator: Hall 2012-2015). These meetings were used to: oversee fiscal and resource management, and annual reporting requirements; plan, coordinate and monitor Center activities including outreach activities; and administer the Pilot Grant Program, including soliciting proposals, reviews, monitoring IRB activities and tracking progress. In addition, agendas for both Internal and External Advisory Meetings are developed during these meetings to ensure an effective flow of communication and synchronization among these groups.

Internal Advisory Committee: Monthly Internal Advisory Committee meetings included Project PIs, key research staff, and members of the evaluation team. These meetings were used to provide project updates, discuss upcoming activities and events, track evaluation of Center activities, and to coordinate and plan Center activities (e.g., the 2012 Total Worker Health Symposium® hosted by the Healthier Workforce Center, editorial activities and participation in regional and national meetings).

Each month, Project PIs were asked to provide research updates describing current activities, challenges, and outputs. In addition, pilot grant awardees were asked to present research updates to the Internal Advisory Committee. This allowed the Committee to provide feedback and guidance as needed. During 2013-2014, the Healthier Workforce Center website was revised and meetings were used to discuss updates, addressing both

format and content, and to review design and layout features. Potential collaborators were also invited to these meetings to provide information to the Committee about their activities and to discuss opportunities to engage with the Center. In January 2015, following the Center leadership transition, the monthly meetings were used to conduct strategic planning, including a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) among all members of the Center. This was an opportunity to evaluate the current progress of the Center, planned activities, and to accelerate preparations for the upcoming Center renewal.

External Advisory Committee: Annual meetings of the External Advisory Committee have been held since 2007 and advisors received Center updates through the delivery of the eBulletin. The second funding cycle demonstrated continuity from the first cycle, as all the advisors from the first cycle remained on the committee (Table 1). Due to retirements and to address the expanded scope of the Center, additional experts were invited to join the committee. Based on the results of statewide surveys (2010-2012), which identified a need to focus resources and dissemination activities towards small businesses, the Committee expanded to include employers, practitioners, and stakeholders from organizations that interact with workplaces, particularly small businesses. Several new members were also identified through the collaborations developed through Outreach and the Education and Translational Project.

Table 1. External Advisory Committee members and affiliations.

Member	Since	Affiliations
Wes Alles, PhD	2006	Stanford University
Jane Lipscomb, RN, PhD	2006	University of Maryland
Michael Parkinson, MD, MPH	2006	Lumenos
Nico Pronk, PhD	2006	HealthPartners Health Behavior Group
Martin Sepulveda, MD	2006	Global Wellbeing Services & Global Health Benefits, IBM
Barbara Silverstein, PhD, MPH, CPE	2006	Dept of Labor & Industries, Olympia, WA
Peter Wald, MD, MPH	2006	USAA
Neal D. Kohatsu, MD, MPH	2008	California Dept of Health Services
Bradley Evanoff, MD MPH	2014	Washington University-St Louis
Lauren Gant, PhD, CPE	2015	Allsteel (a division of the HNI Corporation
Lori Hoffman, PHR	2015	Cedar Falls Utilities
Tonya Vyhlidal, MEd	2015	Nebraska Safety Council
Ryan Picarella, MS, SPHR	2015	WELCOA

Evaluation

Evaluation of the Center progress occurred on a regular basis through the collection of both process and outcome data (qualitative and quantitative). The Center Evaluation Plan was designed with a “nested” case study design, with activities of individual research and translational projects “nested” within the case study design of Center activities. Processes and products were monitored through five mechanisms:

1) An online reporting system developed to track project outputs and outcomes across all NIOSH funded centers in the Department of Occupational and Environmental Health (Healthier Workforce Center, the Great Plains Center for Agricultural Health, and the Heartland Center for Occupational Health and Safety). Center members report their activities each month, and the online system allows the evaluation teams of the three centers to efficiently generate reports best suited to their needs.
2) A formal evaluation of the Center Projects and Cores that was conducted in mid-funding cycle (2013). At that time, progress was reviewed through in-depth interviews of Center members conducted by Drs. Parker and Kelly.
3) Monthly meetings of Center personnel during which project and core directors report on activities and issues from the preceding month.
4) Mandatory mid-year and final formal reporting of progress by pilot grant recipients, capped by a formal presentation of findings at a monthly Center meeting.
5) Regular communications between evaluation staff (Parker, Kelly) and Center personnel and advisors. These interactions are noted and reported to the Director and Deputy Director at weekly management meetings.

6) Following the leadership transition, a SWOT analysis was conducted to review current progress of the Center, planned activities, and to begin planning for the renewal.

Information gathered by these various methods formed the bases for discussions at the monthly Internal Advisory Committee meeting, yearly meetings of the External Advisory Committee, and formal regular written reports to NIOSH (e.g., annual progress reports and non-competitive renewals), as well as occasional requests for information from various administrative units (e.g. University, College, Department, NIOSH).

Outreach Program

The program aimed to promote Total Worker Health™, translate research into practice and disseminate evidence-based practices and resources through multiple communication channels. Resources were designed to provide employers and stakeholders with evidence-based resources for creating healthier and safer work environments and promoting healthier and safer lifestyles for their employees and their families. Outreach and communication activities included, distribution of a monthly e-bulletin, the HWCE website, social media channels, presentations, conferences, manuscripts, serving on committees, developing partnerships/collaborations, and providing guidance to organizations in the community pilot project program.

All outreach activities were informed by input from the Internal and External Advisory boards. Through their input and through input from the evaluation team, several modifications were made to the outreach activities, including the website redesign and the shift in the Education and Translational Project from low bandwidth live PowerPoint presentations to short YouTube videos tailored for specific business environments. A range of communication activities were used that fit the topic and audience including lunch and learns, classroom lectures, seminar speakers, webinars, service on committees, online resources including more traditional and more active learning resources, social media, sample policies, programs and practices, consultations, and the development of the video series, all based on formative and process evaluation to be sure we were meeting various needs throughout the region.

Pilot Grant Program

The Healthier Workforce Center's Pilot Project Program was included in the 2011-2016 funding cycle as an activity within the Center's Administrative Core. While there were no explicit Specific Aims associated with the Pilot Project Program in the Center's 2010 competing renewal application, the stated purpose of the Pilot Project Program was to serve as an incubator for new research, intervention, outreach, education, evaluation, and translation activities consistent with Total Worker Health®. The program was led by the Center Deputy Director (Fethke), with administrative support from the Center Coordinator (Dr. Kevin Kelly) and the Center Administrator (Ms. Mindy Sickels). The Administrative and Planning Core budget included $50,000 annually to support the Pilot Project Program, which was allocated entirely to funded projects (i.e., the program did not incur other costs, such as salary support for Center faculty and staff).

As proposed, we modeled the program after a similar program operated by the NIEHS-funded Environmental Health Sciences Research Center at the University of Iowa. The Pilot Project Program aimed to fund three types of projects: 1) new investigator research awards for junior faculty, post-doctoral trainees and graduate students, 2) community-based projects, and 3) small student research projects. We developed a request for proposals (RFP) in early in Year 1 (Fall 2011) of the project period, drawing from examples provided by two other NIOSH-funded centers housed in the Department of Occupational and Health: the Heartland Center for Occupational Health and Safety (an Education and Research Center) and the Great Plains Center for Agricultural Health. All applications were reviewed through a standardized process and evaluated on NIH criteria. Once an applicant is notified of their award, Center staff was available to assist with the IRB process, study design and analyses, developing strategies to remediate barriers to progress, and dissemination of findings.

The review criteria as outlined in the 2010 competing renewal application included: originality and scientific relevance; validity and reliability of methods; qualifications of investigators; relevance to the Healthier Workforce Center, WorkLife (the former name of the Total Worker Health® program) and the NIOSH National Occupational Research Agenda (NORA) priorities; interdisciplinary nature of research; potential for future

extramural funding; and appropriateness of the budget. The pilot project proposals were independently reviewed and rated by three faculty/staff experts within the Center, with a formal discussion at a special Internal Advisory Committee meeting. Experts external to the Center were also sought to review applications addressing topics outside the expertise of those within the Center. During this process, reviewers evaluated the significance, investigator background, innovation, approach, and environment of the work, scoring each project proposal in a manner consistent with NIH scoring procedures for evaluation of grant applications. Due to the relative newness of the Total Worker Health® program in 2011, discussion during the review meetings also addressed the relevance of each proposal to Total Worker Health®.

Results

Center Accomplishments: In brief, during the current funding cycle members of the Healthier Workforce Center have:

- Published 20 articles addressing Total Worker Health®.
- Delivered more than 70 Total Worker Health® presentations at local, regional and national meetings.
- Submitted 15 grant applications, five from Center pilot grant awardees, to federal agencies (NIH, NIOSH, DOJ, AHA, BOJ) addressing Total Worker Health®; seven were funded and three are pending.
- Promoted Total Worker Health® by serving on over 25 local, regional, national, and international committees addressing occupational safety, occupational health, and health promotion
- Hosted the first conference convening researchers from NIOSH and all four Centers of Excellence (*Total Worker Health Symposium: Safe, Healthy and Cost-Effective Solutions* 2012, Coralville, IA)
- Coordinated and edited the publication of a Total Worker Health® Supplement in the *Journal of Occupational and Environmental Medicine*: this was funded by a NIOSH conference grant.
- Collaborated with NIOSH and other Total Worker Health® Centers to organize and promote the *1st International Symposium to Advance Total Worker Health* (2014, Bethesda, MD).
- Partnered with Heartland Education and Research Center and WORKSAFE Iowa to host a conference uniting occupational health and safety practitioners with representatives from NIOSH Total Worker Health® programs and affiliates (*17th Annual Occupational Health Symposium: Total Worker Health*, 2015, Cedar Rapids, IA).
- Conducted statewide surveys to identify the burden of occupational injury and illness and to identify needs of employed and self-employed workers and employers (http://RealIowans.org).
- Investigated the outcomes of an integrated health protection (participatory ergonomics) and health promotion intervention (motivational interviewing/health coaching) among manufacturing workers, demonstrated a reduction of musculoskeletal pain and also identified important workplace factors that impact health and well-being including seasonal variations due to production demand and management changes.
- Collaborated with small businesses and other content experts to produce a series of 16 peer-to-peer online videos promoting NIOSH's Total Worker Health® essentials (http://TotalWorkerHealthEssentials.org) and addressing specific topics within Total Worker Health® (http://TotalWorkerHealthInDepth.org).
- Awarded $315,565 to 18 pilot project grantees (10 new investigators, 4 student projects and 4 community partners).
- Engaged over 30 researchers from five colleges at the University of Iowa, as well as colleagues at other universities, hospital associations and policy groups in Federal Region VII.
- Disseminated findings from our research and pilot grants were disseminated to over 100 media outlets including the *Atlantic, National Public Radio, Yahoo News, Christian Science Monitor, Consumer Reports on Health,* and *Science Daily.* In addition, testimony was presented at President Obama's task force on 21st-century policing, and shared with safety directors at Fortune 500 companies.

During Years 1 and 2 Internal Advisory meetings were used to plan the 2012 *Total Worker Health Symposium on Safe, Healthy, Cost-Effective Solutions* hosted by the University of Iowa and the subsequent special edition in the *Journal of Occupational and Environmental Medicine* showcasing Total Worker Health®. A supplemental

conference grant from NIOSH was received to pay publishing costs for this special edition. This symposium was the first national meeting addressing Total Worker Health® and involved directors and members from all four Total Worker Health Centers® of Excellence, key NIOSH staff including Director Dr. John Howard, and presentations by then Senator Tom Harkin and Iowa Governor Terry Branstad.

The weekly meetings were also used to identify opportunities to partner with federal and state funded centers and community partners. The department of Occupational and Environmental Health at the University of Iowa is home to three NIOSH funded Centers (the Healthier Workforce Center, the Heartland Center for Occupational Health and Safety an Education and Research Center, and the Great Plains Center for Agricultural Health) as well as a CDC funded Injury Prevention Research Center. At the time we were the only institution in the nation to house all of these centers; this provides a unique opportunity to develop collaborative education and outreach activities across centers. For example, Center investigators have directed research projects, provided academic training, reviewed pilot grant applications, and co-hosted conferences; participated in continuing education opportunities by leading break-out sessions and serving as members of panel discussions at these events; co-hosted departmental seminar speakers; and provided research and practicum opportunities for trainees (Table 2). We are able to cross-promote our activities among these other centers. During Year 4 these meetings were used to plan the *17th Annual Occupational Health Symposium focused on Total Worker Health*™, jointly sponsored by the Healthier Workforce Center and two other NIOSH funded centers at the University of Iowa, the Great Plains Center for Agricultural Health the Heartland Center for Occupational Health and Safety (an Education and Research Center). In 2016, the three NIOSH centers, the Injury Prevention Research Center and the Department of Occupational and Environmental Health will co-sponsor a student symposium.

Table 2. Collaborative education, research and outreach activities across NIOSH/CDC groups.

ACTIVITY	PARTICIPANTS
Gallup Daily Tracking Poll Extramural-Intramural Collaboration	
Collaborator	Kelly
Great Plains Center for Agricultural Health (U Iowa)	
Director/Deputy Director	Gerr
Pilot Grant Reviewer	Rohlman, Fethke, Kelly, Merchant, Gerr
Project Investigator/Project Director	Fethke, Rohlman, Gerr
Heartland Center ERC (U Iowa)	
Training Program Director	Rohlman, Fethke, Gerr
Pilot Grant Reviewer	Rohlman, Fethke, Merchant, Gerr
Hosted Joint Conference	All
Supported Academic and CEUs	Rohlman, Fethke, Campo, Merchant, Gerr
Injury Prevention Research Center (U Iowa)	
Co-host seminars and academic lectures	Merchant, Rohlman, Fethke
National Children's Center for Rural & Ag Health & Safety (Marshfield)	
Project Investigator for TWH research project	Rohlman, Campo
NIOSH Joint Activities	
Keokuk County Rural Health Study Data Sharing Agreement	Merchant, Kelly
Corresponding Member, NORA AFF Vulnerable Workers	Rohlman
Oregon Health Workforce Center (OHSU)	
Project Investigator for TWH research project	Rohlman
Pilot Grant Reviewer	Rohlman
Internal Steering Committee	Rohlman
Pacific Northwest Agricultural Safety and Health (U Washington)	
Project Investigator for TWH research project	Rohlman
Pilot Grant Reviewer	Rohlman
NIOSH National Construction Center (CPWR)	
Research Consortium Project Director	Fethke
OSH National Construction Center (CPWR)	
Research Consortium Project Director	Fethke

Incorporation of Feedback from Advisory Committees: Throughout the history of the Healthier Workforce Center, both Advisory Committees have played an important role in evaluating Center activities, products and outputs, and disseminating information through their networks. A summary of key input from the External Advisory Committee includes:

- Recommendation to expand the focus of the Center to develop, evaluate and disseminate resources for small businesses and to include small business stakeholders in the External Advisory Committee
- Approval of the proposed leadership transition plans
- Approval of the revised, theory-based approach to the Education and Translation Project, which incorporated peer opinion leaders and state of the art technology to more effectively engage employers
- Review of pre-proposal applications and proposed outreach and educational activities for the current Center renewal application
- Unanimous approval of the expansion of the Healthier Workforce Center to the Midwest Center for a Healthier Workforce to better address regional needs
- Feedback on Center communication, website content and social media including the *Total Worker Health Essentials* video series developed through the Education and Translation Project

Evaluation Activities: Table 3 quantifies the summary of key indicators that the Center evaluated over the 2011-2016 project period. A full enumeration of items is included in the Appendix to the Planning & Evaluation Core of this Center proposal.

Table 3: Key Output Indicators Tracked in Center-Wide Evaluation

Center Outputs	FY1 (2011-12)	FY2 (2012-13)	FY3 (2013-14)	FY4 (2014-15)	FY5 (2015-16)	Total (2011-2016)
Publications	1	1	7	6	5	**20**
Abstracts & Presentations	3	23	15	24	8	**73**
Lectures, Seminars, Webinars & Workshops	0	0	2	9	1	**12**
Grant Submissions	3	1	4	5	3	**16**
Pilot Grants Awarded	4	3	5	3	3	**18**
Instructional Videos	0	0	0	16	2	**18**
Conferences Hosted	0	1	0	1	1	**3**
eBulletins	2	9	12	6	8	**38**

Outreach Activities: The Outreach Program promoted Total Worker Health through several activities including the creation of a new monthly e-bulletin, social media applications (Pinterest & Twitter), website expansion, committee membership, presentations, and conferences. Specific details are described below.

Healthier Workforce e-Bulletin

The Healthier Workforce e-Bulletin was launched in November 2012 and continues to be distributed monthly to the Center's Healthier Workforce Learning Network (HWLN), which includes over 1220 members interested in workplace safety and health.

HWCE Website

In year 4, the HWCE website was redesigned to make the site more user-friendly and easier for audience members to access research, resources and low-cost solutions related to Total Worker Health. The new site includes 150+ pages, with new pages and content added monthly. New topics are guided by the monthly e-Bulletin topics (e.g., heat safety and hydration promotion; sleep promotion and fatigue management; diabetes; cardiovascular well-being; moving more during the workday; office ergonomics; off-the-job safety; and distracted driving). There is also a calendar page with events and professional development opportunities. Audience traffic to the website has increased annually

Social Media

We are using social media (Facebook, Twitter) to promote and engage audience members in our e-bulletin, TWH events/opportunities, TWH research, and videos, resources and opportunities developed under the Education-Translation/Small Business Outreach project.

Presentations

We also translate research and promote center research and resources through invited and peer-reviewed presentations at local, state and national levels. In year 4, we estimate that over 1500 employers, practitioners, safety and wellness professionals, public health professionals, human resource directors, researchers and other stakeholders were reached through presentations.

Partnerships & Collaborations (Committees, Meetings, Conferences)

Active involvement in committees, meetings, and conferences at the local, state and national levels help create connections and foster valuable relationships that are important for advancing Total Worker Health research and best practices. The Outreach Program planned the Total Worker Health® Symposium on Safe, Healthy and Cost-Effective Solutions in November 29-30, 2012 in Coralville, IA. The symposium brought together national experts from across the country and provided a platform for networking and sharing research. In all, over 120 people from 18 states and Washington DC were in attendance. Opening comments from Iowa Senator Tom Harkin and Iowa Governor Terry Branstad and 22 sets of presentation slides are available on the Center website. The Outreach Program also organized and coordinated the peer review and technical review process for the Total Worker Health Supplement published by the Journal of Occupational and Environmental Medicine (JOEM) in November 2013. The supplement is publicly available by open access on JOEM's website and includes opening comments from John Howard, a commentary with expert's views on Total Worker Health, 7 reviews, 4 research articles and 3 research-to-practice articles

We have also collaborated with the University of Iowa Heartland Center for Occupational Safety and Health and WorkSafe Iowa to coordinate and host the 17th Annual Occupational Health Symposium held April 16-17, 2015, in Cedar Rapids, IA. In addition, we have partnered with the Nebraska Safety Council/WorkWell to actively communicate and promote Total Worker Health® in the Midwest. In year 4, the Nebraska Safety Council was named a Total Worker Health® Affiliate. Additional activities included partnering with the Corridor Business Journal for their annual Health Summit and being an active member in both the Linn and Johnson County Worksite Wellness Committee and Mercy Business Solutions Informal Wellness Roundtable. We have also participated in regional and national meetings (e.g., the Iowa Governor's Conference on Public Health [Des Moines, IA], Corridor Business Journal Health Summits [Coralville, IA], Nebraska Safety Council Summits [Lincoln, NE], BJC Wellness Summit [St. Louis, MO], National League of Cities Risk Information Sharing Consortium [Annapolis, MD], Work Stress and Health [Los Angeles, Atlanta], the 2014 NIOSH Total Worker Health® Symposium [Bethesda, MD], and planning for the upcoming Understanding Small Enterprises meeting to be held in 2018).

Pilot Program Activities: During the 2011-2016 project period, the Center awarded 18 pilot project grants from among 34 grant application submissions. This was an average of 3.6 funded projects per year and 6.8 grant application submissions per year. Grants were competitive, as just more than half of all applications received funding. The Center awarded a total of $315,565 across the 18 funded projects. This amount exceeds the amount expressly budgeted (i.e., $50,000 annually or $250,000 total over five years). The additional funds were allocated to pilot projects from carryover funding associated with the Center's Administrative and Planning Core budget. Fourteen of the awarded projects were considered academic (10 new investigator awards and 4 student awards) and four awards were made to community-based organizations. Although the 2011-2016 Center was neither proposed nor executed as a "regional" center, seven of the 18 awards (39%) were led by investigators not affiliated with the University of Iowa (and five from investigators outside of Iowa).

The Pilot Project Program successfully engaged new researchers, trainees, and community partners, addressing a range of topics (e.g., stress, injury, MSDs, infection, emerging workforce, physical activity, workplace violence, hearing loss/occupational illness, workplace policies, programs and practices),

occupational sectors (i.e., healthcare systems and providers, law enforcement and corrections, retail and food service workers, childcare, food processing) and populations (younger workers, immigrant workers, self-employed, employers of small- and medium-sized businesses). Follow-up applications based on these pilots were subsequently submitted to NIOSH, NIDDK, and the DOJ. A synopsis of key performance indicators is included in Table 4.

Table 4. Pilot Project Program Indicators of Success, 2011-2016

Indicator	Outcome
Number of applications and awards	34 applications, 18 awards
Total dollars awarded	$315,565
Number of awards to non-UIowa investigators	7 (39%)
UIowa units receiving awards	4 College of Liberal Arts and Sciences (1 award) College of Nursing (1 award) University of Iowa Hospitals and Clinics (2 awards) College of Public Health (7 awards)
Awards to other academic institutions	3 Washington University in St. Louis (1 award) St. Louis University (2 awards)
Number of awards leading to a follow-up proposal	8 (2 funded, 2 pending)
Number of awards to community partners	4 State Public Policy Group [IA] Iowa Hospital Association Nebraska Safety Council St. Louis Area Business Coalition
Number of awards to students	5 (4 student awards, 1 new investigator award)
Number of peer-reviewed publications	6
Number of scientific presentations	14

As proposed, we established in Year 1 the basic infrastructure to enable ongoing evaluation of the Pilot Project Program. Specifically, we developed databases to track (1) award details [e.g., title and type of award, award amount, time period, IRB approvals], (2) award outputs [peer-reviewed manuscripts, scientific presentations, presentations to practitioner groups, technical reports, policy papers], and (3) award outcomes [e.g., follow-up grant proposals, dissemination of findings by external stakeholders]. In addition, we maintained electronic copies of all program records, including the results of merit reviews and written critiques of proposals. We also created in Year 4 a standardized format for project final reports to facilitate review of the scientific significance of the results and the capturing of project outputs and outcomes.

In 2011, the Total Worker Health® program was still evolving and our new pilot project program experienced some “growing pains.” We received many inquiries in response to the Year 1 RFP, mostly from potential investigators wishing to learn more about the program and how their research may be of relevance. However, relatively few applications were received and several were deemed unresponsive – primarily as a result of failure to demonstrate the integration of health protection with health promotion to improve worker health (the operating definition of Total Worker Health® at the time). We revised the RFP in consultation with our External Advisory Committee, and revisited the language annually as the NIOSH Total Worker Health® office reshaped the program messaging and added resources to its website for potential applicants to reference. In addition, we hosted group meetings to facilitate discussion of research ideas between potential applicants and Center leadership to generate interest and answer questions about the program.

We also engaged the other NIOSH Centers at the University of Iowa for assistance with dissemination of the RFP and insights into how to improve our processes. For example, the Great Plains Center also solicits applications from community organizations and has adopted review criteria for these proposals that are more applicable than those for academic/scholarly proposal. The positive experience of the Great Plains Center in this regard has shaped our approach to the Pilot/Feasibility Program in the current 2016-2021 funding cycle.

In summary, the Pilot/Feasibility Program has made important contributions to the breadth and depth of the Healthier Workforce Center since its inception in 2011, and continual improvement efforts and led to the funding of a number of high-quality and relevant pilot projects during the 2011-2016 funding cycle.

