



Healthcare and Commercial Construction: The Role of Inspections Within Health and Safety Interventions in Dynamic Workplaces and Associations With Safety Climate

Citation

Grant, Michael Patrick. 2016. Healthcare and Commercial Construction: The Role of Inspections Within Health and Safety Interventions in Dynamic Workplaces and Associations With Safety Climate. Doctoral dissertation, Harvard T.H. Chan School of Public Health.

Permanent link

<http://nrs.harvard.edu/urn-3:HUL.InstRepos:27201742>

Terms of Use

This article was downloaded from Harvard University's DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at <http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA>

Share Your Story

The Harvard community has made this article openly available.
Please share how this access benefits you. [Submit a story](#).

[Accessibility](#)

**HEALTHCARE AND COMMERCIAL CONSTRUCTION: THE ROLE OF
INSPECTIONS WITHIN HEALTH AND SAFETY INTERVENTIONS IN DYNAMIC
WORKPLACES AND ASSOCIATIONS WITH SAFETY CLIMATE**

MICHAEL PATRICK GRANT

**A Dissertation Submitted to the Faculty of
The Harvard T.H. Chan School of Public Health
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Science
in the Department of Environmental Health**

Harvard University

Boston, Massachusetts

May, 2016

Healthcare and Commercial Construction: The Role of Inspections within Health and Safety Interventions in Dynamic Workplaces and Associations with Safety Climate

Abstract

Statement of problem: Dynamic work environments and physically demanding jobs in the healthcare and commercial construction industries present workers with a constantly changing suite of hazards, and hence the changing need for controls. Workers in these industries experience high rates of MSDs and other illnesses and injuries. Hazard recognition and control are essential and inspections are essential elements used to identify and anticipate hazards and to implement corrective action as part of a systems-level approach to tackle the dynamic worksite.

Methods: Because there is a dearth of practical resources for evaluating ergonomic risk factors in healthcare environments the first step in this dissertation was to explore the development of a tool and process for identifying modifiable aspects of acute care hospital patient care units to prevent work-related MSDs. To address a lack of systems-level approaches to worksite-based interventions in construction, an ergonomics program that relies heavily on inspections was developed and evaluated on five pairs of commercial construction sites. To examine associations between physical working conditions and safety climate, the relationship between weekly safety inspections and weekly safety climate scores was examined on six commercial construction sites.

Results: The inspection process provided a structured method for recognizing hazards in dynamic and physically demanding work environments and reporting both observations and recommendations to decision makers. There were no significant intervention effects, however key challenges to intervention implementation were competing safety and production priorities and break practices leading to inconsistencies delivering the intervention and key resources to workers. Variations in week-to-week safety inspections were highly correlated with variations in week-to-week safety climate.

Conclusions: Inspection tools and processes were useful in a systems-approach to workplace interventions in the dynamic industries of healthcare and commercial construction. Worksite-based ergonomics interventions focusing efforts on hazard identification, recommendations for solutions, and reinforcing both positive and negative feedback to safety management and workers can have a major impact on worker wellbeing. In addition, physical working conditions (as identified through weekly safety inspections) are an important aspect of the week to week changes of safety climate in the dynamic commercial construction environment.

TABLE OF CONTENTS

LIST OF FIGURES	v
LIST OF TABLES	vi
ACKNOWLEDGEMENTS	vii
INTRODUCTION.....	1
CHAPTER 1	An Inspection Tool and Process Identifying Modifiable Aspects of Acute Care Hospital Patient Care Units to Prevent Work Related MSDs11
	Abstract.....12
	Introduction.....13
	Methods.....16
	Results.....23
	Discussion.....25
CHAPTER 2	Weekly Safety Inspections Predict Weekly Safety Climate on Six Commercial Construction Sites.....29
	Abstract.....30
	Introduction.....31
	Methods.....34
	Results.....38
	Discussion.....42
CHAPTER 3	Successes and Challenges of Implementing a Worksite-based Ergonomics Intervention on Five Pairs of Commercial Construction Sites.....45
	Abstract.....46
	Introduction.....47
	Methods.....49
	Results.....56
	Discussion.....61
DISCUSSION	65
APPENDIXES.....	75
BIBLIOGRAPHY	89