Table 5. Descriptions of Funded Pilot Projects and Project-Specific Outputs/Outcomes

Year 1 (September 2011 – August 2012) – 7submitted, 4 funded	
Type:	New Investigator
Project director:	Sandra Ramey, PhD, RN
Affiliation:	University of Iowa, College of Nursing
Title:	*Evaluating stress resilience: a new worksite intervention to reduce stress and CVD risk factors in Police*
Population:	Law enforcement
Topic area:	Occupational psychosocial stressors
Outputs/Outcomes:	Presentation, grant proposal (DOJ), publication
Type:	Student
Project director:	Katherine Jones
Affiliation:	University of Iowa, College of Public Health, Community and Behavioral Health
Title:	*Integrating health, wellness and protection using wellness champions at Rockwell Collins in Coralville*
Population:	Manufacturing workers
Topic area:	Workplace safety and nutrition
Outputs/Outcomes:	Presentation
Type:	Community
Project director:	Arlinda McKeen
Affiliation:	State Public Policy Group
Title:	*Employer wellness and prevention programs in PPACA exchanges and consumer operated and oriented (CO-OP) programs*
Population:	Employers
Topic area:	Organizational programs, policies and practices
Outputs/Outcomes:	Policy paper
Type:	Community
Project director:	Perry Meyer
Affiliation:	Iowa Hospital Association
Title:	*A survey of hospital-based employee health services*
Population:	Healthcare Providers
Topic area:	Organizational programs, policies and practices
Outputs/Outcomes:	Presentation
Year 2 (September 2012 – August 2013) – 8 submitted, 3 funded	
Type:	New Investigator
Project director:	Sharon Tucker, PhD
Affiliation:	University of Iowa Hospitals and Clinics
Title:	*Worksite physical activity intervention for ambulatory clinic registered nursing staff*
Population:	Healthcare workers
Topic area:	Sedentary behavior
Outputs/Outcomes:	None to report at this time
Type:	New Investigator
Project director:	Lucas Carr, PhD
Affiliation:	University of Iowa, College of Liberal Arts and Sciences, Health and Human Physiology
Title:	*Efficacy of a combined ergonomic health promotion intervention on employee health*

Population:	Office-based computer users
Topic area:	Sedentary behavior
Outputs/Outcomes:	Presentation, publication, K01 proposal, substantial mass media coverage
Type:	Student
Project director:	Deidre Green (Heartland Center trainee, Industrial Hygiene)
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health
Title:	*Personal noise exposure assessment study of food servers in locally owned restaurants*
Population:	Food service workers
Topic area:	Noise-induced hearing loss
Outputs/Outcomes:	Presentation, publication, feature story on University College of Public Health website
Year 3 (September 2013 – August 2014) – 7 submitted, 5 funded	
Type:	Community
Project director:	Tonya Vyhlidal
Affiliation:	Nebraska Safety Council
Title:	*Development of a Total Worker Health program in small organizations*
Population:	Small business owners
Topic area:	Organizational policies, programs and practices
Outputs/Outcomes:	Policy paper, presentation
Type:	New Investigator
Project director:	Ann Marie Dale, PhD
Affiliation:	Washington University in St. Louis, School of Medicine
Title:	*Integrated health protection and health promotion program for grocery store workers*
Population:	Retail grocery
Topic area:	Participatory approach
Outputs/Outcomes:	Presentation, R01 proposal, R21 proposal
Type:	New Investigator
Project director:	Carri Casteel, PhD
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health
Title:	*Prevalence and comprehensiveness of intimate partner violence programs, policies and training in mid-sized U.S. businesses*
Population:	Employers, mid-sized
Topic area:	Workplace violence
Outputs/Outcomes:	Presentation, technical reports
Type:	New Investigator
Project director:	Mark Schall, MS (Heartland Center trainee, Ergonomics)
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health
Title:	*Inertial measurement units as a tool for simultaneous worker health protection and promotion*
Population:	Health care workers
Topic area:	Methods development, physical activity and posture measurement
Outputs/Outcomes:	Presentations (2), publications (2), PhD degree, K01 proposal, faculty position
Type:	Student
Project director:	Sophia Chiu, MD (Heartland Center trainee, Occupational Medicine)
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health

Title:	*Transitioning from school to work: Total Worker Health in young adults*
Population:	Younger workers, emerging workforce
Topic area:	Physical activity and sedentary behavior
Outputs/Outcomes:	Data analyses ongoing

Year 4 (September 2014 – August 2015) – 3 submitted, 3 funded

Type:	New Investigator
Project director:	Matt Nonnenmann, PhD
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health
Title:	*Total Worker Health in home-based childcare workers*
Population:	Small business owners, vulnerable population
Topic area:	Musculoskeletal outcomes, infectious diseases, psychosocial stressors, injury
Outputs/Outcomes:	None yet reported

Type:	New Investigator
Project director:	Lisa Jaegers, PhD
Affiliation:	Saint Louis University, College of Health Sciences, Occup. Science & Occup. Therapy
Title:	*Determining the mental health needs of corrections officers in Missouri for the development of a Total Worker Health program*
Population:	Law enforcement, rural/remote workers
Topic area:	Psychosocial stressors, nutrition, injury
Outputs/Outcomes:	None yet reported

Type:	New Investigator
Project director:	Steven Rippentrop, MD (Heartland Center trainee, Occupational Medicine)
Affiliation:	University of Iowa, College of Public Health, Occupational and Environmental Health
Title:	*Workforce-centered outcomes research*
Population:	Meat processing workers, immigrant and vulnerable workers
Topic area:	Health attitudes, injury
Outputs/Outcomes:	None yet reported

Year 5 (September 2015 – August 2016) – 9 submitted, 3 funded
Note: These projects have been carried over into Year 1 of the 2016-2021 cycle and are ongoing

Type:	New Investigator (intervention)
Project director:	Jeremy Hudson, MA
Affiliation:	Spiritual Services, University of Iowa Hospitals and Clinics
Title:	*A comparative effectiveness study of Response, Resiliency & Resources (RRR) and Critical Incident Stress Debriefing: two programs designed to reduce occupational stress among hospital clinic workers*
Population:	Patient care workers, health care setting
Topic area:	Psychosocial stressors
Outputs/Outcomes:	NA – In progress

Type:	New Investigator (basic/etiologic)
Project director:	Lisa Jaegers, PhD
Affiliation:	St. Louis University, College of Health Sciences, Occup. Science & Occup. Therapy
Title:	*A prospective study of health among newly hired corrections officers*
Population:	Law enforcement workers
Topic area:	Psychosocial stressors, mental health, physical health
Outputs/Outcomes:	NA – In progress

Type:	Community (translational)
Project director:	Melissa Hogan, MPH
Affiliation:	St. Louis Business Health Coalition
Title:	*Dissemination of Total Worker Healt® strategies to Midwest employers: addressing employee health in the 21st century*
Population:	Employers
Topic area:	Translation/dissemination of TWH knowledge and best-practices
Outputs/Outcomes:	NA – In progress

Discussion

Activities of the Healthier Workforce Center conducted during the first five years of funding laid the groundwork for the accomplishments in the current funding cycle. Our research, pilot grant, and outreach activities demonstrated our success in designing, implementing, evaluating, and translating evidence-based practices throughout the region and beyond, impacting the health, safety, and well-being of America's workforce. The Administration, Planning, and Outreach Core provided an organizational structure with clearly defined roles and paths of communication. The structure allowed for strategic planning, provided assistance for research and outreach activities, as well as opportunities to build collaborations. The Center leadership and advisory committees included representation from academia, employers, labor and other intermediary organizations. Regular evaluation of our activities was conducted to continuous develop and evolve our programs and activities.

During this most recent funding cycle a primary focus of our outreach and educational activities was the translation of research and practice findings from the Total Worker Health® Centers, including ours, into resources targeting small employers (< 250 employees). This includes the *TWH Essentials (*www.TWHEssentials.org), a series of short-videos promoting NIOSH's Total Worker Health® Essentials (http://www.cdc.gov/niosh/twh/essentials.html) and best practices. Through our participatory research, education, and outreach activities we established partnerships with regional and national researchers and practitioners.

In addition, we have had a strong research presence. Our Transdisciplinary Research Project has generated preliminary findings that support the benefits of integrating health protection with policies, programs and practices to improve worker health and well-being. Furthermore, the project identified workplace and work organizational factors that impact employee health and well-being which can be used to direct future targeted interventions. Our pilot grant program successfully engaged new researchers, trainees, and community partners, addressing a variety of topics, many which that were not addressed by Center research projects. These projects have helped us to build a regional presence with projects funded from both Missouri and Nebraska.

The Outreach Program is becoming an increasingly significant resource, particularly among small Midwest employers, who are looking for evidence-based, low-cost information and resources to start integrated worksite health promotion and health protection programs. By translating and disseminating research and best practices through multiple online communication strategies (bulletin, website, social media), presentations to diverse audiences, conferences and committees; the Outreach Program is establishing the Healthy Workforce Center's identity as a resource center for Total Worker Health. The program engages a growing number of employers and stakeholders that include human resource directors, business owners, senior management, insurance agents, public health specialists and wellness and safety professionals.

Furthermore, the Outreach Program has helped expand the research foundation for the field of Total Worker Health through the coordination of the Total Worker Health Supplement published in JOEM in November 2013. Manuscripts were based on presentations and conversations from the 2012 TWH™ Symposium and TWH™ Coordinating Committee Meeting, both of which provided a timely opportunity for TWH™ experts to share research and ideas for forwarding the TWH™ agenda. The HWCE is also becoming an expanding resource

for researchers interested in the field of Total Worker Health. New web content and a section in the monthly eBulletin provide recommendations for future research on issues related to Total Worker Health.

Our work with small employers demonstrates one impact of a single partnership. The current educational and translation project conducted interviews with employers and intermediaries throughout the region to identify and develop Total Worker Health® resources for small employers. This led to a partnership with the Nebraska Safety Council who was awarded a community pilot grant to implement and evaluate programs in three small businesses, the results of this project were then disseminated through a conference co-hosted by the Center and the Heartland Education and Research Center to a national audience of health and safety practitioners. The Nebraska Safety Council is now a Total Worker Health Affiliate. Our partnership growth is exponential, starting with a single partner we were able to seed a broad network of Total Worker Health® practitioners. This has led to a continuing partnership and an expansion of the Healthier Workforce Center to become a regional center.

Conclusions

The Healthier Workforce Center, founded in 2006, was one of four “Centers of Excellence to Promote a Healthier Workforce” funded through the National Institute for Occupational Safety and Health. We have developed a strong regional and national resource for Total Worker Health. The internal and external leadership brought together a multidisciplinary team actively engaged in addressing Total Worker Health from basic science to translational research. We believe there is no one size fits all approach to Total Worker Health. Therefore, we have developed tools and resources that can be applied across industries, workplaces, and populations by promoting methods to develop, implement, and evaluate Total Worker Health programs that include policies and practices that benefit workers’ safety, health and well-being, increase productivity, and impact the bottom line.

Publications:

Anger WK, Elliot DL, Bodner T, Olson R, Rohlman DS, Truxillo DM, Kuehl KS, Hammer LB, Montgomery D: [2015] Effectiveness of total worker health interventions. Journal of Occupational Health Psychology. 20(2):226-47.

Carr LJ, Leonhard C, Tucker S, Fethke N, Benzo R, Gerr F: [2016] Total Worker Health intervention increases activity of sedentary workers. American Journal of Preventive Medicine. 50(1):9-17.

Cherniack M, Henning R, Merchant JA, Punnett L, Sorensen GR, Wagner G: [2011] Statement on national worklife priorities. American Journal of Industrial Medicine. 54(1):10-20.

Elliot D, Rohlman D, Parish M: [2015] Focus groups move online: Feasibility of Tumblr use for eHealth curriculum development. Journal of Medical Internet Research Protocols. 4(1):e34. PMID 25831197.

Fethke NB, Merlino L, Gerr F: [2013] Effect of ergonomics training on agreement between expert and nonexpert ratings of the potential for musculoskeletal harm in manufacturing tasks. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S):S82-S85.

Franke W, Ramey S: [2013] Stress and cardiovascular disease in law enforcement. In Miller, MK & Bornstein, BH (Eds). Trauma, Stress and Wellbeing in the Legal System (1st Ed.) New York: Oxford University Press.

Green DR, Anthony TR: [2015] Occupational noise exposure of employees at locally-owned restaurants in a college town. Journal of Occupational Environmental Hygiene. 12(7):489-499.

Hall JL, Kelly KM, Burmeister L, Merchant JA: [2016] Workforce Characteristics and Attitudes Regarding Participation in Worksite Wellness Programs. American Journal of Health Promotion. Jan 5 [Epub ahead of print]

Hudson H, Hall J: [2013] Value of social media in reaching and engaging employers in total worker health. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S):S78-S81.

Loeppke RR, Schill AL, Chosewood LC, Grosch JW, Allweiss P, Burton WN, Barnes-Farrell JL, Goetzel RZ, Heinen L, Hudson TW, Hymel P, Merchant J, Edington DW, Konicki DL, Larson PW: [2013] Advancing Workplace Health Protection and Promotion for an Aging Workforce. Journal of Occupational and Environmental Medicine. 55(5):500-506.

Merchant, JA: [2013] Total Worker Health Supplement. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S) Retrievable at http://journals.lww.com/joem/toc/2013/12001.

Merchant JA, Kelly KM, Burmeister LF, Lozier MJ, Amendola A, Lind DP, McKeen A, Slater T, Hall JL, Rohlman DS, Buikema BS: [2014] Employment status matters: a statewide survey of quality-of-life, prevention behaviors, and absenteeism and presenteeism. Journal of Occupational and Environmental Medicine. 56(7):686-698.

Merchant JA, Lind DP, Kelly KM, Hall JL: [2013] An employee total health management-based survey of Iowa employers. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S):S73-S77.

Parish M, Rohlman DS, Elliot DL, Lasarev M: [2015] Factors associated with occupational injuries in seasonal young workers. Occupational Medicine. 10.1093/occmed/kqv183.

White H, Khan K, Lau C, Leung H, Montgomery D, Rohlman DS: [2015] Identifying health and safety concerns in Southeast Asian immigrant nail salon workers. Archives of Environmental & Occupational Health. 70(4):196-203. PMID 25965322.

Ramey S, Perkhounkova Y, Moon M, Tseng H, Wilson A, Hein M, Hood K, Franke W: [2014] Physical activity in police beyond self-report. Journal of Occupational and Environmental Medicine. 56(3):338-43.

Rohlman DS, Parish M, Elliot DL, Montgomery D, Hanson G: [2013] Characterizing the needs of a young working population: making the case for Total Worker Health in an emerging workforce. Journal of Occupational and Environmental Health. 55(Suppl. 12S):S69-S72.

Schall MC, Fethke NB, Chen H: [2016] Evaluation of four sensor locations for physical activity assessment. Applied Ergonomics. 53 Pt A:103-9.

Schall M, Fethke NB, Chen H: [2016] Working postures and physical activity among registered nurses. Applied Ergonomics. 54:243-50.

Snetselaar L, Ahrens L, Johnston K, Smith K, Hollinger D, Hockenberry J: [2016] A participatory integrated health promotion and protection worksite intervention: A cluster randomized controlled trial. Topics in Clinical Nutrition. 31(1):36-46.

CUMULATIVE INCLUSION ENROLLMENT TABLE

N/A

INCLUSION OF GENDER AND MINORITY SUBJECTS

N/A

INCLUSION OF CHILDREN

N/A

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

- **Small Business Outreach Videos**

1. **Total Worker Health® Essentials:** In a series of 8 short videos, business industry leaders share their experiences with designing, implementing and evaluating Total Worker Health® programs, practices and policies. The series is designed to help small businesses utilize innovative techniques to incorporate programs, practices and policies that can be tailored to their workplace. Available at http://TotalWorkerHealthEssentials.org.
    1) **What is Total Worker Health™?** In this introductory video, Midwestern employers and national experts describe Total Worker Health® and encourage viewers to integrate their safety and health programs to improve workers' safety, health and well-being at work and beyond.
    2) **Why Total Worker Health™?** Employers describe how Total Worker Health® translates into healthier and happier workers who are less likely to get injured and be more productive and engaged with their work, thus providing employers and their families with better return and value on their investments.
    3) **Management & Employee Involvement:** The key to success, according to employers, is when managers model safe and healthy behaviors. From top to bottom, health and safety is something that should be emphasized each and every day. Success is achieved when employees and managers jointly develop policies, programs and practices.
    4) **Designing Programs:** Begin by building on what you have. Review existing policies and programs, assess the information that you have to identify needs and priorities that fit your business. It can be as simple as asking employees what they need to help facilitate program development and employee engagement.
    5) **Low-Cost Strategies:** Total Worker Health® does not need to be expensive. Employers share easy, low-cost ideas and tips to get started.
    6) **Engaging Employees:** Employers share tips on how to effectively communicate policies and programs to encourage participation in safety and health programs.
    7) **Evaluating Programs:** Knowing what works and doesn't work is important for developing a Total Worker Health® program that is right for you. Employers describe information they have used to evaluate their programs before, during and after implementation to maximize the benefits and minimize the costs.
    8) **Essential Elements & Closing Tips:** Employers share ways to better protect and promote workers safety, health and well-being at work and beyond. The essential elements of planning, implementing and evaluating Total Worker Health® programs, practices and policies are described.

2. **Total Worker Health® In-Depth:** View experts from academia and industry leaders from small Midwestern businesses as they share their expertise, tips and experiences on issues relevant to Total Worker Health™. Available at http://TotalWorkerHealthInDepth.org.
    1) **Interview with Dr. John Howard**: Total Worker Health® was first introduced in 2011, and the definition has since evolved. View this video to learn how the concept was initially conceptualized from an interview in 2012 with NIOSH Director, Dr. John Howard.
    2) **Ask the Experts:** Occupational safety and health experts from NIOSH and the Total Worker Health Centers address the question: "What it Total Worker Health?"
    3) **Total Worker Health® Tips from Small Employers:** Industry leaders from small businesses in Iowa and Nebraska share their tips and experiences with Total Worker Health™.
    4) **Introduction to Stress:** Dr. John Howard, Director of the CDC National Institute for Occupational Safety and Health, shares his perspective on stress and its role in the workplace for the development of illness.
    5) **Ergonomics:** Did you know that almost 1 in 3 non-fatal work injuries reported are related to soft tissue musculoskeletal disorders? Dr. Nathan Fethke, HWCE Deputy Director and Certified Ergonomist, provides a brief overview of ergonomics with strategies that could provide a better working experience for employees and potentially lower their risks for chronic musculoskeletal health outcomes.

6) **Stress (Part II):** In this follow-up video, industry leaders frame stress as a workplace hazard and offer ways employers can minimize stressors in the workplace to maximize employee health, safety and well-being.
7) **Safety:** For workers, safety is an expectation and an integral piece of Total Worker Health®. In our latest video, employees share how a culture of safety is important in their job, their work environment, and at home. Safety experts from Midwest businesses and from the University of Iowa discuss risks and solutions to increase safety on the job.
8) **Transportation Safety:** Driving plays a role in our everyday lives. From communing to and from work, driving for your job, or driving as part of your home life, transportation safety is often overlooked. In our latest video, safety experts and employers from the Midwest discuss potential transportation hazards and programs, policies, and practices to promote transportation safety across all venues.

Schulte, L. 2017 Employer Guide. Total Worker Health® Missing Pieces to the Employee Well-Being Puzzle. St. Louis Area Business Health Coalition. May 2017. Available at https://c.ymcdn.com/sites/stlbhc.site-ym.com/resource/resmgr/spring_forum/2017_spring_forum/BHC_Total_Worker_Health_Empl.pdf

LabVIEW programs are available to assist in video-based analyses of physical risk factors.

REFERENCES

Anger WK, Elliot DL, Bodner T, Olson R, Rohlman DS, Truxillo DM, Kuehl KS, Hammer LB, Montgomery D: [2015] Effectiveness of total worker health interventions. Journal of Occupational Health Psychology. 20(2):226-47.

Branch C, Fethke N, Merlino L: [2014] A worksite wellness coaching component of a Total Worker Health intervention in a manufacturing setting. 1st International Symposium to Advance Total Worker Health™, Bethesda MD, October 6-8.

Fethke NB, Merlino L, Gerr F: [2013] Effect of ergonomics training on agreement between expert and nonexpert ratings of the potential for musculoskeletal harm in manufacturing tasks. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S):S82-S85.

Merchant JA, Kelly KM, Burmeister LF, Lozier MJ, Amendola A, Lind DP, McKeen A, Slater T, Hall JL, Rohlman DS, Buikema BS: [2014] Employment status matters: a statewide survey of quality-of-life, prevention behaviors, and absenteeism and presenteeism. Journal of Occupational and Environmental Medicine. 56(7):686-698.

Merchant JA, Lind DP, Kelly KM, Hall JL: [2013] An employee total health management-based survey of Iowa employers. Journal of Occupational and Environmental Medicine. 55(Suppl. 12S):S73-S77.

Rohlman D, Campo S, Robinson R, Hall J, Kelly K [2014] *Promoting adoption of Total Worker Health™: lessons learned from small businesses*. 1st International Symposium to Advance Total Worker Health™, Bethesda MD, October 6-8.

Schall MC, Fethke NB, Chen H: [2016] Evaluation of four sensor locations for physical activity assessment. Applied Ergonomics. 53 Pt A:103-9.

FINAL PERFORMANCE REPORT

Education/Translation Project (ETP-2): Promoting Best and Promising Total Worker Health Practices
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Grant number: U19OH008868

Project Starting and Ending Dates: September 1, 2011 – August 31, 2016

Date of Final Report: May 28h, 2017

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Program Area: Total Worker Health®

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ABSTRACT

Most workers are employed in small businesses which tend to have higher rates of occupational injury and illness. Unfortunately, these organizations typically do not have programs addressing worker health promotion. Additionally, small firms are more financially precarious and have owners with multiple responsibilities, including safety and health of employees, despite a lack of expertise. We conducted statewide surveys and focus groups of employees and employers to more specifically identify the health and safety practices and needs of workplaces. Although most employers were found to offer worker's compensation insurance to address injuries on the job and promote health protection (95%), fewer employers offer additional health promotion initiatives, including chronic disease management, behavioral health or wellness programs, health screenings/health risk assessments or other programs, particularly small employers. Recognizing a need, we conducted 28 site visits with small employers (<250 employees) throughout the Midwest, many of whom had won safety or health awards. Using the Diffusion of Innovations Theory, we wanted to learn from employers who were innovators in adopting these practices how they had overcome challenges and facilitated changes in their workplace. These interviews were then coded using a combination of the NIOSH *Essential Elements* and supplemented by criteria used to assess best practices and worksite assessments to identify key themes of the site visits. These themes were identified and used in the formation of the Total Worker Health Essentials (http://TotalWorkerHealthEssentials.org)--a series of eight short videos, in which business industry leaders share their experiences with designing, implementing, and evaluating Total Worker Health programs, practices, and policies. The series is designed to help small businesses utilize innovative techniques to incorporate programs, practices, and policies that can be tailored to their workplace. As part of the post-production phase of development, the videos were reviewed by all affiliated Center investigators and staff as well seventeen employers in Iowa and Nebraska. The completed videos were subsequently reviewed by 27 individuals, 19 of whom completed the evaluation of all eight videos. These participants included human resource directors, wellness directors/managers, safety directors/professionals and CEO's/Presidents. The videos received overall positive reviews. Comments such as "Positive message- with some encouraging ideas to take further", "Good practical information" and "Great information...like the checklists" were typical. Negative comments primarily addressed the production quality (music too loud, didn't like the music) and not content. Since public release in August 2015, the series has had over 4000 views. Of those views, the majority have been in Iowa (46%) however, they have been viewed in 46 states and DC as well as 43 countries outside of the United States.

Significant or Key Findings

The overall goal of this educational and translational project is to speed dissemination and translation of evidence-based practices of integrated approaches to health protection and health promotion, to ultimately decrease disease and improve worker health. In particular, this project will examine short videos (both persuasive and instructional) as an innovative approach for enabling managers in small businesses in Iowa to implement workplace programs to better reduce risks**,** not only from worksite hazards but also from chronic diseases, such as cancer, cardiovascular disease, diabetes, obesity, asthma, and alcohol/tobacco use. This translation project is a logical continuation of our efforts to develop and refine a Healthier Workforce Learning Network (HWLN) (ETP-1). This project provides first-hand experience in developing, implementing and evaluating short videos related to the adoption of Total Worker Health policies, programs and practices and lays the groundwork for developing similar videos on a fuller range of relevant subjects directed at the specific needs of employees and employers in different industries.

Employers need resource to address the growing burden of occupational injuries and illnesses and their related costs to workplaces and workers and the reduction in productivity. Total Worker Health® research provides effective solutions. Total Worker Health® programs, policies and practices address the underlying causes that impact the health and safety of workers and demonstrate a return on investment from double to quadruple the value of each dollar spent on such programs. However, there is a need to translate these research findings into practice. Furthermore, effective communication is needed to impact adoption. Small businesses, which represent more than 90% of all workplaces and 50% of the workforce, have different needs and one size does not fit all. Likewise, these workplaces have fewer resources to dedicate and employers crave easy, low-cost solutions that can be tailored to their workplaces. Moreover, existing occupational health, safety; wellness and human resources staff, among others, must be more broadly educated in the need to integrate safety and health to effectively reduce injuries and illness and promote health and well-being among workers. Employers want continuing education that is easy to do from the workplace at low costs (e.g., online), and the emerging workforce seeks added credentials, whether their goals are practice or research. We will leverage our interdisciplinary team, extensive resources, and partnerships to meet needs and effectively disseminate research findings in every appropriate channel to maximize impact.

Despite the fact that most workers are employed in small businesses (Bowen et al., 2009), these organizations typically do not have programs addressing worker health promotion (Pronk, 2013). In addition, occupational injury and illness rates are higher among small businesses (Cunningham & Sinclair 2015). Although employers are typically cognizant of the traditional hazards in the workplace that put workers at risk of injury or illness (e.g., chemical exposure, repetitive motion, machinery), they often fail to consider the impact of the work environment or organization on long-term health outcomes or lifestyle behaviors (e.g., obesity, cardiovascular disease, loss of sleep). Additionally, small firms are more financially precarious (Antonsson, 1997; Lamm, 1997) and have owners with multiple responsibilities, including safety and health of employees, despite a lack of expertise (Gardner et al., 1999; Lamm 1997). As a result smaller employers may use less effect methods of hazard control (Antonsson, 1997, Gardner et al 1999). Finally, even though evidence supports the benefits of integrated programs, very little evidence exists for small employers (Pronk, 2013). Qualitative research we conducted with small Midwest employers indicated that small employers, while emotionally invested in the health and safety of their workers, are limited by small budgets, time, and expertise to implement Total Worker Health®. Furthermore, results indicated that employers require tools which allow them to tailor Total Worker Health® programs and policies to the needs and available resources of their specific workplace. Research from our Center has recognized that interventions focusing on the process of implementing Total Worker Health® programs and policies, rather than interventions that target a single behavior, are needed.

Consequently, our efforts focused on the development of a series of targeted health modules/tutorials, in the form of short videos, to address key components of an integrated workplace health promotion/health protection program. Utilizing a peer-to-peer model, the videos focus on case studies from small businesses who have adopted best practices and shown innovation, with the goal of persuading and instructing other small businesses on how to implement a total worker health program. The goal was to craft short videos that are

persuasive – indicating why a company should implement a TWH program and also instructive –providing examples from successful businesses and specific guidelines on how to get started.

Translation of Findings
This education/translation project determined how well a series of short videos can assist managers in small businesses in Iowa to identify and implement "best and promising practices" for improving worker health and wellbeing. There are many wellness vendors with a wide variety of products that lack the "evidence base" the Healthier Workforce Center can provide. This project was based on evidence-based methods for both specific aims. It documented how the *Essential Elements* can be, and are being, implemented by small businesses to "translate" existing knowledge about health topics and about proven workplace policies and practices into effective and sustainable workplace programs. Additionally, it examined how a series of tutorial videos can facilitate the adoption of integrated workplace health promotion/health protection activities.

Research Outcomes/Impact
Through the efforts of the Education and Translation Project with support from the Outreach Program, the Healthier Workforce Center is recognized as a regional and national resource for Total Worker Health. During the funding cycle, the Education and Translational Project interacted with all components of the Healthier Workforce Center and our local, regional, and national partners to conduct communication and dissemination as well as educational activities. We created regional partnerships in Federal Region VII which has led to the natural expansion of the Healthier Workforce Center to a regional center; the Midwest Center for a Healthier Workforce. The major strengths of this program have been: 1) the vetting of materials by our multidisciplinary team of experts; 2) a reliance on communication, social marketing, and health behavior change theories to guide material development and dissemination practices; 3) tailoring communications to the needs of specific audiences and not expecting a one-size-fits-all approach to work for every employer; and 4) focusing particularly on the opportunities to work with small businesses and intermediary organizations to promote change that impacts the vast majority of employers.

These efforts have resulted in a number of significant outcomes:

- Findings from our research and pilot grants were disseminated to over 100 media outlets including the *Atlantic, National Public Radio, Yahoo News, Christian Science Monitor, Consumer Reports on Health* and *Science Daily.* In addition, testimony was presented to President Obama's task force on 21st-century policing, and shared with safety directors at Fortune 500 companies.
- Delivered more than 70 Total Worker Health® presentations at local, regional, and national meetings.
- Expanded the Healthier Workforce Learning Network to over 1000 practitioners who subscribe to our eBulletin, social media and/or and receive other center updates.
- Promoted Total Worker Health® by serving on over 25 local, regional, national, and international committees addressing occupational safety, occupational health, health promotion
- Hosted the first conference convening researchers from NIOSH and all four Centers of Excellence (*Total Worker Health Symposium: Safe, Healthy and Cost-Effective Solutions* 2012, Coralville, IA)
- Partnered with Heartland Education and Research Center and WORKSAFE Iowa to host a conference uniting occupational health and safety practitioners with representatives from NIOSH Total Worker Health® programs and affiliates (*17th Annual Occupational Health Symposium: Total Worker Health*, 2015, Cedar Rapids, IA).
- Conducted statewide surveys to identify the burden of occupational injury and illness and to identify needs of employed and self-employed workers, and employers (http://RealIowans.org).
- Completed nearly 30 site visits to small employers to learn their best practices for safety and health in conjunction with the Education and Translational Project.

Background

The majority of employers in the US (99%) consist of small businesses (<500 employees) who employ roughly half of all workers (US Census Bureau, 2012). These employers tend to have higher rates of occupational injury and illness (Cunningham & Sinclair 2015) and often have limited resources to address safety and even fewer resources addressing health promotion (Merchant et al., 2013; Pronk 2013). Furthermore, small firms are often more financially precarious (Antonsson, 1997; Lamm, 1997) and have owners with multiple responsibilities, including the safety and health of employees, despite a lack of expertise (Gardner et al., 1999; Lamm 1997).

A statewide survey of benefits offered by employers in Iowa found that although most employers (95%) offer worker's compensation insurance to address injuries on the job and promote health protection, fewer employers have the resources to offer additional health promotion initiatives, including behavioral health or wellness programs, health screenings or health risk assessments, and other programs addressing chronic disease management (Lind, 2012). This is particularly true for small- and medium-sized employers. Furthermore, when asked about Return on Investment (ROI), employers with < 250 employees report a savings of $0.39 compared to larger employers, with 250 or more employees, who report a savings of $2.23 (Lind 2012). Evidence of programs combining health protection with health promotion have been shown to benefit employee safety, health, and well-being, as well as provide employers with a positive return on investment (Anger et al., 2015, Sorensen et al., 2013). These findings indicate a need to translate research practices, evaluated in primarily large employers, to assist small employers with the integration of health protection and health promotion programs.

Conveying information to managers, particularly in small businesses, about evidence-based programs, practices and policies that integrated health protection with health promotion and wellbeing is an important component of the NIOSH Total Worker Health Program. Unfortunately, information products intended for managers are often merely abbreviated versions of scientific reports that leave the targeted audience at a loss as to how to improve their day-to-day operations. Additionally, managers in small businesses are often inundated with information from wellness program vendors who claim to have the programs and expertise to improve employee health and wellbeing but lack objective information about what is most likely to benefit their particular industry, facility, and workforce.

In 2008, NIOSH published the *Essential Elements of Effective Workplace Programs and Policies for Improving Worker Health and Wellbeing* (NIOSH, 2008). Intended as a guide for employers, the document identified twenty components of an integrated program addressing safety, health and well-being and includes both guiding principles and practical direction for organizations seeking to develop effective workplace programs, practices and policies. In terms of translational science, the NIOSH *Essential Elements* can be viewed as a public health "roadmap" intended to guide the translation of findings addressing health promotion and health protection into "actionable" items (programs and policies) in the workplace.

The overall goal of this educational and translational project was to speed dissemination and translation of evidence-based practices of integrated approaches to health protection and health promotion, to ultimately decrease disease and improve worker health. In particular, this project examined short videos (both persuasive and instructional) as an innovative approach for enabling managers in small businesses in Iowa to implement workplace programs to better reduce risks**,** not only from worksite hazards but also from chronic diseases, such as cancer, cardiovascular disease, diabetes, obesity, asthma, and alcohol/tobacco use. This translation research project is a logical continuation of our efforts to develop and refine a Healthier Workforce Learning Network (HWLN) a goal of the previous round of funding.

Previous Work

From 2006-2012, a major focus of the Center was to conduct formative research, through statewide surveys and focus groups, of employees and employers to identify current workplace health and safety practices and needs, their burden of injuries and illnesses, and the corresponding impact on rising healthcare costs,

productivity, and, most importantly, worker health and well-being. The process of conducting this formative research, using publicly engaged methods, led to many partnerships and collaborations including the development of the Healthier Workforce Learning Network (HWLN; a listserv of more than 1000 engaged stakeholders interested in Total Worker Health®). During this period, the Center engaged in numerous outreach activities including the development of the initial website, workshops, seminars, and conferences conducted throughout the state. This work identified the health and safety practices and needs of workplaces, examined their burden on employers and the corresponding impact on rising healthcare costs, productivity, and most importantly, worker health and well-being (Merchant et al. 2013, 2014).

Throughout the life of the Center, the HWLN has sponsored 26 seminars related to health promotion and health protection in the workplace. Following the advice of our External Advisory Committee, in 2010 we began creating a more Iowa-centric forum and adapted the National WorkLife Forum into the Iowa WorkLife Forum. Working in conjunction with the Real Iowans Research Initiative, the HWLN created a list of over 1,000 key contacts throughout Iowa interested in workplace health promotion and protection. This newly identified audience was the target of the Iowa WorkLife Forum (IWF). Online forums, addressing various aspects of integrated health protection and health promotion programs, were used to reach out to this group of employers from small- and medium-size workplaces in more than 30 communities across Iowa. In addition to these forums, online interactive tutorials were developed for the National Library of Medicine (NLM) website. These tutorials, focused on prevention and the workplace are available to the public at the following website: http://www.nlm.nih.gov/medlineplus/tutorial.html.

Current Project

Working in conjunction with Center outreach, the current educational and translational project built upon these activities to provide resources to employers to address the growing burden of occupational injuries and illnesses and their related costs to workplaces and workers and the reduction in productivity. Total Worker Health® research provides effective solutions. Total Worker Health® programs, policies and practices address the underlying causes that impact the health and safety of workers and demonstrate a return on investment from double to quadruple the value of each dollar spent on such programs. However, there is a need to translate these research findings into practice. Furthermore, effective communication is needed to impact adoption. Small businesses, which represent more than 90% of all workplaces and 50% of the workforce, have different needs and one size does not fit all. Likewise, these workplaces have fewer resources to dedicate and employers desire easy, low-cost solutions that can be tailored to their workplaces. Moreover, existing occupational health, safety, wellness and human resources staff, among others, must be more broadly educated in the need to integrate safety and health to effectively reduce injuries and illness and promote health and well-being among workers. Employers want continuing education that is easy to do from the workplace at low costs (e.g., online).

There are three underlying assumptions for this project. First, substantial knowledge already exists about the major causes of chronic diseases and about many of the hazards for workplace injuries and illnesses. Secondly, substantial knowledge also exists about the “essential elements” of effective programs for improving workplace health and safety. This project examined the usefulness of two approaches for identifying, describing, and promoting the “translation” of this existing knowledge into workable “best and promising” practices, especially in small businesses. The third underlying assumption for this project is that many small businesses have already translated, or are in the process of translating, health promotion/health protection knowledge within their companies and are currently actively engaged in best and promising practices in their workplaces. This project provided an information infrastructure for sharing, documenting, and advancing knowledge about implementing both new and existing successful workplace practices

Translational Research in the Workplace

Translation research is comprised of dissemination research, implementation research, and diffusion research.

- *Dissemination research* is the systematic study of how to successfully conduct the **targeted distribution of information and intervention materials** to a specific audience to increase the spread of knowledge about evidence-based public health interventions in order to achieve greater use and greater impact.

- *Implementation research* is the systematic study of how a **specific set of activities and designed strategies are used** to successfully integrate an evidence-based intervention within specific settings (e.g., workplace, community, school).
- *Diffusion research* is the systematic study of the factors necessary for successful **adoption by stakeholders and the targeted population** of an evidence-based intervention, which results in widespread use (e.g., state or national level). It includes the **uptake of new practices or the penetration of broad scale recommendations** through dissemination and implementation efforts, educational programs, marketing, laws and regulations, and policies.

Given the above definitions, this proposed project will encompass all three forms of translation research. The video intervention for managers of small businesses allowed us to systematically:

(1) document **how specific workplace activities and strategies are used** by managers in small businesses (implementation); and
(2) evaluate an innovative method for the **targeted distribution of information and materials** regarding health topics and health hazards, and about proven workplace policies and practices, to health managers in small businesses (dissemination); and
(3) identify the **factors that promote or impede the uptake** of effective and sustainable workplace programs and policies by those businesses, statewide (diffusion).

The second approach utilized in this project, the development and promotion of a series of short videos addressing issues for managers and employees, can be classified as dissemination research, that is, evaluating a method which is **targeted at increasing the spread of knowledge** about health promotion and health protection topics among employers in order to facilitate their participation in workplace health promotion/health protection activities.

This education and translation project is innovative because it used social media, implemented through short videos, based on the components of the NIOSH *Essential Elements* document, to reach a large number of small businesses throughout Iowa and the region. The videos were developed to present peer-to-peer or employer-to-employer communication. This principle of homophily, the tendency of people to like people that are similar to themselves (McPherson, et al., 2001), was incorporated into the development of social networking activities. One example is the practice of utilizing chains of recommendations (for example, “if you like…” on Amazon). Presenting messages from small businesses recognized for successful health protection and health promotion programs will have a greater influence on other small business employers. Finally, this project utilized ongoing Center outreach activities and social networking methods (Hudson & Hall, 2013) to distribute the videos and provide new routes for disseminating information about healthier workplaces.

Leadership Transition

In 2013, with the retirement of Dr. Tom Cook from the department of Occupational and Environmental Health, Dr. Rohlman and Dr. Shelly Campo assumed leadership of the Education and Translation Project. Their complementary expertise in intervention research addressing workplace safety and health promotion and health communication enabled the utilization of the most up-to-date technology, social media, and health behavior change theories to develop resources to address the needs of small employers, a need previously identified by the Center. In consultation with the External Advisory Committee and with the additional areas of expertise the new leadership provided, the focus of the project shifted to the development and evaluation of online video education, taking advantage of new social media opportunities. The project went from low-bandwidth PowerPoint presentations with audio to leverage the availability of high-bandwidth technology (i.e., YouTube). The needs of small and rural businesses were also specifically targeted using peer-to-peer messaging and theory-driven approaches. Social media channels were used for dissemination through the Outreach Core (e.g., Facebook, Twitter). In addition, Dr. Jennifer Hall replaced her predecessor, Dr. Matt Lozier, in July 2012 as the ETP-2 Research Manager and Outreach Director.

Specific Aims

The overall goal of the Education and Translation Project (ETP-2) is to improve understanding and implementation of effective, integrated employee health programs by translating evidence-based research into practice for the benefit of employed populations, particularly small- and medium- sized businesses and those with limited resources. The specific aims of this project are:

Aim 1: To use the Healthier Workforce Learning Network to identify, describe and promote successful, evidence-based workplace programs and policies among health managers: in small- and medium-sized businesses.

Aim 2: To develop, evaluate, and disseminate a series of web-based educational modules (tutorials) to promote and support employee participation in workplace programs and policies.

Methodology

Aim 1: To use the Healthier Workforce Learning Network to identify, describe and promote successful, evidence-based workplace programs and policies among health managers: in small- and medium-sized businesses.

In the original proposal, Specific Aim 1 stated our plan "to use the Healthier Workforce Learning Network to conduct a statewide, web-conference-based Iowa WorkLife Forum to identify, describe and promote successful, evidence-based workplace programs and policies among health managers: in small- and medium-sized businesses." From September 2011-May 2012, we used the Healthier Workforce Learning Network (HWLN) for implementing the WorkLife Forums. However, during Year 2, it was decided to discontinue the Forums due to a drop in participation rates, the decision to modify the approach to reach a broader audience and a change in leadership. Therefore, in Year 3, the plan "**to conduct a statewide, web-conference-based Iowa WorkLife Forum**" was removed from Aim 1. Doing this enabled us to broaden our approach to reach a larger number of employers. We have continued to use the HWLN "to identify, describe and promote successful, evidence-based workplace programs and policies among health managers: in small- and medium-sized businesses." However, instead of a webinar approach, we focused on sharing TWH™ best practices through expanded online resources, specifically targeting small- and medium-sized businesses. This was achieved through a monthly e-bulletin and expanded web content

Aim 2: To develop, evaluate, and disseminate a series of web-based educational modules (tutorials) to promote and support employee participation in workplace programs and policies.

During years 1 and 2 we collaborated with the Patient Education Institute and hosted employee tutorials that we helped develop and refine related to WorkLife, later Total Worker Health™ topics. Although this project was reaching a large number of people, based on findings from our statewide surveys and feedback from our advisory board, we decided to modify our approach to more directly target small- and medium-sized employers. In consultation with Dr. Shelly Campo, a health communication expert, the method shifted from the development of online tutorials to the development of short videos. A series of short, case-study vignettes to promote and support employee participation in workplace programs and policies was developed. The vignettes address both the "why" and the "how" of workplace improvements in TWH™.

Development of Essentials Videos

Site visits with small employers (<250 employees) were conducted, many of whom had won safety or health awards. Using the Diffusion of Innovations Theory (Rogers, 2003), we wanted conduct a needs assessment with employers who were innovators in adopting these practices how they had overcome challenges and facilitated changes in their workplace. The site visits included videotaping of interviews and footage that were used in the formation of our video series. A scripted format was used to collect information describing specific examples of wellness and safety activities, participation and engagement of employees, management support and evaluation of these programs. Interviews were videotaped to provide specific examples of these programs presented by the employers/employees. These interviews were then coded using a combination of the NIOSH *Essential Elements* and supplemented by criteria used to assess best practices and worksite assessments to

identify key themes of the site visits. These themes were identified and used to form specific video topics (Table 1) related to implementing a TWH program. The videos will be approximately 3-5 minutes each.

Table 1. List of video series topics with specific objectives.

Video Theme	NIOSH Essential Elements	Objectives
Introduction to Total Worker Health (Instructional & Persuasive)	Demonstrate Leadership & Commitment (1, 2)	To define and describe TWH and the benefits of integration
		To persuade small employers to adopt integrated TWH program components
Return on Investment (ROI)	NA - Outcomes and Benefits	To discuss ROI and the intangible benefits of taking a TWH approach
Organizational Elements (Culture)	Organizational Culture & Leadership (1, 2, 3, 4, 8)	To demonstrate the need for top management support, multilevel leadership, a participatory approach and developing policies for long-term organization change for creating a culture of TWH
Program Design	Program Design (4, 5, 6, 8, 9, 11, 13)	To get employers to think about what they have and how they can build from there to create TWH programs and policies
Engaging Employees	Program Design (7, 8, 10, 14, 17, 18)	To demonstrate the importance of effective communication strategies
		To show how to ensure confidentiality, build accountability and engage employees
Program Strategies & Resources	Implementation (8, 10, 15, 16, 17, 18)	To share easy, free and low-cost strategies and resources for implementing TWH programs and activities in the workplace
Evaluation	Evaluation (8, 11, 12, 19, 20)	To educate employers how, why and what to evaluate
Closing (Value & Sustainability)	Culture & Sustainability (1, 2, 13)	To motivate/re-motivate employers to adopt a TWH mentality and approach to their companies' safety and wellness programs
		To show employers the value of maintaining their programs for long-term sustainability and culture change

Evaluation of Essential Videos

An iterative approach was used to evaluate the content and format of the TWH Essentials video series. Initial reviews were conducted by content experts and employers including members of the Center External Advisory Board. They were asked to review the videos and provide feedback on the message, graphic and audio format and length. Based on their feedback, the video series was revised. Employers were then recruited to evaluate the video series. Pre- and post-test surveys were used to collect information about the implementation of programs and polices (Table 2). Measures for employers included stages of change measures, questions about safety incidents, and measures from the Health Belief Model (barriers to implementation and adoption,

benefits to workers and the employer, severity of worker health issues, susceptibility to worker health issues, and cues to action). Feedback collect following the viewing of each video will allow us to evaluate whether the intended message was delivered to the recipient. They were asked to view all 8 videos (Table 2) included in the series and complete process evaluation surveys with each video. Upon completion, the employer participants received $50.00. We also collected process evaluation of the locations and the number of views of the various videos.

Results

Aim 1: To use the Healthier Workforce Learning Network to identify, describe and promote successful, evidence-based workplace programs and policies among health managers: in small- and medium-sized businesses.

During the first 2 years of the grant we continued using the Healthier Workforce Learning Network (HWLN) for implementing the WorkLife Forums. From September 2011-May 2012 forums were implemented on Wellness Resources in Iowa; Onsite Clinics and Wellness Programming for Public Employers; Comprehensive Tobacco Cessation Programs; Integrated Workplace Health Promotion and Health Protection Programs; and Safe Patient Lifting Program. However, due to a drop in participation rates and a change in leadership for the project, a decision was made to modify the approach to reach a broader audience. Therefore, a decision was made with input from our External Advisory Committee to utilize different methods to reach employers. Instead of a webinar approach, we focused on sharing TWH™ best practices through expanded online resources, specifically targeting small- and medium-sized businesses. This has been achieved through a new monthly eBulletin and expanded online activities. Online resources include a revamped website. The new website includes 150+ pages, with new content added monthly that include specific examples of programs describing Total Worker Health activities, practices, and model policies for employers. New topics are guided by the monthly eBulletin topics (e.g., heat safety and hydration promotion; sleep promotion and fatigue management; diabetes; cardiovascular well-being; moving more during the workday; office ergonomics; off-the-job safety; and distracted driving). There is also a calendar page with events and professional development opportunities. Audience. Traffic to the website has increased annually. Regular eBulletins, FaceBook posts, YouTube videos, and other social media are used to disseminate Center activities and evidence-based practices.

As originally proposed, activities in ETP-2 and the Outreach Program interrelate and therefore, are mentioned in both sections of this report. Specifically, since 2012, we have innovated and expanded our Outreach activities in a number of ways:

- Increased utilization of best practices based in communication, social marketing, and health behavior change theories to develop materials to change knowledge, attitudes, and behaviors that are tailored to the needs of specific audiences, including employers, intermediaries, and academics
- Development of an expanded website, utilization of social media and domain names, and production of eBulletins
- Increased dissemination of outputs and recommendations from NIOSH and the four Centers of Excellence
- Development of resources addressing the unique needs of small businesses
- Expanded partnerships and activities throughout the region and the US
- Increasing use of video content in order to meet the literacy and health literacy needs of a more diverse audience

These activities resulted in a number of significant outcomes:

- Findings from our research and pilot grants were disseminated to over 100 media outlets including the *Atlantic, National Public Radio, Yahoo News, Christian Science Monitor, Consumer Reports on Health* and *Science Daily.* In addition, testimony was presented to President Obama's task force on 21st-century policing, and shared with safety directors at Fortune 500 companies.
- Delivered more than 70 Total Worker Health® presentations at local, regional, and national meetings.
- Expanded the Healthier Workforce Learning Network to over 1000 practitioners who subscribe to our eBulletin, social media and/or and receive other center updates.

- Promoted Total Worker Health® by serving on over 25 local, regional, national, and international committees addressing occupational safety, occupational health, health promotion
- Hosted the first conference convening researchers from NIOSH and all four Centers of Excellence (*Total Worker Health Symposium: Safe, Healthy and Cost-Effective Solutions* 2012, Coralville, IA)
- Partnered with Heartland Education and Research Center and WORKSAFE Iowa to host a conference uniting occupational health and safety practitioners with representatives from NIOSH Total Worker Health® programs and affiliates (*17th Annual Occupational Health Symposium: Total Worker Health*, 2015, Cedar Rapids, IA).
- Conducted statewide surveys to identify the burden of occupational injury and illness and to identify needs of employed and self-employed workers, and employers (http://RealIowans.org).
- Completed nearly 30 site visits to small employers to learn their best practices for safety and health in conjunction with the Education and Translational Project.