LIST OF FIGURES

- Figure 0.1** An overall conceptual model showing the relationship between organizational policies and practices, the physical working conditions, and worker outcomes. This figure also shows how inspections can be used to examine both the physical conditions of work and organizational policies and practices.
- Figure 1.0.** Be Well Work Well study logo.
- Figure 1.1.** Flowchart of the inspection process including planning, meeting with occupational health, and final feedback to the units.
- Figure 1.2.** Snapshot of the inspection tool report for unit leadership. The report has two columns, the first describing the observation and the second containing the recommendation to modify and mitigate the observation.
- Figure 2.0.** B-SAFE study logo.
- Figure 2.1.** Conceptual model displaying the relationship between physical working conditions and safety climate. The right branch is adapted from Neil and Griffith, 2000. Inspections focusing on existing hazards and associated controls provide a quantifiable measurement of the physical working conditions. The conditions of work (presence of hazards and controls) are influenced by organizational policies and practices and, in turn, influence the safety climate of the workers on the worksite.
- Figure 2.2.** Relationship between weekly safety inspection score (Safety Inspection) and weekly safety climate (Safety Climate) across the six sites included in the study. Safety climate was measured on a scale of 0-50 and safety inspections on a scale of 0-100.
- Figure 3.0.** All the Right Moves study logo.
- Figure 3.1.** All the Right Moves intervention conceptual model. The intervention targets both the conditions of work and the proximal outcomes through a variety of intervention activities.
- Figure 3.2.** A flowchart of the ARM inspection and feedback process. This feedback loop is a part of usual practice for General Contractor safety managers. Everything in black could be considered usual practice for safety walkthroughs. The red depicts where ARM sought to add ergonomics observations to safety walkthroughs as well as a formal weekly feedback component during weekly foremen meetings.

LIST OF TABLES

- Table 2.1.** Description of selected study site characteristics.
- Table 2.2.** Results of repeated measures analysis.
- Table 3.1.** Intervention delivery tracking.
- Table 3.2.** Selected characteristics of survey respondents by time of survey and intervention condition: Frequency (and %) or mean (\pm standard deviation).
- Table 3.3.** Results of fixed effects linear regression models.

ACKNOWLEDGEMENTS

I would definitely not be here without my awesome family. Mom, Dad, and Nana – you taught me the importance and value of hard work and being a good person. You pushed me to succeed while respecting my interests and decisions along the way. It has never mattered what it was that I was doing or planning to do (and we all know how many times “the plan” has evolved over the years...). It was always about working hard, doing well, and being happy no matter what I was doing. I can’t claim to have been a perfect kid and the road has been bumpy at times but looking back on things, I am incredibly fortunate to have you in my life – you’ve done an excellent job! Timmy and Kevin – you’ve always had my back and I’ll always have yours. From the pre-technology-in-the-Grant-home banging on pots and pans to building forts to playing whiffle ball or throwing a baseball around the yard to hanging out at UMass to going to a Bruins or Sox game, I’ve got many awesome memories from growing up. I’ll be farther away but I’m looking forward to many more. You all helped me become the person I am today and I am truly grateful.

The last four years would most definitely have been impossible to get through without my tremendous partner in crime, Emmy. You were always so supportive and caring no matter how grumpy and stressed I got. When I was in the field every day before the sun came up and then sleeping all afternoon you made sure that I was remembering to eat and bugging me about getting enough sleep. When I was holed up in the apartment for days at a time writing and still not remembering to eat you gave me space to work while making sure I was comfortable, even when we barely saw each other. But more than anything else, being able to spend my time with you have made these years some of the best. We’ve had some great adventures so far at home

(Graves and the Cape) and abroad (Italy!) and I'm excited for whatever comes next. Love you, Nugget.

To my advisor, Dr. Jack Dennerlein, thank you for all of your support and advice throughout this journey – and what a journey it has been. From the classroom to field work to writing and everything in between, I've always admired your teaching and mentoring style and hope to emulate that in the future. I've come a long way and have learned so much from my time with you and the Center about organization and project management, writing, and thinking outside the box when it comes to fieldwork in difficult environments like construction. I'll always remember our little sports conversations to help change gears and start meetings and I very much appreciate the opportunities I've had to work with you on many different projects over the last handful of years.

This also could not have been possible without the amazing and thoughtful guidance from my other committee members, Dr. Cassandra Okechukwu and Dr. Justin Manjourides. Your accessibility and willingness to help were the deciding factors when I was choosing my committee members and you have not disappointed. Cassandra, your cheery demeanor and exceptional insight into paper writing were invaluable in this process. Justin, your expertise and patience were much appreciated as I navigated the analysis and interpretation of results. The three of you made an exceptional committee and I can't imagine a better group to learn from. You all have very complementary strengths and your personalities balance each other out (in the best of possible ways) making all of our meetings enjoyable and productive. I know the last few months have been very busy but we did it!