Aim 2: To develop, evaluate, and disseminate a series of short videos to promote and support employee participation in workplace

The goal of Aim 2 is to develop, evaluate and disseminate a series of short-videos to promote and support the development of total worker health programs in small businesses. Initially the Center offered tutorials through the Patient Education Institute addressing Worklife/Total Worker Health® topics with a reach of over 250,000 viewers (Table 3). However, while the number of views was high, it was not addressing employers or academics and only reached one type of intermediary. Furthermore, it requires a subscription and the sole audience of the Patient Education Institute is healthcare organizations to provide them with resources for patient care. We were also committed to the development of open access materials and the need to reach a broader audience, specifically targeting employers, particularly, smaller employers with fewer resources. Therefore, due to the change in leadership for this project, and our desire to more directly target small- and medium-sized employers, the method shifted from the development of online tutorials to short videos addressing both the “why” and the “how” of workplace improvements in TWH™.

Table 2. Tutorials offered through the Patient Education Institute and number of views.

Topic	**Views**
Back Pain – How to Prevent	77,618
Rotator Cuff Injuries	13,082
Sleep Disorders	26,157
Carpal Tunnel Syndrome Surgery	9,007
Back Exercises	41,285
Exercising for a Healthy Life	12,803
Managing Cholesterol	20,239
Managing Stress	23,376
Muscles	13,406
Smoking – The Facts	16,229

Development of Essential Videos

The first step is to translate evidence-based components of health promotion and health protection programs (TWH programs) into short video clips. A series of videos was developed based on a peer-to-peer model of other small businesses who have adopted best practices and shown innovation in workplace wellness and safety programs and/or the integration of the two. This was done through the utilization of case-studies from safety and wellness award winning businesses to demonstrate the principles or components of successful TWH programs (Table 1). The goal was to craft short videos that are persuasive – indicating why a company should implement a TWH program and also instructive –providing examples and specific guidelines on how to get started.

Building on the employee tutorials and using data from statewide surveys that identified the needs of employers and the current programs, policies, and practices that were implemented in workplaces, we formed the basis of selection for 8-10 new topics to be used for the videos. Through our outreach efforts, we had also

identified a strong, award-winning list of small- and medium-sized Iowa employers in the areas of health protection and health promotion. To supplement the early survey work and focus groups, we conducted 28 site visits with small employers (<250 employees) throughout the Midwest (Table 4). These employers and/or their programs will be included in the videos to provide support for targeted messages to employers on best and promising TWH practices. In addition, we interviewed over 15 "experts" in Total Worker Health® at the Total Worker Health® Symposium in November, 2012. Interviewees included Dr. John Howard and representatives from each of the four TWH Centers for Excellence. These interviews are used in our video series promoting TWH.

Table 4. List of site visits by industry and size.

Employer	**Industry**	**Size**
Bergan Paulsen CPA*****	Accounting	< 50
CR/Linn County Solid Waste Agency*****	Government, Waste Management	< 50
Distribution Inc. *****	Warehouse Services	< 50
John's Grocery	Retail	<50
Marion Mixers/Marion Process Solutions*	Manufacturing	<50
Millhiser Smith Agency*****	Insurance	< 50
Norland International*****	Manufacturing, Distribution	< 50
Eastern Iowa Airport*	Transportation	50-99
EF Johnson Technologies*****	Communication Technology	50-99
Geonetric*****	Communication Technology	50-99
Johnson Machine Works*****	Steel Fabrication, Manufacturing	50-99
Lil' Drug Store Products*****	Retail-Distribution	50-99
Lincoln Airport Authority	Transportation	50-99
ALMACO*****	Manufacturing	100-249
Amana Society Inc.		100-249
Amana Society Farms	Agriculture	
Amana Society Forestry	Forestry	
Amana Furniture & Clock Shop	Manufacturing, Retail-Distribution	
Amana Meat Shop & Smokehouse	Retail-Distribution	
Amana Woolen Mill	Manufacturing, Retail-Distribution	
Amana General Store	Retail	
Amana Beef	Agriculture	
Cedar Falls Utilities*****	Utility Management, Service	100-249
City Carton Recycling*	Waste management, Recycling	100-249
Midwest Metal Products*****	Manufacturing	100-249
The ESCO Group*****	Electrical Engineering, Service	100-249
Van Meter, Inc.*****	Distribution, Service	100-249
City of Atlantic, Iowa	Local Government	---
City of Carroll, Iowa	Local Government	---
City of Clive, Iowa	Local Government	---
City of Fairfield, Iowa	Local Government	---
City of Spenser, Iowa	Local Government	---
City of Waukee, Iowa	Local Government	---
Henry County, Iowa	Local Government	---
Region XII Council of Governments, Carroll, Iowa	Local Government	---

**Employers who were recognized award winners in safety or wellness*

Site visits were conducted with workplaces recognized for having exemplary wellness and/or safety programs as well as targeted workplaces identified by the Center to be promote best practice for safety and health. Video content comes from these site visits and is based on the Stages of Change and the Health Belief Models to illustrate the change process including benefits to employers and employees, how they overcame obstacles,

and lessons learned and recommendations for other small employers. The videos include a cross-section of workplace sectors with a primary focus on small-business employers who have <250 employees. Workplace site visits were conducted to learn more about their safety and wellness programs and the integration of these programs into their worksite. A scripted format was used to collect information describing specific examples of wellness and safety activities, participation and engagement of employees, management support and evaluation of these programs. Interviews were video-taped to provide specific examples of these programs presented by the employers/employees. These interviews were then coded using a combination of the NIOSH *Essential Elements* and supplemented by criteria used to assess best practices and worksite assessments to identify key themes of the site visits. These themes were identified and used to form specific video topics (Table 1) related to implementing a TWH program:

Total Worker Health® Essentials: http://TotalWorkerHealthEssentials.org.

- What is Total Worker Health®? In this introductory video, Midwestern employers and national experts describe Total Worker Health® and encourage viewers to integrate their safety and health programs to improve workers' safety, health and well-being at work and beyond.
- Why Total Worker Health®? Employers describe how Total Worker Health® translates into healthier and happier workers who are less likely to get injured and be more productive and engaged with their work, thus providing employers and their families with better return and value on their investments.
- Management & Employee Involvement. The key to success, according to employers, is when managers model safe and healthy behaviors. From top to bottom, health and safety is something that should be emphasized each and every day. Success is achieved when employees and managers jointly develop policies, programs and practices.
- Designing Programs. Begin by building on what you have. Review existing policies and programs, assess the information that you have to identify needs and priorities that fit your business. It can be as simple as asking employees what they need to help facilitate program development and employee engagement.
- Low-Cost Strategies. Total Worker Health® does not need to be expensive. Employers share easy, low-cost ideas and tips to get started.
- Engaging Employees. Employers share tips on how to effectively communicate policies and programs to encourage participation in safety and health programs.
- Evaluating Programs. Knowing what works and doesn't work is important for developing a Total Worker Health® program that is right for you. Employers describe information they have used to evaluate their programs before, during and after implementation to maximize the benefits and minimize the costs.
- Essential Elements & Closing Tips. Employers share ways to better protect and promote workers safety, health and well-being at work and beyond. The essential elements of planning, implementing and evaluating Total Worker Health® programs, practices and policies are described.

Essentials is a series of eight short videos, in which business industry leaders share their experiences with designing, implementing, and evaluating Total Worker Health programs, practices, and policies. The series is designed to help small businesses utilize innovative techniques to incorporate programs, practices, and policies that can be tailored to their workplace.

Evaluation of Essentials

The video series was reviewed by all affiliated Center investigators and staff as well seventeen employers in Iowa and Nebraska who provided feedback. Participants included human resource directors, wellness directors/managers, safety directors/professionals and CEO's/Presidents. They were asked to view all 8 videos included in the series and complete process evaluation surveys with each video. Upon completion, the employer participants received $50.00.

The TWH Essentials videos were evaluated by small employers (<250 employees) in a process that utilized pre- and post-test surveys and gathered ongoing feedback on each video in the series. Employers were recruited using the following methods: the Center eBulletin and website, the Corridor Business Journal, and through targeted emails for stakeholders to recruit through the networks of College of Public Health Business Network, the Quad Cities Health Initiative, Avera Health (South Dakota, Minnesota, Iowa and Nebraska), the

Nebraska Safety Council, Iowa county public health departments, Iowa League of Municipalities, MercyCare Business Solutions and others.

As part of the post-production phase of development, the videos were reviewed by all affiliated Healthier Workforce Center investigators and staff as well seventeen employers in Iowa and Nebraska. The completed videos were subsequently reviewed by 27 individuals, 19 of whom completed the evaluation of all eight videos. These participants included human resource directors, wellness directors/managers, safety directors/professionals and CEO's/Presidents.

The videos received overall positive reviews. Comments such as "Positive message- with some encouraging ideas to take further", "Good practical information" and "Great information...like the checklists" were typical. Negative comments primarily addressed the production quality (music too loud, didn't like the music) and not content. Since public release in August 2015, the series has had over 4000 views. Of those views, the majority have been in Iowa (46%) however, they have been viewed in 46 states and DC as well as 43 countries outside of the United States.

The Development of Total Worker Health In-Depth

Based on the feedback from the evaluation of the Essential Elements videos as well as our continued site visit videos, the need for a second video series with an additional in-depth look at specific topics was warranted. Therefore, production has begun on the secondary series whose topics to date are included in Table 4.

Table 4. Secondary TWH In Depth Video Series

Video Theme	Status	Release Date
Dr. John Howard on Total Worker Health™	Completed	2015
Ask the Experts	Completed	2015
Tips from Small Employers	Completed	2015
Stress 1	Completed	2015
Ergonomics	Completed	2015
Stress 2	Completed	2015
Safety	Completed	2015
Transportation	Completed	2016
Nutrition	Completed	2016
Violence	In Process	

Discussion

To reach employers, we engaged a variety of online resources: eBulletins, websites, memorable domain names, search engine optimization, social media and online videos. The online video series, *Total Worker Health Essentials* (http://TotalWorkerHealthEssentials.org) and *Total Worker Health In Depth* (http://TotalWorkerHealthInDepth.org), use a peer-to-peer model and health behavior theories to provide exemplars and testimonials from small businesses that have adopted best practices and shown innovation. The goal is to instruct and persuade other small businesses on how to develop and implement a Total Worker Health® program and address specific topics in more depth. More than 25 site visits to small employers (< 250 employees) in Federal Region VII were conducted. In addition, we conducted interviews with more than 60 experts from organizations providing safety and health resources to small employers, as well as academic and government experts. These interviews were independently reviewed and coded by study investigators (Campo, Rohlman) using the NIOSH *Essential Elements* in combination with health behavior theories to identify elements that illustrate the change process, the benefits to employers and employees, how they overcame obstacles, and lessons learned and recommendations for other small employers. These were used to develop the video series. The videos include a cross-section of workplace sectors (Rohlman et al., 2014) and provide guidance for employers on implementing Total Worker Health programs, practices and policies. The video series was reviewed by the Healthier Workforce Center Internal and External Advisory Committees, employers and practitioners in Federal Region VII, and federal government employees. Videos were disseminated

through the Healthier Workforce Learning Network, the College of Public Health Business Leadership Network, social media, NIOSH eNews, American Public Health Association, other media outlets, and national meetings.

Conclusions
This project provided first-hand experience in developing, implementing and evaluating case-study videos related to health promotion/health protection topics and will lay the groundwork for developing similar videos on a fuller range of relevant subjects. These future activities included videos directed more specifically at the information needs of employers as well as employees in different industries. In Year 5, the HWLN used to promote a series of short evidence-based videos that will be developed under AIM 2 of ETP-2. Videos were disseminated through outreach activities including the HWCE website, monthly Healthier Workforce eBulletin, social media channels, presentations and conferences.

Through the efforts of the Education and Translation Project with support from the Outreach Program, the Healthier Workforce Center is recognized as a regional and national resource for Total Worker Health. During the funding cycle, the Education and Translational Project interacted with all components of the Healthier Workforce Center and our local, regional, and national partners to conduct communication and dissemination as well as educational activities. We created regional partnerships in Federal Region VII which has led to the natural expansion of the Healthier Workforce Center to a regional center; the Midwest Center for a Healthier Workforce. The major strengths of this program have been: 1) the vetting of materials by our multidisciplinary team of experts; 2) a reliance on communication, social marketing, and health behavior change theories to guide material development and dissemination practices; 3) tailoring communications to the needs of specific audiences and not expecting a one-size-fits-all approach to work for every employer; and 4) focusing particularly on the opportunities to work with small businesses and intermediary organizations to promote change that impacts the vast majority of employers.

PUBLICATIONS

N/A

CUMULATIVE INCLUSION ENROLLMENT TABLE

N/A

INCLUSION OF GENDER AND MINORITY SUBJECTS

N/A

INCLUSION OF CHILDREN

N/A

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

- **Small Business Outreach Videos**
    1. **Total Worker Health® Essentials:** In a series of 8 short videos, business industry leaders share their experiences with designing, implementing and evaluating Total Worker Health® programs, practices and policies. The series is designed to help small businesses utilize innovative techniques to incorporate programs, practices and policies that can be tailored to their workplace. Available at http://TotalWorkerHealthEssentials.org.
        9) **What is Total Worker Health™?** In this introductory video, Midwestern employers and national experts describe Total Worker Health® and encourage viewers to integrate their safety and health programs to improve workers' safety, health and well-being at work and beyond.
        10) **Why Total Worker Health™?** Employers describe how Total Worker Health® translates into healthier and happier workers who are less likely to get injured and be more productive and engaged with their work, thus providing employers and their families with better return and value on their investments.
        11) **Management & Employee Involvement:** The key to success, according to employers, is when managers model safe and healthy behaviors. From top to bottom, health and safety is

something that should be emphasized each and every day. Success is achieved when employees and managers jointly develop policies, programs and practices.

12) **Designing Programs:** Begin by building on what you have. Review existing policies and programs, assess the information that you have to identify needs and priorities that fit your business. It can be as simple as asking employees what they need to help facilitate program development and employee engagement.
13) **Low-Cost Strategies:** Total Worker Health® does not need to be expensive. Employers share easy, low-cost ideas and tips to get started.
14) **Engaging Employees:** Employers share tips on how to effectively communicate policies and programs to encourage participation in safety and health programs.
15) **Evaluating Programs:** Knowing what works and doesn't work is important for developing a Total Worker Health® program that is right for you. Employers describe information they have used to evaluate their programs before, during and after implementation to maximize the benefits and minimize the costs.
16) **Essential Elements & Closing Tips:** Employers share ways to better protect and promote workers safety, health and well-being at work and beyond. The essential elements of planning, implementing and evaluating Total Worker Health® programs, practices and policies are described.

2. **Total Worker Health® In-Depth:** View experts from academia and industry leaders from small Midwestern businesses as they share their expertise, tips and experiences on issues relevant to Total Worker Health™. Available at http://TotalWorkerHealthInDepth.org.
    9) **Interview with Dr. John Howard**: Total Worker Health® was first introduced in 2011, and the definition has since evolved. View this video to learn how the concept was initially conceptualized from an interview in 2012 with NIOSH Director, Dr. John Howard.
    10) **Ask the Experts:** Occupational safety and health experts from NIOSH and the Total Worker Health Centers address the question: "What it Total Worker Health?"
    11) **Total Worker Health® Tips from Small Employers:** Industry leaders from small businesses in Iowa and Nebraska share their tips and experiences with Total Worker Health™.
    12) **Introduction to Stress:** Dr. John Howard, Director of the CDC National Institute for Occupational Safety and Health, shares his perspective on stress and its role in the workplace for the development of illness.
    13) **Ergonomics:** Did you know that almost 1 in 3 non-fatal work injuries reported are related to soft tissue musculoskeletal disorders? Dr. Nathan Fethke, HWCE Deputy Director and Certified Ergonomist, provides a brief overview of ergonomics with strategies that could provide a better working experience for employees and potentially lower their risks for chronic musculoskeletal health outcomes.
    14) **Stress (Part II):** In this follow-up video, industry leaders frame stress as a workplace hazard and offer ways employers can minimize stressors in the workplace to maximize employee health, safety and well-being.
    15) **Safety:** For workers, safety is an expectation and an integral piece of Total Worker Health®. In our latest video, employees share how a culture of safety is important in their job, their work environment, and at home. Safety experts from Midwest businesses and from the University of Iowa discuss risks and solutions to increase safety on the job.
    16) **Transportation Safety:** Driving plays a role in our everyday lives. From communing to and from work, driving for your job, or driving as part of your home life, transportation safety is often overlooked. In our latest video, safety experts and employers from the Midwest discuss potential transportation hazards and programs, policies, and practices to promote transportation safety across all venues.

REFERENCES

Antonsson, A-B (1997) Small companies. In: D. Brune et al. (Eds.). *The Workplace*, vol. 2, part 5.3. pp. 466–477.

Bowen HM, Smith TD, Wilson MG, DeJoy DM. Health promotion programming in small, medium, and large businesses. In: Pronk NP, editor. ACSM's Worksite Health Handbook. A Guide to Building healthy and productive companies. 2. Human Kinetics; Champaign, IL, USA: 2009. pp. 41–48.

Cunningham TR, Sinclair R (2015) Application of a model for delivering occupational safety and health to smaller businesses: Case studies from the US. *Safety Science,* 71: 213-225.

Lamm F (1997) Small businesses and OH&S advisors. *Safety Science*, 25 (1–3):153–161.

Merchant JA, Lind DP, Kelly KM, Hall JL (2013) A total health management questionnaire-a statewide survey of Iowa employers. *Journal of Occupational and Environmental Medicine*, 55: S73-S77.

Merchant JA, Kelly KM, Burmeister L, Lozier M, Amendola A, Lind DP, McKeen A, Slater T, Hall JL, Rohlman D, Buikema B (2014) Employment status matters—a statewide survey of quality-of-life, prevention behaviors, and absenteeism and presenteeism. *Journal of Occupational and Environmental Medicine*, 56(7): 686-698.

Pronk, NP (2013). Integrated Worker Health Protection and Promotion Programs: Overview and Perspectives on Health and Economic Outcomes. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, *55*(12 0), S30–S37. http://doi.org.proxy.lib.uiowa.edu/10.1097/JOM.0000000000000031

FINAL PERFORMANCE REPORT:

Healthier Workforce Center for Excellence

Transdisciplinary Research Project 4

Comprehensive Evaluation of an Integrated Health Protection and Health Promotion Program

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Grant number: U19OH008868

Project Starting and Ending Dates: September 1, 2011 – February 28, 2017

Date of Final Report: May 28, 2017

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ABSTRACT

Introduction. Musculoskeletal symptoms and disorders continue to be important occupational health problems in most industries, including manufacturing. In addition to occupational exposure to physical risk factors and psychosocial stressors, non-occupational factors (such as increased body mass and tobacco use) contribute to the burden of musculoskeletal outcomes among working people. Consistent with the 2011 operational definition of Total Worker Health®, we assessed the effects of an integrated occupational health protection and health promotion intervention on a variety of individual and enterprise-level outcome measures.

Methods. The intervention involved the integration of health promotion with an existing occupational safety and health operational structure. The intervention included (i) ergonomics activities to improve the musculoskeletal health status of employees, augmented with digital human modeling to evaluate current work practices and explore design alternatives and (ii) health promotion activities to improve employee engagement with health benefits and wellness programs, augmented with on-site health and wellness coaching using motivational interviewing techniques. The intervention was implemented in one facility of a global manufacturing company (n=212 participants), with a second facility serving as the referent site (n=252 participants). Measures of effect data collected at the facility-level (e.g, exposure to physical risk factors estimated using established observation-based techniques [e.g., the Strain Index], the incidence of musculoskeletal outcomes, and workers' compensation claim costs) and at the individual-level (e.g., musculoskeletal symptom status, measures of physical and mental health status [e.g., subscales from the SF-36v2], and indicators of modifiable health risks [e.g., results of biometric screening]. Analyses included multivariable models with intervention status as the primary independent variable and time as a covariate.

Results. Facility-level exposures to physical risk factors for distal upper extremity musculoskeletal outcomes were reduced, with a statistically significant effect of the intervention when the Strain Index was used as the exposure metric. Approximately 50% of the total study sample was lost to follow-up due to a termination of employment, limiting exposure to intervention and the ability to track outcomes over time. The physical composite score of the SF-36v2 also increased to a greater extent among intervention site participants (especially those who engaged in the coaching activity) compared to referent site participants during the early stages of the intervention. However, the effect was not maintained for the full duration of the study. Participants who engaged in the coaching activity set and reported achieving personal goals across a range of health and wellness topics, most commonly physical activity, nutrition, and stress. No other meaningful intervention effects were observed.

Conclusion. In general, robust effects of the intervention were not observed in this study. Several factors outside the control of the research team impacted the study, including sale of the company and subsequent changes to key partners involved in the design and execution of intervention activities. Although the intervention appeared to reduce exposure to physical risk factors for distal upper extremity musculoskeletal outcomes, the observed reductions did not translate to reduced incidence of musculoskeletal events or workers' compensation claim costs.

Significant Findings

A statistically significant effect of the intervention was observed on facility-level exposures to physical risk factors for distal upper extremity musculoskeletal health outcomes when using the Strain Index as the exposure metric. Reductions were also observed when using the ACGIH TLV® for Hand Activity Level as the exposure metric, although the effect of the intervention was not statistically significant.

Increases in the physical composite score (PCS) from the SF36v2 among intervention site participants exceeded those observed among referent site participants during the early stages intervention activities (through year 2), suggesting an intervention effect. However, PCS scores among intervention site participants returned to baseline levels in subsequent rounds of follow-up data collection.

Meaningful effects of the intervention were not observed on (i) musculoskeletal symptom status, (ii) occupational psychosocial stress, (iii) the incidence of musculoskeletal injuries, (iv) annual workers' compensation expenses, or (v) several individual-level indicators of physical and mental health status [e.g., body mass index, the mental composite score from the SF36v2, blood pressure, or other modifiable indicators of chronic health conditions].

On-site health and wellness coaching was accessed by 70 intervention site participants, who engaged in a total of 393 30-minute encounters with a coach trained in the use of motivational interviewing. During these sessions, participants established more than 400 personal health and wellness goals, most commonly related to physical activity/fitness, stress, nutrition, or other general health-related topics. Although participants reported achieving a substantial proportion of these goals by the end of the study (e.g., 32% of physical activity/fitness goals were reported as achieved), the results did not translate to measurable outcomes.

Although not formally analyzed, the use of digital human modeling during intervention activities provided unique opportunities to (i) increase the intervention site's awareness of and ability to control physical risk factors for musculoskeletal outcomes and (ii) explore the consideration of non-occupational factors (e.g., body mass) in establishing work design criteria.

Translation of Findings

In the early stages of study activities, members of the safety and wellness committee at the study site received specialized training in the identification and evaluation of physical risk factors for musculoskeletal outcomes. Training effectiveness was estimated through pre- and post-training ratings (using visual analog scales) of the overall potential for production tasks in the facility to expose workers to harmful levels of physical risk factors. Results of this activity were published in a special issue of the *Journal of Occupational and Environmental Medicine*, arising from the 2012 "Total Worker Health® Symposium – Safe, Healthy and Cost-Effective Solutions" [Fethke, et al. 2013]. Additional dissemination activities include presentations describing the study and preliminary results at the 1st International Symposium to Advance Total Worker Health®, and an upcoming presentation at the 2017 Work, Stress and Health conference. We continue efforts to publish results from the study and seek opportunities for purposeful outreach in consultation with the Center's outreach team.

Research Outcomes / Impact

Substantial barriers were encountered during the course of the study that undoubtedly contributed to the mostly null effects of the intervention. Understanding the nature and consequences of such barriers represents a key **potential outcome** that could impact design and execution of future intervention research in the Total Worker Health® domain. Perhaps most importantly, the company experienced a change of ownership. As a result, turnover occurred among those in key leadership positions that were involved in the strategic planning, design, and implementation of intervention activities, from executive management to facility-level champions.

In addition, large and unanticipated increases in production demand were observed in the intervention facility as a result of the transfer of production from a sister facility that was closed following the change in corporate leadership. Consequently, production initiatives may have received greater priority and shifted resources (both human and financial) away from safety/ergonomics and (especially) workplace health promotion activities that were not directly supported by the research team. Moreover, turnover among production employees available to participate in the study was much greater than expected, resulting in a loss to follow-up of approximately 50% of the study sample and a much shorter average duration of participation (about two years) compared to the total duration of intervention activities (3.5 years).

SECTION 2: SCIENTIFIC REPORT

Background and Specific Aims

Work-related musculoskeletal disorders (MSDs) remain a persistent and burdensome occupational health problem across virtually all industry sectors. Although the annual number of reported work-related MSD cases in private industry has been declining in recent years, the proportion of all nonfatal occupational injuries and illnesses with lost work days classified as MSDs has remained at about 30% [US Bureau of Labor Statistics 2015]. Because of the magnitude of this problem, the Occupational Safety and Health Administration (OSHA) has targeted work-related MSDs as a priority area. In addition, NIOSH included the control of MSDs prominently in seven of eight National Occupational Research Agenda (NORA) industry sector agendas.

Physical risk factors in the workplace (i.e., job risks), such as forceful exertions, awkward postures, and exposure to highly repetitive work, are associated with increased risk of MSDs [Bernard 1997; National Research Council - Institute of 2001; Punnett, et al. 2000; Silverstein, et al. 1997; Viikari-Juntura and Silverstein 1999]. In industry, safety managers and safety and health committees are often accountable for identifying, evaluating, and modifying workplaces in order to reduce exposure to these risk factors. This process of corporate health protection is considered a primary prevention intervention and is typically called “ergonomics”.

While the personal and economic consequences of MSDs are substantial, employers are also impacted by increasing health care costs related to lifestyle health behaviors and chronic conditions such as tobacco use, obesity, coronary artery disease, hypertension, and diabetes. Estimates of the proportion of after-tax profits spent on corporate health care benefits approach 60% [Heffler, et al. 2003; Villaire and Mayer 2007]. Many employers attempt to positively influence employee health behavior by implementing wellness and health promotion programs. Historically, however, health promotion programs have not traditionally been integrated into occupational safety and health programs.

This project evaluated the effectiveness of an integrated health protection and health promotion intervention on musculoskeletal symptoms and indicators of modifiable health risks and overall health. This knowledge is critical to further the understanding of the potential benefits of integrated health protection and health promotion programs to employee health and employer profitability. Ultimately, evidence of positive effects of integrated health protection and health promotion interventions are needed to encourage widespread adoption of such interventions among employers in the manufacturing sector. Model interventions can then be translated to employers in other industries.

This project augmented traditional approaches to health protection health promotion with emerging but understudied methodologies. Specifically, we augmented traditional approaches to the identification and control of physical risk factors for musculoskeletal outcomes with innovative digital human modeling software, allowing for efficient optimization of alternative workspace configurations without incurring the cost of building physical mock-ups. In addition, we incorporated motivational interviewing (MI) techniques into an existing employer-based health promotion program, providing a potentially powerful approach to affecting change in employee health behaviors. Wellness coaching and motivational interviewing have been impactful for improving health behaviors in clinical settings [Martins and McNeil 2009], but are understudied in the context of employer-based health promotion programs.

The following specific aims and hypotheses were addressed in the project:

Aim 1: **Examine the effects of an integrated health protection and health promotion intervention on (a) occupational exposures to ergonomic hazards, (b) musculoskeletal symptoms, and (c) OSHA-recordable events consistent with musculoskeletal disorders.**

Hypothesis 1a: Workers in the intervention facility will experience reductions in occupational exposures to ergonomic hazards in comparison to workers in the control facility.

Hypothesis 1b: Workers in the intervention facility will report fewer musculoskeletal symptoms in comparison to workers in the control facility.

Hypothesis 1c: The incidence of OSHA recordable musculoskeletal events will be reduced in the intervention facility in comparison to the control facility.

Aim 2: **Examine the effects of an integrated health protection and health promotion intervention on (a) participation in employer-sponsored disease management programs and (b) indicators of modifiable health risks.**

Hypothesis 2a: More workers in the intervention facility will participate in employer-sponsored disease management programs in comparison to workers in the control facility

Hypothesis 2b: Workers in the intervention facility will experience greater improvement in indicators of modifiable health risks and overall health in comparison to workers in the control facility.

Aim 3: **Estimate the economic impact of an integrated health protection and health promotion intervention.**

Hypothesis 3a: The intervention facility will experience reductions in workers' compensation claim costs associated with musculoskeletal disorders in comparison to the control facility.

Hypothesis 3b: The intervention facility will experience reductions in total health insurance claim costs when compared to the control facility.

Hypothesis 3c: The intervention will result in a positive return on investment.

Methods

Study design and setting

We conducted a non-randomized trial to examine the effects of an integrated health protection and health promotion intervention. Study activities occurred in two manufacturing facilities operated by the same company, one in central Iowa (the intervention facility) and the other in central Ohio (the referent facility). The study facilities produce identical vinyl-framed window and door assemblies for residential construction using similar manufacturing processes and workstation configurations, and are located in regions with similar sociodemographic characteristics.

The company is self-insured and offers employer-sponsored health insurance plans to full-time, permanent employees. The corporate health benefits administration also offers incentives (i.e., reductions in insurance premiums) for insured employees to participate in an annual health risk appraisal (HRA) and biometric screening, and provides access to a variety of employee assistance programs for management of chronic health conditions. The HRA, biometric screening, and employee assistance programs are administered by third-party vendors.

Study activities began in September 2011. All participants provided written informed consent and all study procedures were approved by the University of Iowa Institutional Review Board.

Description of the Intervention

Consistent with the goals and intent of the National Institute for Occupational Safety and Health (NIOSH) Total Worker Health® program and in accordance with the operational definition of Total Worker Health® at the time funding began, the intervention was designed to integrate traditionally disparate *occupational safety and health protection* activities with *workplace health promotion and chronic disease prevention* activities [Schill and Chosewood 2013]. The intervention activities included the formation of two distinct entities under the direction of company personnel but trained and advised by the research team. In September 2011, an intervention "strategic planning committee" was convened that included representation from corporate executive management; corporate risk management; corporate health benefits management; facility-level general, production, human resources, and safety management; production employees; and the research team.

The strategic planning committee met via monthly conference call from September 2011 through March 2012 and was responsible for developing and adopting a formalized work plan for the integrated intervention. The work plan contained a series of strategic goals, objectives relative to each goal, and specific action steps (including performance metrics) to meet each objective. The strategic goals addressed employee health and

well-being from the perspectives of both occupational safety and health and workplace health promotion and disease management.

Concurrent with the activities of the strategic planning committee, workplace health promotion was integrated into an existing safety committee at the intervention facility. The integrated committee was subsequently renamed the “safety and wellness” committee, and included representation from facility-level general, production, human resources, and safety management; production employees; fabrication and maintenance personnel; and the research team. The safety and wellness committee was responsible for executing the work plan developed during the strategic planning process and for the development and implementation of new health protection and health promotion activities at the intervention facility in response to ongoing and emerging needs of all facility employees. The safety and wellness committee met monthly, and the research team participated in these meetings.

With respect to occupational health protection, the research team supported the safety and wellness committee primarily through ergonomics activities intended to improve the musculoskeletal health status of employees. Ergonomics activities included: training to improve employees’ recognition of physical risk factors associated with musculoskeletal health outcomes [Fethke, et al. 2013]; review of existing administrative controls (e.g., the timing of training received by new employees); development of new administrative controls (e.g., design of job rotation strategies for areas of the facility); review of existing exposure assessment methods; and walkthroughs of production areas to identify targets for immediate workstation redesign.

In addition, digital human modeling (DHM) software (Santos™, SantosHuman Inc., Iowa City, IA) was made available to the safety and wellness committee and used to create virtual work environments, evaluate current practices, and explore alternative designs. The DHM component of the intervention was introduced at the beginning of the second year of intervention activities when the safety and wellness committee was operating smoothly. The safety and wellness committee selected at each monthly meeting a task to model prior to the next team meeting. The tasks selected ranged in topic, but were typically chosen based on (i) known hazardous and/or physically demanding working conditions, and/or (ii) difficulty in evaluation using traditional exposure assessment methods. For example, in one case, a new production area was being introduced and the committee was interested in better understanding the physical risk factors associated with different workstation configurations before the line was fully operational. Another example was examining the effect of non-occupational risk factors (i.e., BMI) on the expected physical demands of a manual material handling task in order to best establish task design criteria.

After a task was identified for evaluation by the safety and wellness committee, the project research staff obtained measurements needed to model the work with help from a committee member. Images and videos of the workstation or task were collected with the help of a production manager, the safety manager, and the production employee most familiar with the work. In some cases, an ergonomic hazard assessment was conducted by the safety and wellness committee. These pieces of information were then used by the project research staff to create scenarios in the DHM environment and the results and recommendations (as appropriate) were presented to the safety and wellness committee at the next monthly meeting. The safety and wellness committee would then use this information to propose modifications (depending on the purpose of the model).

With respect to workplace health promotion, the research team supported the safety and wellness committee through activities intended to create a culture of wellness and improve employee engagement. Wellness activities included: a review of facility needs related to creating and sustaining a culture of wellness (e.g., prioritized areas of need/interest by surveying employees); creation of environmental supports (e.g., evaluation and improvement of healthy vending options); review and development of a comprehensive communication plan (e.g., monthly wellness newsletter distributed to employees); and promotion of facility-wide wellness activities (e.g., implementation of walking program). In addition, a component of the intervention included on-site access to a health and wellness coach who had received specialized training in motivational interviewing. Participants who expressed interest in meeting with the study health and wellness coach were enrolled into the

health and wellness coaching intervention (HWCI). The HWCI participants were provided up to four in-person encounters annually during work time (i.e., no wages were lost to participate in the HWCI). Each health and wellness coaching encounter was approximately 30 minutes in duration and occurred in a private office provided by the employer. During a participant's first coaching encounter, certain pre-determined items were discussed, including a brief description of health and wellness coaching, the participant's wellness vision, health-related limitations, and an initial set of potential long-term and short-term goals. In subsequent encounters, progress was discussed and goals were adjusted as necessary.

The referent facility continued its usual occupational health protection and workplace health promotion activities during the course of the study. The geographic separation between the study sites limited contamination between the facilities. Inclusion of corporate and facility-level management in both the strategic planning committee and the safety and wellness committee at the intervention site increased the potential for communication about study-related activities between the sites. However, intervention activities were not replicated at the referent facility.

Eligibility and enrollment of study participants

At each facility, all permanent employees between the ages of 18 and 70 were eligible to participate in the study. Initial enrollment and data collection began in April 2012. Additional enrollment and data collection occurred at six-month intervals through December 2015. In conjunction with providing written informed consent, participants with employer-sponsored health insurance allowed the research team to obtain, from the company's third party vendors, their personal HRA and biometric screening results and their use of employee assistance programs. Participants at the intervention facility with employer-sponsored health insurance were also eligible to enroll in the health and wellness coaching component of the intervention. We restricted eligibility for the health and wellness coaching intervention to participants with employer-sponsored health insurance because (i) we hypothesized that engagement with the health and wellness coach would, over time, impact participants' HRA and biometric screening results and (ii) available study resources did not allow for a broader roll-out of the health and wellness coaching activity.

Data collection instruments, procedures, and statistical analyses, by study hypothesis

Aim 1

Hypothesis 1a

The manufacturing operations in the study facilities were organized first by department (e.g., glass preparation, distribution), then by lines within department, and finally by tasks within line. There were approximately 110 tasks in each facility. Many of the tasks were identical, i.e., the same task was performed in multiple product lines. Consequently, we identified approximately 60 unique manufacturing tasks in each facility during the project planning stage. We obtained, in each facility, video footage of workers performing these unique tasks at baseline and every six months during follow-up for estimation of exposure to physical risk factors.

We obtained 20 minutes of video of each task using two handheld digital video cameras positioned approximately 10m from the worker. The two cameras were positioned to minimize parallax errors and obstructed views (prioritizing the latter). One camera was used to obtain a sagittal view and the other to obtain a frontal view. The videos recorded by each camera were synced by positioning a notecard containing information about the task into each camera's view and then dropping the notecard from view (i.e., functionally similar to a clapper board used in movie production). Software (Premiere Elements, Adobe Systems Inc., San Jose, CA) was then used to construct a single side-by-side digital video from the separate video recordings for analysis purposes.

Multiple observation-based exposure assessment methods were used for video-based exposure assessments since no single method adequately evaluates all physical risk factors (e.g., forceful exertion, non-neutral postures, and repetition or frequency of exertions) or all anatomic regions [Drinkaus, et al. 2003; Juul-Kristensen, et al. 1997; Li and Buckle 1999].

OWAS. OWAS was used to assess posture of the back, upper extremities, and lower extremities, and to assess handled loads [Karhu, et al. 1977]. OWAS is a reliable observational method both in real-time and using video [de Bruijn, et al. 1998; Karhu, et al. 1977; Scott and Lambe 1996], and remains widely used in ergonomics research [Gangopadhyay, et al. 2010; Gilkey, et al. 2007; Grecchi, et al. 2009; Kee and Karwowski 2007; Kumar, et al. 2005]. Using work sampling methods, a worker's posture and handled loads are observed repeatedly over a specific sampling period. At each observation time (every 30 seconds, in this study), back posture is assigned one of four scores, upper extremity posture is assigned one of three scores, and lower extremity posture is assigned one of seven scores. The resulting OWAS score for the observation time is a four-digit code that identifies the posture and load. The OWAS scores are then assigned one of four "action categories." Action Category 1 postures do not need any special attention, Category 2 postures must be considered for corrective action in the near future, Category 3 postures need to be considered soon, and Category 4 postures need to be considered immediately. For each task, the metric of OWAS was the percentage of time in Action Categories 2, 3, or 4 across the 20-minute video recording. OWAS analyses were performed using a custom program written in LabVIEW (National Instruments, Austin, TX).

The *Strain Index (SI)*. The SI evaluates forceful exertions, non-neutral postures, and repetitive motions of the hand and wrist [Moore and Garg 1995]. The SI is reliable, valid, and widely used [Bao, et al. 2009; Knox and Moore 2001; Moore, et al. 2001; Rucker and Moore 2002; Spielholz, et al. 2008; Stephens, et al. 2006; Stevens, et al. 2004]. To estimate the SI score, several task variables are evaluated including the intensity of exertion, duration of exertion cycle, frequency of exertions, wrist posture, speed of work, and duration of the work. Each of these variables is given a rating value. Intensity of exertion is the most critical variable of the SI, and is classified as light, somewhat hard, hard, very hard, or near maximal. Each rating value is then assigned a multiplier, and the multipliers are then multiplied. For each task, the metric of the SI was the SI score.

ACGIH® TLV® for Hand Activity Level. The ACGIH ® TLV ® for Hand Activity Level has gained in popularity among ergonomics researchers since its introduction in 2001 [Bao, et al. 2006; Dempsey, et al. 2005; Drinkaus, et al. 2005; Franzblau, et al. 2005; Spielholz, et al. 2008; Tomei, et al. 2005; Wurzelbacher, et al. 2010]. The method uses 1) the Hand Activity Level (HAL) to estimate hand “busyness” on a 0 – 10 visual analog scale [Latko, et al. 1997] and, in this study, 2) an observer-based estimate of normalized peak hand force (NPF) during work. The HAL and NPF ratings are combined into a ratio which is compared to suggested action and threshold limit values. For each task and for each hand separately, the metric of the ACGIH® TLV® for Hand Activity Level was the ratio: NPF/(10-HAL).

We examined the effect of the intervention on the exposure assessment metrics using generalized linear models fit with general estimating equations and task as the unit of analysis. For each task, we computed the difference between the exposure assessment score at a given observation time and the score from the previous observation time. The models included this difference as the dependent variable, intervention status as the primary explanatory variable, time as a covariate (i.e., 1st follow-up, 2nd follow-up, etc.), and a repeated statement (repeated = task) to account for the correlation among repeated observations of tasks across follow-up. We also adjusted for confounding by additional factors including, for example, the gender of the worker performing the task at each observation, and whether or not the task had been modified with respect to the baseline. A time by intervention interaction term was included to examine differences in the temporal trends of exposure assessment metrics during follow-up. All statistical modelling (for this and all other analyses described in this report) was performed using SAS (versions 9.3 and 9.4, SAS Institute Inc., Cary, NC).

Hypothesis 1b

Participants in each study facility completed a self-administered questionnaire at baseline and every six months during follow-up. The questionnaire included the following elements:

Demographics and personal health information included age, race/ethnicity, gender, height/weight, education level, and household income. Personal health information included tobacco use, alcohol consumption, diabetes, osteoarthritis, rheumatoid arthritis, prior low back neck/shoulder, and distal upper extremity musculoskeletal conditions, and medication use. We also collected information about employment outside the

study site (average weekly hours, industry, and job title). Potentially time-varying information was reassessed each six-month interval during follow-up.

Self-reported musculoskeletal symptoms of the low back, neck/shoulder, or distal upper extremity during the prior two-weeks were assessed with standard questions about symptom quality, severity, and duration. A positive response to the symptoms questionnaire was defined as a report of pain, numbness, tingling, or burning 1) of 60 minutes or more total duration over the course of the previous two weeks, 2) of intensity "5" or higher on a 0-10 visual analog scale and 3) not resulting from acute trauma. Similar scales have been used extensively in studies of physical risk factors and musculoskeletal symptoms [Fethke, et al. 2015; Gerr, et al. 2014].

Occupational psychosocial stress was assessed using scales selected from the Job Content Questionnaire (JCQ) [Karasek 1985; Karasek and Theorell 1990]. The JCQ has good reliability and validity and has been used in several studies of work-related MSDs. For each participant and at each data collection round, the score from JCQ items comprising the "psychological job demands" sub-scale (i.e., demand) was divided by the score from JCQ items comprising the "decision latitude" sub-scale (i.e., control) in order to create a continuous variable of "job strain" [Fethke, et al. 2015; Landsbergis, et al. 1994].

A repeated measures analysis was used to identify proportionate changes in reported symptoms over time within the intervention and control facilities. Simple frequencies and distributional tests were used to examine demographic, personal health, occupational psychosocial stress, and overall health characteristics and to identify if these factors influenced the proportionate changes in reported symptoms. Any variable related to symptom changes at the $p = 0.20$ level or less was examined as a potential confounder in multivariable modeling. We examined the effect of the intervention on musculoskeletal symptoms using generalized linear models fit with general estimating equations and individual participants as the unit of analysis. The logit link function was used for these analyses. Separate models were constructed for body area-specific symptoms (i.e., low back, neck/shoulder, and distal upper extremity).

Hypothesis 1c

From the workplace injury/illness database maintained by the company's centralized risk management group, we obtained a monthly count of OSHA-recordable events consistent with musculoskeletal outcomes and monthly record of production hours. Because workplace injuries/illnesses can be compensable without meeting criteria for OSHA-recordable status (and vice versa), we combined monthly counts of both OSHA-recordable and compensable events into a single metric of monthly "musculoskeletal events." Based on review of records, musculoskeletal events were identified as those with the following injury natures: strained body part, sprained body part, inflammation, numbness, carpal tunnel syndrome, and continuing trauma. For each study site and for each six-month interval starting 24 months prior to baseline data collection and ending with the final follow-up data collection, the sum of the number of musculoskeletal events and the sum of the production hours was used to estimate the "musculoskeletal incidence rate." Incidence rates were normalized to 100 full time equivalent workers (FTE). Note that in this study, 100,000 hours was used as the basis for normalizing incidence rates to 100 FTE since the rates were calculated in six-month intervals rather than in 12-month intervals (i.e., 100 workers * 2000 hours per year per worker * 0.5 years = 100,000 hours). Using this information, we constructed charts to display time histories of musculoskeletal event incidence rates by study site and examined temporal trends for descriptive purposes.

Aim 2

The analyses associated with Aim 2 relied on information obtained (i) directly from consented participants who completed the self-administered study questionnaire and (ii) indirectly from all consented participants through the company's third-party health benefits vendors (i.e., individual-level results of the annual HRA and biometric screening). Moreover, because the intervention included access to the study's health and wellness coach, additional details of the health and wellness coaching component of the intervention are provided here. Recall that participants were afforded up to four, 30-minute, in-person sessions annually during the intervention period (i.e., starting with the first follow-up data collection round and ending with the final follow-up data collection round). Thus, the maximum number of sessions was 16 for any one participant.

Quality control of health and wellness coaching. As proposed, to ensure quality control and systematic mentoring, the health and wellness coach worked closely with a mentor who is a member of the Motivational Interviewing Network of Trainers. With permission, participant encounters with the health and wellness coach were audio recorded (two participants declined) to facilitate review and tabulation of the health and wellness topics discussed and specific goals set. In addition, 20% of the audio recordings were randomly selected for scoring of MI fidelity using the OnePass coding system [McMaster and Resnicow 2015]. The OnePass coding system includes items that assess MI performance. Example items include (i) specific MI-based constructs, such as how well and how often the wellness coach "collaboratively set the session agenda" with the participant, "used reflective listening," and "used open-ended questions," (ii) an assessment of the overall performance of the wellness coach, and (iii) an assessment of the ratio of participant "talk time" to the wellness coach talk time. Except for the talk time ratio, each item is rated using a 1-7 ordinal scale, where a higher rating value is associated with increased MI performance. The talk time ratio is rated using an ordinal scale with three possible values: 1 (< 50% participant talk time), 4 (50 % participant talk time), and 7 (> 50% participant talk time). Each MI-based construct may or may not be used in every coaching encounter; therefore a final score is derived from the mean value of the scored constructs.

The health and wellness coach and the mentor independently scored each randomly selected audio recording and then, together, reviewed the audio recordings and the scoring results to provide the health and wellness coach with feedback and strategies for MI skill improvement. The distributions of the OnePass scores from the health and wellness coach and the mentor were summarized using means and standard deviations. The OnePass scores were then dichotomized as < 4 (indicating inadequate MI performance) and ≥ 4 (indicating adequate MI performance). Inter-rater agreement of the dichotomized OnePass scores was then assessed using Cohen's kappa.

Hypothesis 2b

In conjunction with providing written informed consent, each participant in each study site signed a HIPAA-compliant authorization for the company's third-party vendors to release individual-level HRA and biometric screen results to the research team. The HRA/biometric screen was conducted once annually (typically in July), so the frequency of data collection was less than that for the self-administered questionnaire (described under Hypothesis 1b). In addition to the elements listed under Hypothesis 1b, the self-administered questionnaire included the SF-36v2 to assess both physical and mental well-being. The SF-36v2 contains 36 items pooled into eight scales which are further aggregated into two summary measures (the "physical composite score" and "mental composite score"), and has been used extensively in epidemiologic research, including studies of back pain and musculoskeletal illness [Turner-Bowker, et al. 2002]. The HRA/biometric screen was conducted once annually (typically in July), so the frequency of data collection was less than that for the self-administered questionnaire.

From the HRA/biometric screening and the self-administered study questionnaire, the variables extracted as indicators of modifiable health risks and overall health for the purpose of this study are shown below. With regard to the study timeline, the years available for the HRA/biometric data correspond to our data collection rounds as follows: 2012 – baseline; 2013 – follow-up 2; 2014 – follow-up 4; 2015 – follow-up 6.

Description (units, as applicable)	**Source**	**Frequency**
Physical composite score	SF-36v2	semi-annual
Mental composite score	SF-36v2	semi-annual
Body mass index (kg/m^2)	Self-admin	semi-annual
Systolic blood pressure (mmHg)	HRA/biometric	annual
Diastolic blood pressure (mmHg)	HRA/biometric	annual
Total cholesterol (mg/dL)	HRA/biometric	annual
Low-density lipoprotein (md/dL)	HRA/biometric	annual

Triglycerides (mg/dL)	HRA/biometric	annual
Hemoglobin A1c (%)	HRA/biometric	annual

The analytic approach was similar to the repeated-measure models described for Hypotheses 1a and 1b. The outcomes described above were independent variables in multivariate models. The main exposure variable was intervention status (with time as a covariate), and the appropriate link function was used for the general linear models based on the distribution of the SF-36v2 and HRA/biometric outcome measures. Demographic characteristics (age, gender, body mass index, etc.) were also included as covariates in the models.

Aim 3

Hypothesis 3a

From the workplace injury/illness database maintained by the company's centralized risk management group, we obtained information about the workers' compensation expenses associated with each compensable musculoskeletal event (as defined under Hypothesis 1c). The company tracked workers' compensation expenses on a per-claim basis rather than on a monthly-basis. Therefore, for each study site, we calculated the annual (calendar year) expenses for year starting five years prior to baseline (i.e., 2007) through the final year of data collection activities (i.e., 2015). Intervention activities occurred in the 2012-2015 calendar years. We also calculated the median expenses per claim annually over the same time frame. All expenses were expressed in 2010 US dollars using Consumer Price Index (CPI) information published on the Bureau of Labor Statistics website (https://www.bls.gov/cpi/cpid1512.pdf; Table 25; "All items"). Similar to Hypothesis 1c, we constructed charts to display time histories of workers' compensation expenses and examined temporal trends for descriptive purposes.

Data Delivery Challenges and Barriers (Hypotheses 2a, 3b and 3c)

At the time the project was funded, the company's health benefits administrators and third-party health benefits vendors had agreed to provide facility-level data (for each site) regarding employee use of third-party employee assistance programs for chronic disease management (Hypothesis 2a) and health insurance claims and claim costs (Hypothesis 3b). Unfortunately, several factors outside the control of the research team led to insurmountable delays and, ultimately, barriers to receiving these data elements. Most importantly, less than one year from the start of project funding, a majority stake in the company was purchased by a private equity firm. In subsequent years, the company's executive and health benefits management personnel (our key contacts) turned over and the company made a change to its third-party health benefits vendors. Consequently, the structure, content and delivery of the employee assistance programs changed and the data we had proposed to collect for Hypothesis 2a were not available. Moreover, the health benefits administrators elected to discontinue the annual Health Risk Appraisal in project year 4 (2014-2015), and, although the annual biometric screening continued, changes were made to the specific lab results available for each consented participant (these changes also impacted Hypothesis 2a). It became clear during the final year of funding (2015-2016) that delays in data delivery were imminent and would impact our ability to complete analyses associated with Hypotheses 2a, 3b and 3c before the end of project year 5, and so we requested a no-cost extension.

From late February to early March 2017 we received from the company's third party health benefits vendors the results of annual health risk appraisals and biometric screening for each consented participant at each study site. Ultimately, however, the company's health benefits administrators elected not to provide the research team with facility-level or individual-level health insurance claims and claim costs. Therefore, we were unable to complete Hypotheses 3b (estimating intervention effects on health insurance claims costs) and 3c (estimating return on investment) by the time of this Final Performance Report. Although we continue to communicate with our company contacts, at this time we do not anticipate that additional data will be delivered.

Results

Note: Tables and figures referred to in-text are located at the end of the "Results" section.

Participants and demographic/personal health characteristics

The status of both recruitment and participation at each study site at baseline and each six-month interval is provided in Table 1. Importantly, for each study site, a substantial proportion of participants who provided written informed consent were lost to follow-up because of either voluntary or involuntary termination of employment (114 of 212 [53.8%] intervention participants and 122 of 252 [48.4%] referent participants terminated employment during the study). Overall, intervention site participants remained in the study for 2.1 ± 1.2 years and referent site participants remained in the study for 2.2 ± 1.3 years (data not shown in Table 1). The average proportion of available participants who completed the self-administered questionnaires (i.e., across all rounds of data collection) was somewhat lower in the intervention site (46.7%) compared to the referent site (55.5%). Of the intervention site participants, 70 engaged with the study's health and wellness coach.

Among participants who completed the self-administered questionnaire, the distributions of gender, age, BMI and other demographic/personal health characteristics at baseline and at each six-month interval are provided in Table 2. Overall, referent site participants were more frequently male than intervention site participants at each data collection round. The mean age of participants was typically in the early fourth decade and, in general, referent site participants had been employed by the company an average of two to three years longer than intervention site participants. Regardless of study site, participants' body mass index values were above recommended values. The majority of participants were enrolled in an employer-sponsored health insurance plan. At least 74% of participants in each study site worked in production areas, and the majority reported annual household income levels of $35,000 or less. The majority of participants at each site and data collection round reported education at the high school level. However, a greater proportion of intervention site participants reported education at the community college level, whereas a greater proportion of referent site participants reported education at the technical/trade school level. Depending on data collection round and site, between 28.2% and 44.9% of participants reported currently using tobacco products (including smokeless tobacco).

Aim 1

Digital Human Modeling

Although not tied directly to the Aim 1 analyses, the DHM component of the intervention was expected to influence exposure to physical risk factors among the production tasks at the intervention site. As originally envisioned, two company personnel and one member of the research team would be trained in the use of the Santos™ DHM software ahead of the baseline round of data collection. Training occurred in project year 1 as expected. However, several personnel changes in project years 1 and 2 resulted in the development and execution of an alternative plan. Personnel changes included (i) a new general manager at the intervention facility (limiting time available for company personnel to perform DHM activities), (ii) both company personnel originally trained in the use of the software were reassigned to different locations, (iii) the safety manager at the intervention facility left the company and a new safety manager was hired, and (iv) two project research assistants trained in the use of the software changed employment in project years 1 and 2. Therefore, we elected to redirect resources allocated to the DHM component of the intervention to the Santos™ distributor (SantosHuman Inc.) through a professional services agreement, which was executed early in project year 3 (i.e., year 2 of intervention activities). From then, the safety and wellness committee identified tasks for which DHM would be useful, and the research team worked (i) with the committee to collect the data needed to complete each modeling exercise (as described in the Procedures and Methods section, above) and (ii) a SantosHuman Inc. engineer to construct and finalize modeling scenarios and results.

In total, 12 unique tasks were modelled during the course of intervention activities, with numerous extensions (e.g., models with different strength capabilities, body weights, etc.) for follow-up analyses. In general, the DHMs could be broadly categorized as having the following objectives: 1) to characterize and evaluate exposure to physical risk factors associated with the development of work-related MSDs for a work task; 2) to

develop and/or evaluate alternative workstation designs and/or interventions intended to reduce exposure to physical risk factors and/or improve productivity; 3) to evaluate the role of non-occupational risk factors with respect to exposure to physical risk factors during the completion of a work task. Examples of each situation are described in the following subsections.

Evaluation of Existing Tasks: One task that the safety and wellness committee was particularly interested in examining was the act of pushing and pulling the manual material handling (MMH) carts used throughout the manufacturing facility. Specifically, the safety and wellness committee was interested in determining a maximum recommended weight limit that a MMH cart may hold in an effort to reduce the risk of back injuries. Each MMH cart used in the facility was designed to hold up to 50 window panes of glass that weighed, on average, 18.15 kg (40 lbs). Most of the carts were fully loaded when moved and approached a maximum possible cart weight of 1134 kg. (2500 lbs.), considering both the weight of the cart itself (150 lbs.) plus the load.

To develop this DHM, a measurement of a standard cart's dimensions was made and estimates of the push and pull forces required to move the carts (both empty and fully loaded) were obtained using a Baseline® Electronic Push-Pull Dynamometer (Nexgen Ergonomics, Inc., Pointe Claire, Quebec, CAN) by a member of the safety and wellness committee. To determine the maximum recommended weight limit a cart should hold, estimates of spine compression and spine shear were calculated using the Santos™ DHM software for both pushing and pulling scenarios. These resulting estimates were evaluated against the recommended action limit of 3400 N for spine disc compression and 330 N for spine shear. Overall, the results indicated that the carts should not be loaded with more than 227 kg. (500 lbs.) or 12 panes of glass to reduce the risk of low back injury. Additionally, the results identified pushing, particularly straight ahead, as the safest mode to move the carts. The safety and wellness committee used this information to develop new training procedures as well as cart loading and travel path recommendations in all areas of the facility.

Development/Evaluation of New Workstation Designs: An example of the DHM software being leveraged to evaluate a new work task was when a new painting line was added to the facility. Previous to the new line, all production processes were completed with components that were painted off site. The addition of a new line to the facility presented an opportunity to evaluate a range of workstation configuration options. For this new task, potential workstation designs were brainstormed and discussed by the safety and wellness committee. These options included working with the window frames lying flat on a table and in different upright orientations. Similar to previous DHMs, various metrics were developed using the Santos™ prediction techniques such as L5-S1 joint displacement, estimates of static fatigue, spine compression, and overall discomfort. Work zone models were also developed using the "zone differentiation" tool that analyzes a specified volume of range of motion from the current position within the volume space. Ultimately, the safety and wellness committee used the information output from the models to select the workstation design that reduced the theoretical exposures to physical risk factors to the greatest extent while maximizing (predicted) worker comfort.

Modeling of Non-Occupational Risk Factors: To illustrate the potential negative effects of personal risk factors such as an unhealthy BMI (i.e., overweight or obese classification) on employee health and safety to employees at the facility, the safety and wellness committee asked that DHMs be developed to simulate a MMH cart moving task for males and females with different BMI classifications (e.g., normal, overweight, obese). For this request, DHMs for both male and female avatars were derived from the strength and mobility profiles of 100 individuals classified with a normal BMI (≥18.5 kg/m2 and ≤24.9 kg/m2), an overweight BMI (≥25.0 kg/m2), and an obese BMI (≥30.0 kg/m2) for the MMH cart task previously described. The strength profiles at each BMI and gender combination included estimates for a 5^{th}, 50^{th}, and 95^{th} percentile human. In general, results of these models indicated that while the MMH cart task could be performed by all of the avatars, simulation comparisons suggested that increased BMI led to range of motion restrictions and reduced capacity to generate joint torque under certain task conditions. The safety and wellness committee used this information to fine-tune its previous cart loading recommendations and reinforce facility-wide health promotion activities and messaging.

Intervention Effects on Exposure to Physical Risk Factors (Hypothesis 1a)

Distributions (means, standard deviations) of the OWAS, SI, and ACGIH® TLV® for Hand Activity Level (right and left hands separately) at baseline and at each subsequent data collection round are available in Table 3. Notable differences between the intervention and referent sites include (i) somewhat lower (more desirable)

percent time in OWAS categories 2-4 among tasks in the intervention site across all rounds and (ii) somewhat higher (less desirable) SI and TLV scores among tasks at the intervention site for most rounds. In general, the mean values of each exposure assessment method decreased from baseline during the follow-up period in both the intervention and referent sites. However, the effect of the intervention, estimated as the interaction between site and round, was statistically significant only for the SI scores ($p<0.05$). In other words, although SI scores decreased from baseline in each site, the magnitude of the reduction was greater in the intervention site compared to the referent site.

Secondary analyses (data not shown) suggested that task changes from baseline through the follow-up periods tended to reduce exposure levels. In particular, SI and TLV scores (both right and left hand) tended to be lower following task changes, with the greatest reductions occurring as a consequence of (i) modification to elements comprising a task (i.e., "sub-tasks") and (ii) the installation of new equipment to perform the task (e.g., material handling aids or new production fixtures). The effect of task changes on exposure levels did not differ by site over time (i.e., no evidence of an intervention effect).

Intervention Effects on Musculoskeletal Symptoms (Hypothesis 1b)

In general, estimates of the two-week prevalence of low back, neck/shoulder, and hand/wrist/elbow pain were greater among intervention site participants than among referent site participants (Table 4). However, the prevalence estimates exhibited no clear temporal trends within a particular study site, and few (if any) meaningful differences were observed between study sites. Importantly, for each pain location, the final multivariable model included job strain ratio as a covariate (among other demographic and personal health variables) based on its consistent strength as a confounder of the relationship between intervention status and musculoskeletal symptom status.

Intervention Effects on Musculoskeletal Events Consistent with Musculoskeletal Outcomes (Hypothesis 1c)

Incidence rates of musculoskeletal events in the intervention and referent sites across the study timeline are shown in Figure 1. The six-month interval starting 24 months prior to baseline and ending 18 months prior to baseline appears to be anomalous. Disregarding this interval, the average musculoskeletal incidence rate up to the first follow-up round of data collection (when intervention activities began) was 1.5 cases per 100 FTE in the intervention site and 1.2 cases per 100 FTE in the referent site. During the intervention period (administered from the first to final follow-up data collection rounds), the average musculoskeletal incidence rate was 2.0 cases per 100 FTE in the intervention site and 1.5 cases per 100 FTE in the referent site. Examination of trends from the first to final follow-up data collection rounds suggests a similar musculoskeletal incidence rate temporal pattern for each site and no meaningful reduction of rates as a consequence of the intervention.

Aim 2

Quality Control of Health and Wellness Coaching

The health and wellness coach conducted a total of 393 sessions with 70 unique consented intervention site participants during the course of the study. Of these, 79 (20.1%) were randomly selected for independent scoring (using the OnePass method) by the coach and mentor. Fidelity in the use of MI during the coaching sessions was assessed separately for all six-month intervals between data collection rounds during the intervention period (coaching began after the baseline data collection round and ended at the final data collection round). For each interval, median OnePass scores from the scored sessions from both the coach and the mentor exceed 4 (the lower threshold of MI proficiency), with no meaningful difference observed between the coach and mentor score distributions. Cohen's kappa values, used to estimate inter-rater agreement in the OnePass scores, ranged from 0.9 to 1.0. Therefore, the study goal of delivering health and wellness coaching with the use of MI was met.

Participation in the Health and Wellness Coaching Component of the Intervention

Across the 70 participants who engaged with the health and wellness coach, the median number of sessions was 5 (IQR: 3-8 sessions; range: 1-16 sessions). Forty-six participants completed at least four sessions, and

21 participants completed at least eight sessions. Eight participants met with the coach on a single occasion. Of these, five did not continue for employment reasons (i.e., termination) and three elected not to continue voluntarily. Data from these three participants were excluded from further analyses.

Characteristics of Participants who Engaged in the Health and Wellness Coaching Component of the Intervention

Compared to all intervention site participants who completed the self-administered study questionnaires, those who engaged with the health and wellness coach tended to be older (mean age approximately 2-3 years greater at each data collection round), more frequently female, more frequently worked in production areas of the facility (versus an office setting), and had been employed with the company up to two years longer (on average). No other notable demographic and or personal health differences were observed.

Description of Participant Health and Wellness Goal-setting and Goal-completion

Participants set ~400 unique personal health and wellness goals during sessions with the health and wellness coach. Approximately 30% of these goals related to physical activity/fitness, 14% to nutrition, 5% to weight loss, 19% to stress (both occupational and non-occupational), 21% to general health and well-being, and 11% to other topics (e.g., tobacco cessation, sleep habits, and financial planning, among others). The distribution of health and wellness goal topics, by study timeline, is provided in Figure 2. Participants reported complete attainment of 32% of physical activity/fitness goals, 21% of nutrition goals, 38% of weight loss goals, 27% of stress goals, 51% of general health and well-being goals, and 56% of other goals. Open-ended responses to a health and wellness coaching satisfaction survey suggested that “having an outside person to talk to without judgement” and having “information to make goals possible” were important motivators for participants.

Intervention Effects on Indicators of Modifiable Health Risks and Overall Health (Hypothesis 2b)

Distributions (mean, sd) of body mass index, the physical and mental composite scores of the SF36v2, and of the of key indicators of modifiable health risks extracted from the annual biometric screening are provided for (i) all intervention site participants, (ii) intervention site participants who also engaged with the study health and wellness coach, and (iii) all referent site participants at baseline and selected follow-up time points in Table 5. Because the annual biometric screen was performed once annually by one of the company’s third party health benefits vendors, and because we had no control over the timing of the biometric screen, data from the study questionnaire (BMI and SF36v2 PCS/MCS) are provided from the follow-up round closest in time to the biometric screening. In general, mean BMI, the SF36v2 MCS, blood pressure, and lab results (total cholesterol, low-density lipoprotein, triglycerides, and hemoglobin A1c) were similar for each group of participants and stable over time, changing only small fractions of a standard deviation between any two observation times. From baseline to the fourth follow-up, the SF36v2 PCS metric improved by approximately two-thirds of a standard deviation among intervention site participants who engaged the health and wellness coach (and to lesser extent among all intervention site participants). During this same time period, the SF36v2 only marginally improved among referent site participants. This result is suggestive of an intervention effect. However, at the sixth follow-up round, the mean SF36v2 PCS scores fell back to or below baseline levels among all participant groups. Interpretation is complicated, however, given that the high employment turnover in each facility made the recruitment and retention of a stable cohort of participants impossible (i.e., ~50% of all consented participants terminated employment during the study).

Aim 3

Intervention Effects on Workers’ Compensation Costs (Hypothesis 3a)

During the 2012-2015 calendar years (i.e., the period of active intervention activities), the intervention site recorded 66 workers’ compensation claims with associated expenses (range: 9 to 21 claims per year) and the referent site recorded 60 workers’ compensation claims with associated expenses (range: 6 to 22 claims per year). In general, the time series of (i) the annual number of workers’ compensation claims, (ii) the annual total workers’ compensation costs, and (iii) the annual median cost per clam show substantial variation with little evidence to suggest a meaningful effect of the intervention (Figures 3-5). The relatively small numbers of claims per year precluded formal statistical analyses, as small numbers of expensive claims greatly influenced the annual total workers’ compensation costs (e.g., in 2014, three of 21 intervention site claims accounted for

67% of the total workers' compensation costs) and the annual median cost per claim (e.g., in 2015, seven of eight referent site claims cost <$1,800 but the median cost of all eight claims was ~$4,500). In summary, this was unable to detect an effect of the intervention on workers' compensation costs.

Table 1: Recruitment and participation status, by site and timeline.

	Baseline	Follow-up round						
		1	2	3	4	5	6	7
Intervention Site								
Consented	94	16	25	35	25	17	-	-
Total sample (cumulative)[1]	94	110	135	170	195	212	212	212
No longer employed (cumulative)[2]	-	15	29	42	55	76	99	114
Left study (cumulative)[3]	-	1	1	1	2	2	2	2
On leave/layoff	-	3	2	0	1	6	1	1
Available to complete questionnaire	94	91	103	127	137	128	110	95
Completed questionnaire	56	49	49	54	56	51	50	40
Did not complete questionnaire	38	42	54	73	81	77	60	55
Engaged health & wellness coach[4]	-	39	46	50	60	67	70	70
Referent Site								
Consented	102	32	29	39	28	22	-	-
Total sample (cumulative)[1]	102	134	163	202	230	252	252	252
No longer employed (cumulative)[2]	-	9	25	42	59	76	103	122
Left study (cumulative)[3]	-	5	6	7	7	7	7	7
On leave/layoff	-	1	3	7	1	1	4	3
Available to complete questionnaire	102	119	129	146	163	168	138	120
Completed questionnaire	65	64	70	78	91	90	76	66
Did not complete questionnaire	37	55	59	68	72	78	62	54

[1]Cumulative sum of all those who provided written informed consent.
[2]Cumulative sum of all consented participants no longer employed at the study site.
[3]Cumulative sum of all consented participants who left the study voluntarily but remained employed at study site.
[4]Cumulative sum of participants who engaged in the health and wellness coaching component of the intervention.

Table 2: Sample size and distributions of demographic and personal health variables by site and timeline (Int = Intervention site; Ref = referent site). Significant between-site (within-round) differences identified in boldface.

	Baseline (n=121)		**Follow-up round**													
			1 (n=113)		**2 (n = 119)**		**3 (n=132)**		**4 (n=147)**		**5 (n=141)**		**6 (n = 126)**		**7 (n=107)**	
	Int (n=56)	Ref (n=65)	Int (n=49)	Ref (n=64)	Int (n=49)	Ref (n=70)	Int (n=54)	Ref (n=78)	Int (n=56)	Ref (n=91)	Int (n=51)	Ref (n=90)	Int (n=50)	Ref (n=76)	Int (n=39)	Ref (n=67)
Age (mean, sd)	41.8 (11.4)	42.0 (11.9)	43.5 (10.7)	40.8 (12.0)	42.5 (11.3)	41.4 (12.0)	41.9 (10.9)	41.4 (11.8)	42.3 (12.6)	41.5 (13.7)	43.7 (10.7)	40.5 (13.8)	43.0 (11.2)	40.6 (13.0)	43.0 (11.4)	42.9 (12.3)
Male gender (N, %)	34 (60.7)	41 (63.1)	**23 (46.9)**	**43 (67.2)**	23 (46.9)	45 (64.3)	29 (53.7)	46 (59.0)	31 (55.4)	52 (57.1)	25 (49.0)	52 (57.8)	26 (52.0)	42 (55.3)	22 (56.4)	40 (59.7)
BMI (kg/, m^2) (mean, sd)	28.3 (5.4)	29.0 (5.9)	29.0 (6.1)	29.6 (6.8)	30.2 (6.3)	30.3 (7.3)	29.0 (5.6)	28.8 (6.4)	30.5 (7.9)	29.1 (6.5)	30.6 (7.3)	29.0 (6.2)	30.7 (7.0)	29.3 (6.7)	30.7 (7.0)	29.8 (6.4)
Caucasian ethnicity (N, %)	53 (96.4)	65 (100.0)	47 (97.2)	63 (98.4)	43 (89.7)	69 (98.6)	48(94.1)	76 (96.2)	54 (98.2)	88 (96.7)	47 (92.2)	86 (95.6)	**43(87.8)**	**74 (97.4)**	35 (92.1)	67 (100.0)
Education level (N,%)																
Some high school	3 (5.4)	1 (1.5)	1 (2.0)	1 (1.6)	2 (4.1)	2 (2.9)	3 (5.7)	3 (3.9)	3 (5.4)	2 (2.2)	0	2 (2.2)	0	1 (1.3)*	0	3 (4.5)
High school graduate	31 (55.4)	36 (55.4)	22 (44.9)	32 (50.0)	20 (40.8)	35 (50.0)	27 (50.9)	39 (50.0)	26 (46.4)	47 (51.7)	28 (54.9)	49 (54.4)	23 (46.9)	44 (57.9)	17 (43.6)	35 (52.2)
Technical/trade school	**2 (3.6)**	**10 (15.4)**	**5 (10.2)**	**15 (23.4)**	**5 (10.2)**	**10 (14.3)**	**4 (7.6)**	**11 (14.1)**	**5 (8.9)**	**17 (18.7)**	**4 (7.8)**	**15 (16.7)**	**4 (8.2)**	**16 (21.1)**	**2 (5.1)**	**12 (17.9)**
Community college degree	**11 (19.6)**	**9 (13.9)**	**15 (30.6)**	**9 (14.1)**	**14 (28.6)**	**10 (14.3)**	**14 (26.4)**	**14 (18.0)**	**15 (26.8)**	**16 (17.6)**	**12 (23.5)**	**16 (16.7)**	**13 (26.5)**	**9 (11.8)**	**14 (35.9)**	**11 (16.4)**
University degree	9 (16.1)	9 (13.9)	6 (12.2)	7 (10.9)	8 (16.3)	13 (18.6)	5 (9.4)	11 (14.1)	7 (12.5)	9 (9.9)	7 (13.7)	9 (10.0)	9 (18.4)	6 (7.9)	5 (15.4)	5 (9.0)
Household income (N, %)																
Less than$15,000	4 (7.6)	1 (1.5)	4 (8.5)	2 (3.2)	3 (6.5)	1 (1.5)	0	1 (1.3)	1 (1.9)	1 (1.1)	1 (2.0)	0	1 (2.1)	0	0	0
$15,000 - $24,999	10 (18.9)	12 (18.5)	7 (14.9)	17 (27.4)	3 (6.5)	12 (17.6)	11 (22.0)	17 (22.1)	8 (15.4)	15 (16.7)	9 (18.4)	11 (12.5)	8 (16.7)	9 (11.8)	3 (7.9)	8 (11.9)
$25,999 - $34,999	15 (28.3)	28 (43.1)	17 (36.2)	23 (37.1)	17 (37.0)	26 (38.2)	11 (22.0)	26 (33.8)	15 (28.9)	39 (43.3)	21 (42.9)	36 (40.9)	22 (45.8)	40 (52.6)	14 (39.5)	26 (38.8)
$35,000 - $49,999	5 (9.4)	11 (16.9)	5 (10.6)	9 (14.5)	9 (19.6)	18 (26.5)	8 (16.0)	18 (23.4)	10 (19.2)	18 (20.0)	7 (14.3)	18 (20.5)	7 (14.6)	14 (18.5)	9 (23.7)	18 (26.9)
$50,000 - $74,999	12 (22.6)	6 (9.2)	10 (21.3)	9 (14.5)	9 (19.6)	6 (8.8)	16 (32.0)	9 (11.7)	11 (21.2)	10 (11.1)	7 (14.3)	14 (15.9)	6 (12.5)	5 (7.9)	4 (10.5)	9 (13.4)
$75,000 and over	7 (13.2)	7 (10.8)	4 (8.5)	2 (3.2)	5 (10.9)	5 (7.4)	4 (8.0)	6 (7.8)	7 (13.5)	7 (7.8)	4 (8.2)	9 (10.2)	4 (8.3)	7 (9.2)	7 (18.4)	6 (9.0)
Years with employer (mean, sd)	**6.6 (6.9)**	**9.7 (9.2)**	**6.2 (7.0)**	**9.7 (9.3)***	**6.4 (7.6)**	**9.9 (10.0)***	**6.3 (7.3)**	**9.3 (10.2)**	7.4 (7.8)	9.2 (10.4)	6.8 (8.0)	9.0 (10.1)	6.9 (7.4)	9.2 (10.3)	8.2 (7.3)	10.5 (10.5)
Health insurance source (N, %)																
Employer-provided	41 (73.2)	55 (84.6)	40 (81.6)	56 (87.5)	44 (89.8)	63 (91.3)	48 (90.6)	69 (88.5)	50 (89.3)	81 (89.0)	43 (87.8)	79 (86.7)	47 (94.0)	66 (86.8)	33 (84.6)	61 (92.4)
Other (e.g., spouse)	3 (5.4)	6 (9.2)	3 (6.1)	3 (4.7)	4 (8.2)	4 (5.8)	4 (7.6)	7 (9.0)	4 (7.1)	8 (8.9)	3 (6.1)	11 (12.2)	2 (4.0)	8 (10.6)	6 (15.4)	5 (7.6)
None	**12 (21.4)**	**4 (6.2)**	5 (10.2)	5 (7.8)	1 (2.0)	2 (2.9)	1 (1.9)	2 (2.6)	2 (3.6)	2 (2.2)	3 (6.1)	1 (1.1)	1 (2.0)	2 (2.6)	0	0
Tobacco use (N, %)																
Never used tobacco	22 (40.0)	22 (34.4)	20 (40.8)	21 (33.3)	19 (38.8)	26 (37.1)	17 (32.1)	23 (29.5)	19 (33.9)	30 (33.0)	17 (33.3)	26 (29.2)	15 (30.0)	20 (26.3)	10 (25.6)	17 (25.4)
Currently use tobacco	23 (41.8)	26 (40.6)	22 (44.9)	20 (31.8)	20 (40.8)	23 (32.9)	20 (37.8)	22 (28.2)	23 (41.1)	28 (30.8)	20 (39.2)	32 (36.0)	17 (34.0)	29 (38.2)	15 (38.5)	19 (28.4)
Previously used tobacco	10 (18.2)	16 (25.0)	**7 (14.3)***	**22 (34.9)**	10 (20.4)	21 (30.0)	16 (30.2)	33 (42.3)	14 (25.0)	33 (36.3)	14 (27.5)	31 (34.8)	18 (36.0)	27 (35.5)	14 (36.9)	31 (46.3)
Previous musculoskeletal condition (N, %)																

Neck	2 (3.6)	7 (10.8)	2 (4.1)	9 (14.1)	4 (8.3)	7 (10.1)	4 (7.6)	4 (5.1	3 (5.4)	9 (9.9)	5 (9.8)	9 (10.1)	5 (10.0)	8 (10.5)	4 (10.3)	7 (10.5)
Shoulder	6 (10.7)	6 (9.2)	6 (12.2)	6 (9.5)	6 (12.8)	8 (11.6)	6 (11.5)	6 (7.7)	5 (8.9)	10 (11.1)	6 (11.8)	12 (13.5)	7 (14.3)	13 (17.1)	5 (12.8)	8 (11.9)
Back	4 (7.1)	8 (12.3)	4 (8.2)	13 (20.6)	7 (14.9)	14 (20.0)	8 (16.0)	9 (11.5)	7 (12.5)	15 (16.5)	9 (17.7)	15 (16.9)	8 (16.7)	14 (18.7)	8 (20.5)	12 (17.9)
Elbow	4 (7.1)	4 (6.2)	6 (12.2)	2 (7.9)	4 (8.5)	7 (10.0)	3 (5.7)	6 (7.8)	5 (9.8)	10 (11.1)	6 (12.0)	6 (6.9)	4 (8.3)	6 (8.0)	1 (2.6)	9 (13.6)
Hand/wrist	12 (21.4)	8 (12.3)	14 (28.6)	11 (17.7)	12 (24.5)	13 (18.6)	13 (24.5)	15 (19.2)	12 (21.4)	17 (18.7)	**14 (27.5)**	**12 (13.5)**	11 (22.0)	17 (22.4)	7 (18.0)	12 (17.9)
Autoimmune disease (N, %)	1 (1.8)	0	1 (2.0)	0	1 (2.1)	3 (4.4)	0	3 (3.9)	1 (1.8)	3 (3.3)	1 (2.0)	1 (1.1)	1 (2.1)	2 (2.7)	2 (5.1)	0
Work area (N, %)																
Production	42 (75.0)	56 (86.2)	39 (79.6)	55 (89.9)	37 (75.5)	60 (85.7)	43 (79.6)	62 (79.5)	43 (76.8)	76 (83.5)	42 (83.4)	76 (84.4)	43 (86.0)	68 (89.5)	**29 (74.4)**	**61 (91.0)**
Office	14 (25.0)	9 (13.9)	10 (20.4)	9 (14.1)	12 (24.5)	10 (14.3)	11 (20.4)	16 (20.5)	13 (23.2)	15 (16.5)	9 (17.7)	14 (15.6)	7 (14.0)	8 (10.5)	**10 (25.6)**	**6 (9.0)**
Has a second job (N, %)	7 (12.5)	4 (6.2)	6 (12.2)	6 (9.4)	7 (14.3)	9 (12.9)	5 (9.4)	7 (9.0)	6 (10.7)	8 (8.8)	**9 (17.7)**	**5 (5.6)**	6 (12.0)	3 (4.0)	2 (5.1)	3 (4.5)
Second job weekly hours (mean, sd)	19.1 (12.0)	14.4 (6.4)	23.2 (13.4)	20.8 (11.3)	22.1 (6.3)	21.7 (10.7)	12.5 (6.6)	20.3 (8.4)	20.2 (10.4)	13.4 (7.7)	17.8 (5.7)	16.3 (5.1)	22.3 (9.4)	14.5 (9.2)	12.5 (3.5)	16.5 (8.3)

Table 3: Mean(sd) OWAS, Strain Index, and ACGIH® TLV® for Hand Activity Level by site and timeline.

	Baseline	Follow-up Round						
		1	2	3	4	5	6	7
OWAS[1]								
Intervention site	15.1 (11.7)	12.1 (11.8)	11.9 (10.0)	9.8 (9.3)	9.3 (8.5)	9.6 (9.6)	9.6 (16.2)	11.8 (10.3)
Referent site	19.6 (15.0)	17.1 (18.2)	13.7 (11.3)	13.4 (12.4)	14.1 (14.2)	12.5 (11.7)	12.2 (12.2)	15.7 (15.4)
Strain Index								
Intervention site	37.9 (32.6)	19.9 (22.4)	30.1 (29.9)	18.6 (12.8)	20.8 (14.8)	14.8 (10.3)	16.7 (16.3)	17.1 (12.2)
Referent site	23.8 (24.8)	19.8 (24.0)	28.7 (29.4)	17.1 (13.3)	16.9 (13.4)	15.6 (12.2)	14.0 (13.1)	13.1 (15.4)
ACGIH® TLV®[2] (right hand)								
Intervention site	0.96 (0.58)	0.92 (0.42)	0.95 (0.71)	0.82 (0.41)	0.81 (0.39)	0.77 (0.41)	0.81 (0.45)	0.81 (0.41)
Referent site	0.80 (0.46)	0.67 (0.38)	0.92 (0.66)	0.63 (0.37)	0.68 (0.34)	0.67 (0.34)	0.63 (0.35)	0.65 (0.32)
ACGIH® TLV®[2] (left hand)								
Intervention site	0.81 (0.56)	0.72 (0.42)	0.80 (0.57)	0.65 (0.33)	0.63 (0.34)	0.61 (0.36)	0.60 (0.29)	0.65 (0.36)
Referent site	0.74 (0.63)	0.59 (0.35)	0.75 (0.47)	0.52 (0.30)	0.54 (0.25)	0.55 (0.24)	0.50 (0.28)	0.54 (0.22)

[1]Percent time in OWAS categories 2, 3 or 4
[2]Ratio of Normalized Peak Force rating to one minus the Hand Activity Level rating

Table 4: Musculoskeletal pain prevalence and job strain ratio distributions, by site and timeline.

	Baseline	Follow-up Round						
		1	2	3	4	5	6	7
Low back pain *2-week prevalence (N,%)*								
Intervention site	18 (32.1)	15 (30.6)	17 (35.4)	17 (31.5)	21 (38.9)	15 (30.0)	20 (40.0)	15 (39.5)
Referent site	12 (18.5)	20 (31.3)	17 (25.0)	20 (26.3)	18 (19.8)	22 (24.4)	17 (22.4)	25 (37.9)
Neck/shoulder pain *2-week prevalence (N,%)*								
Intervention site	13 (23.2)	13 (26.5)	10 (20.4)	14 (26.4)	13 (24.1)	17 (34.7)	16 (32.0)	12 (30.8)

Referent site	19 (29.2)	18 (28.1)	15 (22.1)	15 (19.5)	20 (22.0)	21 (23.3)	18 (23.7)	18 (27.3)
Hand/wrist/elbow pain								
2-week prevalence (N,%)								
Intervention site	18 (32.1)	14 (28.6)	15 (31.3)	13 (25.0)	14 (25.5)	12 (24.5)	19 (38.0)	5 (12.8)
Referent site	16 (25.4)	15 (23.4)	11 (15.7)	13 (16.7)	19 (20.9)	18 (20.2)	12 (16.8)	12 (18.2)
Job Strain Ratio[1] (mean, sd)								
Intervention site	0.52 (0.14)	0.54 (0.16)	0.51 (0.15)	0.53 (0.15)	0.52 (0.14)	0.54 (0.14)	0.55 (0.15)	0.54 (0.16)
Referent site	0.55 (0.16)	0.54 (0.19)	0.54 (0.15)	0.51 (0.14)	0.53 (0.16)	0.51 (0.16)	0.51 (0.13)	0.52 (0.15)

[1]Job strain ratio = ratio of the psychological job demands and decision latitude sub-scale scores

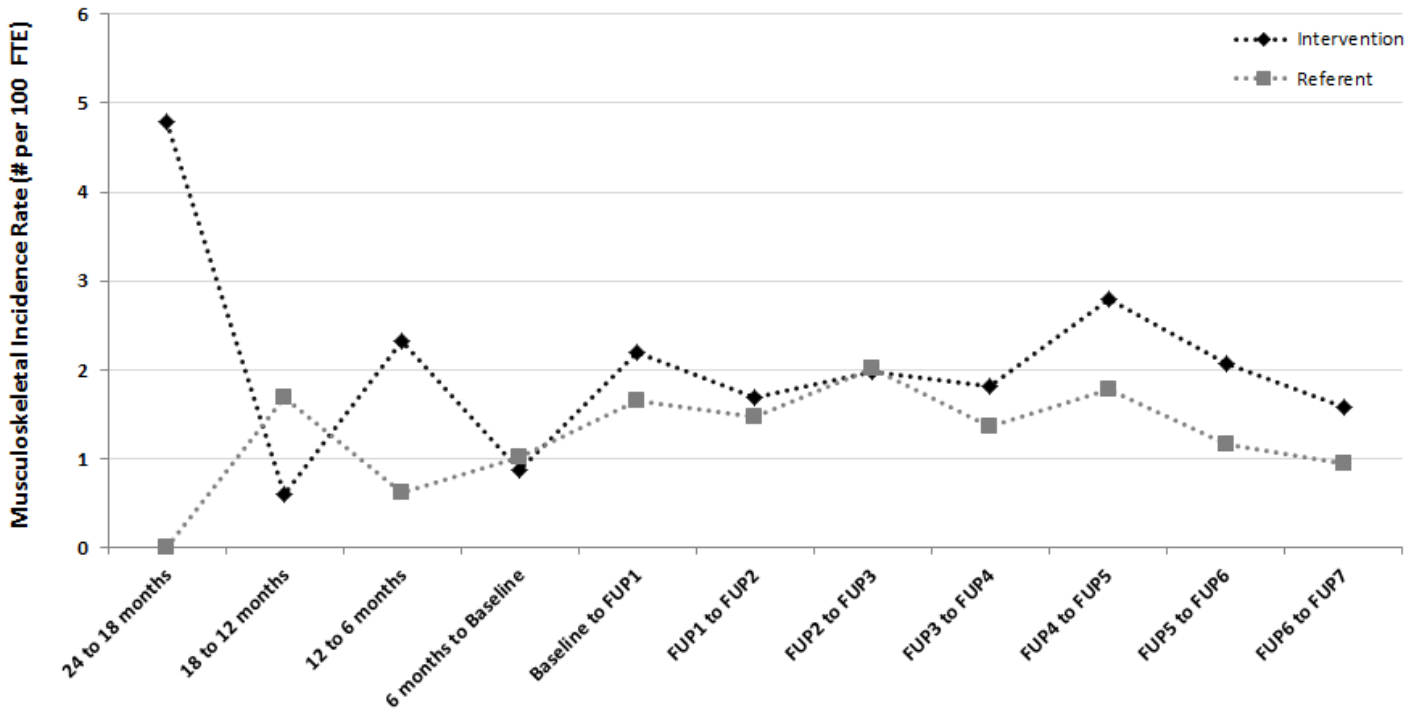

Figure 1: Incidence rates of musculoskeletal events, by site. Each data point reflects incidence rate over the 6-month interval from the prior data point. FUP = follow-up.

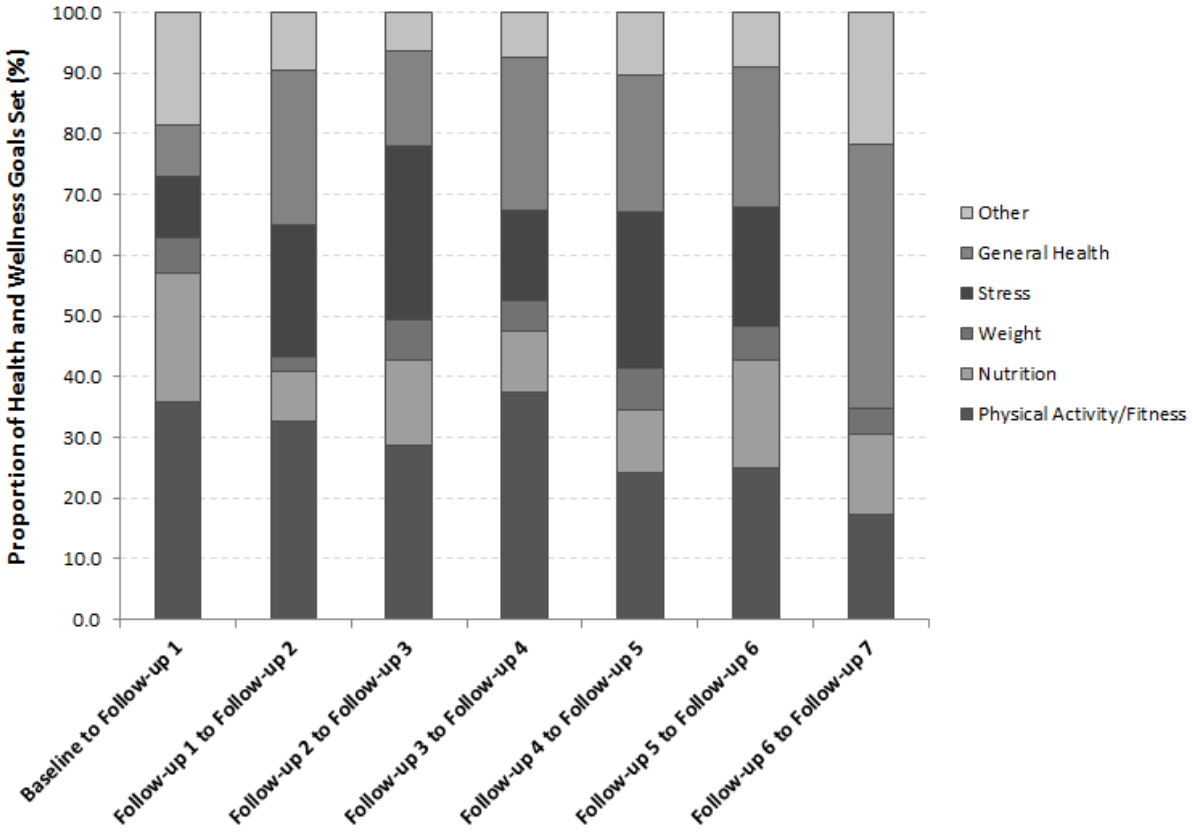

Figure 2: Health and wellness goals set during coaching sessions, by topic and study timeline. (ordered)

Table 5: Distributions of modifiable health risks and overall health, by participant group and study timeline.

	Health benefits plan year (closest corresponding follow-up data collection round)							
	2012 (Baseline)		**2013 (FUP2)**		**2014 (FUP4)**		**2015 (FUP6)**	
	N	Mean(sd)	N	Mean(sd)	N	Mean(sd)	N	Mean(sd)
Data from study questionnaire								
Body mass index (kg/m^2)								
Intervention site (all)[1]	56	28.3 (5.4)	49	30.2 (6.3)	55	30.5 (7.9)	50	30.7 (7.0)
Intervention site (coach)[2]	33	29.7 (5.9)	28	30.6 (6.4)	38	31.4 (8.0)	32	30.1 (6.1)
Referent site	65	29.0 (5.9)	70	30.3 (7.3)	91	29.1 (6.5)	76	29.3 (6.7)
Physical composite score								
Intervention site (all)	56	50.2 (7.3)	48	51.2 (6.9)	54	52.1 (5.7)	47	48.9 (6.9)
Intervention site (coach)	33	48.5 (7.5)	28	50.7 (6.7)	38	52.5 (5.2)	31	48.8 (7.3)
Referent site	65	52.1 (6.4)	70	53.0 (6.6)	89	53.1 (6.6)	72	52.1 (50.5)
Mental composite score								
Intervention site (all)	56	48.5 (10.1)	48	49.2 (10.0)	84	48.9 (9.1)	47	50.0 (9.7)
Intervention site (coach)	33	50.4 (10.3)	28	49.7 (10.3)	38	48.7 (9.6)	31	49.2 (11.3)
Referent site	65	49.7 (9.1)	70	50.7 (9.8)	89	51.3 (8.4)	72	52.0 (7.7)
Data from biometric screen								
Systolic blood pressure (mmHg)								
Intervention site (all)	85	119.2 (12.3)	88	118.6 (11.8)	94	120.2 (12.9)	70	118.0 (11.7)
Intervention site (coach)	34	118.1 (11.1)	42	116.6 (12.0)	40	118.0 (11.7)	33	115.6 (10.4)
Referent site	109	125.1 (13.6)	154	125.3 (15.1)	167	122.1 (13.1)	131	120.8 (12.2)
Diastolic blood pressure (mmHg)								
Intervention site (all)	85	77.3 (7.1)	88	74.4 (11.2)	94	76.8 (9.4)	70	74.0 (8.2)
Intervention site (coach)	34	77.0 (6.0)	42	74.4 (11.3)	40	75.5 (10.1)	33	73.0 (8.9)
Referent site	109	81.8 (10.3)	154	81.5 (10.6)	167	76.7 (8.7)	131	74.7 (8.3)
Total cholesterol (mg/dL)								
Intervention site (all)	89	188.9 (34.8)	91	196.4 (33.6)	94	188.8 (30.0)	70	193.5 (32.8)
Intervention site (coach)	36	189.1 (35.0)	44	197.4 (32.4)	40	191.3 (29.0)	33	197.2 (32.0)
Referent site	112	184.9 (38.5)	161	189.5 (41.4)	167	184.7 (38.2)	131	188.3 (45.2)

Low-density lipoprotein (mg/dL)								
Intervention site (all)	89	112.3 (30.8)	91	113.7 (33.2)	94	107.3 (27.8)	70	108.0 (28.7)
Intervention site (coach)	36	110.0 (28.2)	44	111.4 (30.6)	40	110.6 (28.2)	33	109.5 (26.4)
Referent site	111	107.3 (32.4)	161	109.9 (36.3)	167	101.1 (32.5)	130	107.2 (37.0)
Triglycerides (mg/dL)								
Intervention site (all)	89	143.3 (106.3)	91	156.1 (146.0)	94	168.3 (143.8)	70	168.3 (143.8)
Intervention site (coach)	36	156.3 (118.2)	44	167.7 (170.3)	40	171.6 (127.6)	33	162.5 (163.6)
Referent site	112	150.0 (163.2)	161	152.2 (96.4)	167	173.4 (140.5)	131	180.7 (296.4)
Hemoglobin A1c (%)								
Intervention site (all)	89	5.6 (0.7)	91	5.5 (0.7)	94	5.7 (1.0)	70	5.7 (1.0)
Intervention site (coach)	36	5.8 (1.0)	44	5.6 (0.9)	40	5.9 (1.4)	33	6.1 (1.6)
Referent site	111	5.6 (0.7)	161	5.7 (1.1)	167	5.7 (0.9)	131	5.9 (1.1)

[1] Intervention site (all) includes all participants providing informed consent
[2] Intervention site (coach) includes only intervention site participants who also engaged the study health and wellness coach

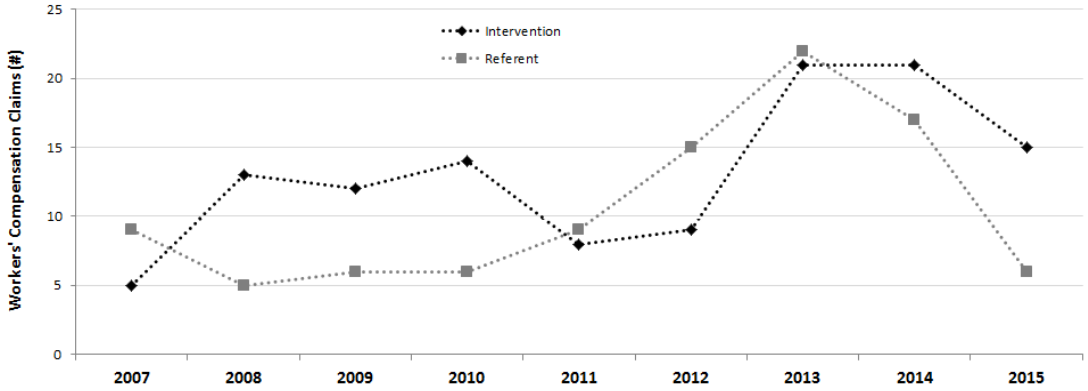

Figure 3: Number of workers' compensation claims for musculoskeletal events, by study site and timeline (intervention activities occurred in years 2012-2015).

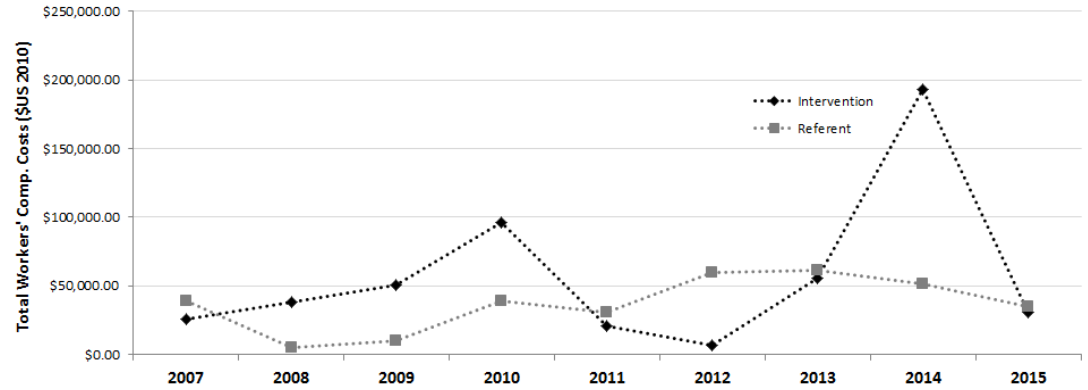

Figure 4: Total workers' compensation expenses for musculoskeletal events, by study site and timeline (intervention activities occurred in years 2012-2015).

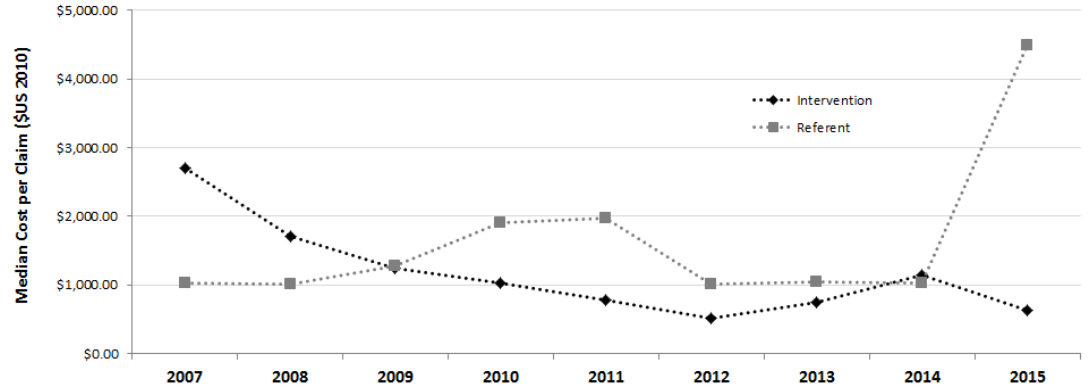

Figure 5: Median worker's compensation expenses per claim for musculoskeletal events, by study site and timeline (intervention activities occurred in years 2012-2015).

Discussion and Conclusions

We conducted a non-randomized trial of a Total Worker Health® intervention in a manufacturing environment. The intervention involved integration of workplace health promotion activities with existing occupational health protection activities, consistent with the operational definition of Total Worker Health® at the beginning of the funding cycle. The intervention included ergonomics activities intended to improve the musculoskeletal health status of employees and activities intended to create a culture of wellness and improve employee engagement.

The intervention was implemented in one manufacturing facility, with a second facility operated by the same company serving as a referent site. Information sources included individual-level data collected by questionnaire every six months for a maximum of 3.5 years (e.g., demographics, musculoskeletal health status, and occupational psychosocial stress), individual-level data delivered to the research team by the company's third-party health benefits vendors (e.g., results of annual biometric screening), facility-level data collected by the research team concerning exposure to physical risk factors (e.g., video-based analyses), and facility-level data delivered to the research team from the company's corporate risk management group (e.g., workplace injury/illness data and workers' compensation information). With few exceptions, the study failed to demonstrate robust effects of the intervention across of range of individual- and facility-level metrics of employee health and well-being.

An effect of the intervention on reducing facility-level exposure to physical risk factors for distal upper extremity musculoskeletal health outcomes was observed when using the Strain Index score as the exposure metric (i.e., greater reductions in the intervention site compared to the referent site). The effect was not observed when using the ACGIH TLV for Hand Activity Level as the exposure metric, although reductions were observed in both facilities over time. Both the Strain Index and the ACGIH TLV for Hand Activity Level have been associated with distal upper extremity outcomes in recent epidemiological studies [Kapellusch 2016; Kapellusch, et al. 2016], and represent methods generally accessible for use by practitioners.

The apparent reductions in exposures to physical risk factors, however, did not translate to observed reductions in musculoskeletal symptoms or other measures of physical well-being (i.e., the physical composite score of the SF-36v2) among intervention site participants compared to referent site participants. However, caution is needed in the interpretation of this finding, since the estimated exposure data were not linked directly to individual participants (i.e., the results are ecological). Thus, it is possible that individual-level reductions in exposure could have resulted in improved individual-level musculoskeletal or physical health status.

The use of digital human modeling to assist in the evaluation and design of production tasks was an important feature of the occupational health protection aspect of the intervention. Digital human modeling and simulation software has been suggested as a valuable method for proactively understanding the dynamic work practices and human performance limitations typical of a manufacturing environment [Chaffin 2005; Kim, et al. 2006]. Many software platforms have been developed and used to evaluate the ergonomics of existing work tasks and to evaluate design alternatives without requiring the expense of creating physical mock-ups and conducting production trials. [Lämkull, et al. 2009; Santos, et al. 2007; Sundin, et al. 2004] Some examples of these platforms include Santos™ (VSR, 2004), Jack™ [Badler, et al. 1999], RAMSIS [Bubb, et al. 2006], Safework™, and the AnyBody Modeling System™ [Damsgaard, et al. 2006]. However, examples of the use of digital human modeling in coordination with an occupational safety and health process are lacking in the available literature. In this report, we

provided several examples of how the software was leveraged to evaluate existing work tasks, identify and examine potential design alternatives, and model the effects of non-occupational risk factors on work task design criteria in a manufacturing environment.

Although personnel changes (detailed in the Results section) required alteration of our proposed approach to the use of digital human modeling during the course of the study, the activity provided the safety and wellness committee with important information to guide the design and implementation of control measures in the live production environment. Still, two key limitations must be addressed. First, while developers have made many advancements in recent years, most digital human modeling software still lacks the ability to simulate “the human variability component” inherent to human movement and work [Perez and Neumann 2015]. Many times, requests of the safety and wellness committee could not be accurately modelled because of limitations of the computationally intensive, mathematical prediction algorithms. Key characteristics of real human motions, such as smooth velocity and acceleration, were not considered and frequently led to the use of less generalizable static models [Zhang and Chaffin 2005]. Second, the safety and wellness committee indicated that cost was a barrier to implementation of several of the workplace design recommendations resulting from the models. Again, the changes in corporate leadership may have affected the committee’s ability to secure resources.

One important aspect of our intervention approach was to provide study participants access to an on-site health and wellness coach trained in motivational interviewing. Moreover, few other studies of coaching interventions using motivational interviewing report information describing fidelity,[Burke, et al. 2003] which is critical to ensuring consistent intervention implementation. Learning motivational interviewing is a complex process requiring more than a brief exposure to a training curriculum [Madson, et al. 2009]. In addition to initial MI training, regular and systematic feedback through review of recorded encounters can increase post-training MI proficiency [Bennett, et al. 2007; Madson, et al. 2009; Miller, et al. 2004; Moyers, et al. 2008]. In this study, the recording of nearly all coaching encounters and use of the OnePass scoring system to assess coaching proficiency were used to provide feedback to the health and wellness coach and ensure maintenance of motivational interviewing skills during the course of the intervention. The range of OnePass scores observed in this study is comparable to that reported in previous research [Resnicow, et al. 2006].
The SF-36v2 PCS and MCS distributions observed in this study are similar to those reported in previous research using motivational interviewing as a worksite wellness intervention [Butterworth, et al. 2006]. The effect of group status on the PCS summary measure (averaged across all data collection rounds) approached statistical significance, suggesting that the intervention site participants reported poorer physical health in comparison to the referent site participants. Although not formally tested, the mean baseline PCS among the HWCI subgroup (48.5 ± 7.5) was lower than the mean baseline PCS among all intervention participants (50.2 ± 7.3). Together, these observations suggest (i) the physical health status of employees in the intervention facility was less desirable than the physical health status of employees in the referent facility at baseline, and (ii) the HWCI reached intervention participants who might benefit most from the activity. In general, individuals with poorer health may be more likely to engage in workplace-based health coaching programs [Grossmeier 2013], and the availability of the service during work hours and without loss of wages may have encouraged participation. The effect of the intervention on PCS and MCS scores was not statistically significant. However, from baseline to fourth follow-up data collection round, the mean PCS scores among all intervention site participants improved by approximately two points (or about 30% of a standard deviation), whereas the mean PCS scores among the HWCI subgroup improved by approximately four points (or about 60% of a standard deviation). During the same timeframe,

the mean PCS scores among referent site participants improved by approximately one point (or less than 15% of a standard deviation). This result was suggestive of an intervention effect overall, and a greater effect among those engaged in the health and wellness coaching. For context, among groups of diabetic persons, it has been observed that each one point reduction in the group mean PCS scores increased the risk of being unable to work by 4-7% [Bjorner, et al. 2013]. Unfortunately, the time trends observed up to the fourth follow-up data collection round were not sustained to the end of the study. The substantial losses of participants to follow-up is likely a contributing factor has only a small proportion of those enrolled early in the study were still employed with the company in the latter stages.
In summary, few statistically significant intervention effects were observed. Several issues may explain these mostly negative observations. As noted earlier, approximately 50% of the study sample in each facility was lost to follow-up due to termination of employment. This level of turnover was not anticipated, and as a consequence, a core group of stable participants was not available from which to estimate the distributions of the individual-level dependent variables over time. In addition, because participants were enrolled in the study for an average of just over 2 years, it is possible that their limited exposure to the intervention was insufficient to produce meaningful change in many of the study dependent variables (e.g., biometric screening variables). Furthermore, several changes to corporate-level and facility-level leadership during the course of the study influenced our ability to maintain relationships with key facility-level partners and sustain intervention activities without disruption. These changes are identified in the Results section and included the sale of the company leading to subsequent changes in executive leadership, facility-level general management (both the intervention and referent sites), facility-level production management, and facility-level safety management, each of who were involved in the initial planning and ongoing execution of the project. Although the intervention received continued support following these changes, consistency in its implementation required several cycles of relationship building during the course of the study.

In addition to personnel changes, the new company leadership elected to close a facility similar to the intervention and referent facilities (i.e., producing the same products). A large proportion of the production from the closed facility was transferred to the intervention facility, leading to increased production demands (from about 500,000 production hours to about 900,000 production hours) and an increase in the average monthly production workforce by approximately 33%. The direct impact of these corporate changes on the intervention is unknown. However, it is assumed that had the corporate changes not occurred, the safety and wellness committee may have had more opportunities to examine and resources available to implement changes.

PUBLICATIONS

Peer-reviewed journal articles

Fethke N, Merlino L, Gerr F: [2013] Effect of ergonomics training on agreement between expert and non-expert ratings of the potential for musculoskeletal harm in manufacturing tasks. Journal of Occupational and Environmental Medicine, 22 (12 Suppl): S82-S85.(PMID: 24284748)

Conference Presentations/Abstracts

Branch CA, Fethke NB, Merlino L, Smith K: [2017] A worksite wellness coaching component of a Total Worker Health® intervention in a manufacturing setting: coaching summary and select

effects on stress. Work, Stress, and Health Conference. Minneapolis, MN, June 7-10, 2017. (abstract accepted for oral presentation).

Branch C, Fethke N, Merlino L: [2014] A worksite wellness coaching component of a Total Worker Health intervention in a manufacturing setting. 1st International Symposium to Advance TOTAL WORKER HEALTH. Bethesda, MD, October 2-8, 2014.

Schall M, Fethke N: [2014] Digital human modeling of non-occupational risk factors for manufacturing work task design. 1st International Symposium to Advance TOTAL WORKER HEALTH. Bethesda, MD, October 2-8, 2014.

Fethke N, Gerr F, Merlino L, Branch C, Hanson S: [2012] Effect of participatory ergonomics training on non-ergonomist ratings of ergonomics exposures. Total Worker Health Symposium – Safe, Healthy and Cost-Effective Solutions. Iowa City, IA. November 29-30, 2012.

CUMULATIVE INCLUSION ENROLLMENT TABLE

PHS Inclusion Enrollment Report

OMB Number: 0925-0001 and 0925-0002
Expiration Date: 10/31/2018

This report format should NOT be used for collecting data from study participants.

***Study Title (must be unique):** TRP4-Comprehensive evaluation of an integrated health protection/promotion intervention

* Delayed Onset Study? ☐ Yes ☒ No

If study is not delayed onset, the following selections are required:

Enrollment Type ☒ Planned ☐ Cumulative (Actual)

Using an Existing Dataset or Resource ☐ Yes ☒ No

Enrollment Location ☒ Domestic ☐ Foreign

Clinical Trial ☐ Yes ☒ No **NIH-Defined Phase III Clinical Trial** ☐ Yes ☒ No

Comments:

Racial Categories	Ethnic Categories									
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			Total
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	2	3		0	0					5
Asian	0	0		0	0					0
Native Hawaiian or Other Pacific Islander	0	0		0	0					0
Black or African American	1	2		0	0					3
White	112	164		2	7					285
More than One Race	0	0		0	0					0
Unknown or Not Reported							43	128		171
Total	115	169		2	7		43	128		464

Report 1 of 1

INCLUSION OF GENDER AND MINORITY SUBJECTS

Women and those of minority racial/ethnicity were not excluded from participating in the research project. The proportions of women and those of minority status among the study sample reflected the gender and minority make-up of the population of manufacturing workers employed within the study facilities. Ethnicity was unknown for 171 participants (128 males, 43 females); these participants provided written informed consent and contributed biometric data, but did not complete the self-administered study questionnaires.

INCLUSION OF CHILDREN

N/A – No children were included in this study

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

LabVIEW programs are available to assist in video-based analyses of physical risk factors.

REFERENCES

Badler NI, Palmer MS, Bindiganavale R. 1999. Animation control for real-time virtual humans. Communications of the ACM 42: 64-73.

Bao S, Spielholz P, Howard N, Silverstein B. 2006. Quantifying repetitive hand activity for epidemiological research on musculoskeletal disorders--part I: individual exposure assessment. Ergonomics 49: 361.

Bao S, Spielholz P, Howard N, Silverstein B. 2009. Application of the Strain Index in multiple task jobs. Applied Ergonomics 40: 56.

Bennett GA, Moore J, Vaughan T, Rouse L, Gibbins JA, Thomas P, James K, Gower P. 2007. Strengthening motivational interviewing skills following initial training: A randomised trial of workplace-based reflective practice. Addictive Behaviors 32: 2963-2975.

Bernard BP. 1997. Musculoskeletal Disorders and Workplace Factors: A critical review of epidemiologic evidence for work-related disorders of the neck, upper extremity, and low back Cincinatti, OH: US Department of Health and Human Services (DHHS) Public Health Service Centers for Disease Control and Prevention National Institute for Occupational Safety and Health (NIOSH).

Bjorner JB, Wolden ML, Gundgaard J, Miller KA. 2013. Benchmarks for interpretation of score differences on the SF-36 health survey for patients with diabetes. Value in Health 16: 993-1000.

Bubb H, Engstler F, Fritzsche F, Mergl C, Sabbah O, Schaefer P, Zacher I. 2006. The development of RAMSIS in past and future as an example for the cooperation between industry and university. International Journal of Human Factors Modelling and Simulation 1: 140-157.

Burke BL, Arkowitz H, Menchola M. 2003. The efficacy of motivational interviewing: a meta-analysis of controlled clinical trials. Journal of Consulting and Clinical Psychology 71: 843.

Butterworth S, Linden A, McClay W, Leo MC. 2006. Effect of motivational interviewing-based health coaching on employees' physical and mental health status. Journal of Occupational Health Psychology 11: 358.

Chaffin DB. 2005. Improving digital human modelling for proactive ergonomics in design. Ergonomics 48: 478-491.

Damsgaard M, Rasmussen J, Christensen ST, Surma E, de Zee M. 2006. Analysis of musculoskeletal systems in the AnyBody Modeling System. Simulation Modelling Practice and Theory 14: 1100-1111.

de Bruijn I, Engels JA, van der Gulden JW. 1998. A simple method to evaluate the reliability of OWAS observations. Applied Ergonomics 29: 281.

Dempsey PG, McGorry RW, Maynard WS. 2005. A survey of tools and methods used by certified professional ergonomists. Applied Ergonomics 36: 489.

Drinkaus P, Sesek R, Bloswick D, Bernard T, Walton B, Joseph B, Reeve G, Counts JH. 2003. Comparison of ergonomic risk assessment outputs from Rapid Upper Limb Assessment and the Strain Index for tasks in automotive assembly plants. Work 21: 165.

Drinkaus P, Sesek R, Bloswick DS, Mann C, Bernard T. 2005. Job level risk assessment using task level ACGIH hand activity level TLV scores: a pilot study. International Journal of Occupational Safety and Ergonomics 11: 263.

Fethke NB, Merlino L, Gerr F. 2013. Effect of ergonomics training on agreement between expert and nonexpert ratings of the potential for musculoskeletal harm in manufacturing tasks. J Occup Environ Med 55: S82-85.

Fethke NB, Merlino LA, Gerr F, Schall MC, Jr., Branch CA. 2015. Musculoskeletal pain among Midwest farmers and associations with agricultural activities. Am J Ind Med 58: 319-330.

Franzblau A, Armstrong TJ, Werner RA, Ulin SS. 2005. A cross-sectional assessment of the ACGIH TLV for hand activity level. Journal of Occupational Rehabilitation 15: 57.

Gangopadhyay S, Das B, Das T, Ghoshal G, Ghosh T. 2010. An ergonomics study on posture-related discomfort and occupational-related disorders among stonecutters of West Bengal, India. International Journal of Occupational Safety and Ergonomics 16: 69.

Gerr F, Fethke NB, Merlino L, Anton D, Rosecrance J, Jones MP, Marcus M, Meyers AR. 2014. A prospective study of musculoskeletal outcomes among manufacturing workers: I. Effects of physical risk factors. Hum Factors 56: 112-130.

Gilkey DP, Keefe TJ, Bigelow PL, Herron RE, Duvall K, Hautaluoma JE, Rosecrance JS, Sesek R. 2007. Low back pain among residential carpenters: ergonomic evaluation using OWAS and 2D compression estimation. International Journal of Occupational Safety and Ergonomics 13: 305.

Grecchi A, Cristofolini A, Correzzola C, Piccioni A, Buffa C, Pol G. 2009. Ergonomic assessment of technical improvements in the work of manual labourers of a porphyry quarry. La Medicina del lavoro 100: 142.

Grossmeier J. 2013. The influence of worksite and employee variables on employee engagement in telephonic health coaching programs: a retrospective multivariate analysis. American Journal of Health promotion : AJHP 27: e69.

Group VR. 2004. Technical report for project virtual soldier research. Center for Computer-Aided Design, the University of IOWA.

Heffler S, Smith S, Keehan S, Clemens MK, Won G, Zezza M. 2003. Health spending projections for 2002-2012. Health Affairs (Project Hope) Suppl Web Exclusives: W3.

Juul-Kristensen B, Fallentin N, Ekdahl C. 1997. Criteria for classification of posture in repetitive work by observation methods: a review. International Journal of Industrial Ergonomics: 397.

Kapellusch J. 2016. S02-2 The strain index and risk of upper limb musculoskeletal disorders: results from the wistah hand study. Occupational and Environmental Medicine 73: A96-A96.

Kapellusch J, Harris-Adamson C, Rempel D. 2016. S02-1 Associations between force, repetition, posture, duty cycle, threshold limit value for hand activity level (tlv for hal) and risk of carpal tunnel syndrome. Occupational and Environmental Medicine 73: A95-A96.

Karasek RA. 1985. Job Content Questionnaire and Users Guide Los Angeles, CA: University of Southern California Department of Industrial and Systems Engineering.

Karasek RA, Theorell T. 1990. Healthy Work: Stress, Productivity and the Restructuring of Working Life New York, NY: Basic Books.

Karhu O, Kansi P, Kuorinka I. 1977. Correcting working postures in industry: A practical method for analysis. Applied Ergonomics 8: 199.

Kee D, Karwowski W. 2007. A comparison of three observational techniques for assessing postural loads in industry. International Journal of Occupational Safety and Ergonomics 13: 3.

Kim JH, Abdel-Malek K, Yang J, Marler RT. 2006. Prediction and analysis of human motion dynamics performing various tasks. International Journal of Human Factors Modelling and Simulation 1: 69-94.

Knox K, Moore JS. 2001. Predictive validity of the Strain Index in turkey processing. Journal of Occupational and Environmental Medicine 43: 451.

Kumar R, Chaikumarn M, Lundberg J. 2005. Participatory ergonomics and an evaluation of a low-cost improvement effect on cleaners' working posture. International Journal of Occupational Safety and Ergonomics 11: 203.

Lämkull D, Hanson L, Örtengren R. 2009. A comparative study of digital human modelling simulation results and their outcomes in reality: A case study within manual assembly of automobiles. International Journal of Industrial Ergonomics 39: 428-441.

Landsbergis PA, Schnall PL, Warren K, Pickering TG, Schwartz JE. 1994. Association between ambulatory blood pressure and alternative formulations of job strain. Scand Journal of Work, Environment & Health 20: 349-363.

Latko WA, Armstrong TJ, Foulke JA, Herrin GD, Rabourn RA, Ulin SS. 1997. Development and evaluation of an observational method for assessing repetition in hand tasks. AIHA Journal 58: 278.

Li G, Buckle P. 1999. Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. Ergonomics 42: 674.
Madson MB, Loignon AC, Lane C. 2009. Training in motivational interviewing: a systematic review. J Subst Abuse Treat 36: 101-109.
Martins RK, McNeil DW. 2009. Review of Motivational Interviewing in promoting health behaviors. Clinical Psychology Review 29: 283.
McMaster F, Resnicow K. 2015. Validation of the one pass measure for motivational interviewing competence. Patient Education and Counseling 98: 499-505.
Miller WR, Yahne CE, Moyers TB, Martinez J, Pirritano M. 2004. A randomized trial of methods to help clinicians learn motivational interviewing. Journal of Consulting and Clinical Psychology 72: 1050.
Moore JS, Garg A. 1995. The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. AIHA Journal 56: 443.
Moore JS, Rucker NP, Knox K. 2001. Validity of generic risk factors and the strain index for predicting nontraumatic distal upper extremity morbidity. AIHA Journal 62: 229.
Moyers TB, Manuel JK, Wilson PG, Hendrickson SM, Talcott W, Durand P. 2008. A randomized trial investigating training in motivational interviewing for behavioral health providers. Behavioural and Cognitive Psychotherapy 36: 149-162.
National Research Council - Institute of M. 2001. Musculoskeletal Disorders and the Workplace Washington, DC: National Academy Press.
Perez J, Neumann W. 2015. Ergonomists' and engineers' views on the utility of virtual human factors tools. Human Factors and Ergonomics in Manufacturing & Service Industries 25: 279-293.
Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB. 2000. Shoulder disorders and postural stress in automobile assembly work. Scandinavian Journal of Work, Environment & Health 26: 283.
Resnicow K, Davis R, Rollnick S. 2006. Motivational interviewing for pediatric obesity: Conceptual issues and evidence review. Journal of the American Dietetic Association 106: 2024-2033.
Rucker N, Moore JS. 2002. Predictive validity of the strain index in manufacturing facilities. Applied Occupational and Environmental Hygiene 17: 63.
Santos J, Sarriegi JM, Serrano N, Torres JM. 2007. Using ergonomic software in non-repetitive manufacturing processes: A case study. International Journal of Industrial Ergonomics 37: 267-275.
Schill AL, Chosewood LC. 2013. The NIOSH Total Worker Health® program: an overview: LWW.
Scott GB, Lambe NR. 1996. Working practices in a perchery system, using the OVAKO Working posture Analysing System (OWAS). Applied Ergonomics 27: 281.
Silverstein BA, Stetson DS, Keyserling WM, Fine LJ. 1997. Work-related musculoskeletal disorders: comparison of data sources for surveillance. American Journal of Industrial Medicine 31: 600.
Spielholz P, Bao S, Howard N, Silverstein B, Fan J, Smith C, Salazar C. 2008. Reliability and validity assessment of the hand activity level threshold limit value and strain index using expert ratings of mono-task jobs. Journal of Occupational and Environmental Hygiene 5: 250.
Stephens JP, Vos GA, Stevens EM, Jr., Moore JS. 2006. Test-retest repeatability of the Strain Index. Applied Ergonomics 37: 275.
Stevens EM, Jr., Vos GA, Stephens JP, Moore JS. 2004. Inter-rater reliability of the strain index. Journal of Occupational and Environmental Hygiene 1: 745.

Sundin A, Christmansson M, Larsson M. 2004. A different perspective in participatory ergonomics in product development improves assembly work in the automotive industry. International Journal of Industrial Ergonomics 33: 1-14.

Tomei G, Draicchio F, Nicassio P, Palermo A, Violante FS, Graziosi F, Caciari T, Rosati MV, De Rose E, Ciarroccal M, Cardella C, Capozzella A. 2005. Use of TLV-ACGIH (HAL) and Strain Index for the evaluation of the upper extremity biomechanical overload. Giornale italiano di medicina del lavoro ed ergonomia 27: 351.

Turner-Bowker DM, Bartley PJ, Ware JE. 2002. SF-36 Health Survey & "SF" Bibliography Lincoln, RI: QualityMetric Inc.

US Bureau of Labor Statistics. 2015. Nonfatal occupational injuries and illnesses requiring days away from work, 2014 Washington, DC: US Department of Labor.

Viikari-Juntura E, Silverstein B. 1999. Role of physical load factors in carpal tunnel syndrome. Scandinavian Journal of Work, Environment & Health 25: 163.

Villaire M, Mayer G. 2007. Low health literacy: the impact on chronic illness management. Professional Case Management 12: 213.

Wurzelbacher S, Burt S, Crombie K, Ramsey J, Luo L, Allee S, Jin Y. 2010. A comparison of assessment methods of hand activity and force for use in calculating the ACGIH(R) hand activity level (HAL) TLV(R). Journal of Occupational and Environmental Hygiene 7: 407.

Zhang X, Chaffin DB. 2005. Digital human modeling for computer-aided ergonomics. Handbook of Occupational Ergonomics Taylor & Francis, CRC Press, London, Boca Raton.