It couldn't be a proper acknowledgements section without taking the time to thank some folks at HSPH who weren't my official advisors or a part of my committee but nevertheless were

very important to the process. Thanks to Bob Herrick, you took me in and served as my unofficial mentor for my masters (and beyond). Every step of the way you were there with advice and support for whatever I was working on or trying to figure out. When I was looking for internships, trying to figure out whether I should stick around for a few more years, and finding a “real job” you were there with very useful insight (even if it was 20+ years old) and to make connections with people who could answer my questions even if you couldn’t. And not to be left out, thanks to Rose West, you were always patient and seemingly had all the answers even if you won’t admit it. Whenever there was a question about who to go to or how to get something done at HSPH you were there with guidance. It says a lot about how awesome you are that your response to my job offer was to respond with the important beer and sports opportunities in Cincinnati.

I’d also like to thank my fellow students and friends that have been there along the way. You all had a hand in keeping me sane and relaxed when I needed to blow off some steam. You were also there when I needed someone to bounce ideas off of. I couldn’t possibly list all of you but some that come to mind are Mike Lin and Emily Sparer for your friendship and guidance throughout the program. Also Molly, Torey, and Erin for being there throughout the headaches of coursework and group projects. Thanks to Luz and Sandra for defense preparation and reminding me of the important things. All of you kept me sane and relatively balanced throughout this journey. A few non-students need to be mentioned as well. Thanks to Tom for “funding” my training and future employment. Thanks to Mason, Tory, Dennis, Kevin, and Talib for being great friends and excellent residents. Thanks to Christin, Bryan, Julian, and Sharon for all of your support early on and your continued friendship to this day. With respect to field work, I would like to thank Kristen Ironside and Andrea Sheldon for their tireless efforts to support

these studies and keep me in line and motivated – this truly could not have happened without you!

This journey started long before my time at HSPH. In the wild western lands at UMass I started my collegiate marathon as a concerned environmentalist who wasn't entirely sure whether I was a tree hugger or not. Dr. Guy Lanza knew right away that I was destined for the human health side of things and immediately, unselfishly, pointed me in the right direction and allowed me to start my trek towards occupational health. Dr. Christine Rogers deserves recognition for her unwavering support and always telling me I can sleep when I'm done. Chris, you've been a great mentor and friend to this day and I am fortunate that we were able to connect all those years ago. Thanks to Jules, Gaurav, and Mel for putting up with my complaints – you guys rock! I'm still tired but I have more time to nap nowadays.

While still trying to figure out what I wanted to do next I found myself working with the laboratory safety group delivering chemicals. Glenda Pons took a chance on the student looking to make extra money (me), and luck placed me under the very capable supervision of Allen Juskiewicz and Jim Field. My first real foray into the field of occupational health and safety had me sorting batteries out of 55 gallon drums. Allen appreciated my curiosity about why he was examining discarded equipment (using an autopsy table) and took me under his wing, showing me the ropes of hazardous waste management. You and Jim sparked my interest in why this stuff is important and I never looked back. We were also able to work in some of the best Homer Simpson quotes, mainly “Just because I don't care doesn't mean I don't understand”. You also had some pretty good non-attributable ones. “We get paid by the hour, not by the job” has stuck with me in the spirit of doing things right and “Poor planning on your part does not constitute an emergency on mine” on the importance of not rushing

This work was supported in part by a grant from the National Institute for Occupational Safety and Health (U19 OH008861) for the Harvard School of Public Health Center for Work, Health and Well-being. The Center and everyone involved in the projects there has been the bulk of my research and experience at HSPH. Special thanks to Glorian for the opportunity and the office with an amazing view, Deborah for being an excellent collaborator and neighbor, Eve and Lorraine for their guidance and teamwork, and of course Linnea for her technical assistance and guidance through the system.

I likely would not be here without the help of the National Institute for Occupational Safety and Health Education and Research Center at Harvard University (T42 OH008416). The ERC supported the entirety of my training at HSPH and I am eternally grateful for their generous support.

Chapter one would not have been accomplished without the participation of Partners HealthCare System and leadership from Dennis Colling, Sree Chaguturu, and Kurt Westerman. I would also like to thank Partners Occupational Health Services including Marlene Freeley and Dean Hashimoto for their guidance, as well as Karen Hopcia, Elizabeth Taylor, Elizabeth Tucker O'Day, Terry Orechia, and Terry Snyder. Additional thanks to Evan McEwing and Julie Theron, Project Directors.

Chapters two and three would not have been possible without the participation and enthusiasm of our partners in the commercial construction industry in New England: The Harvard Construction Safety Group, Suffolk Construction Company, Shawmut Design and Construction, Gilbane Building Company, and John Moriarty and Associates. Special thanks goes out to the hundreds of construction workers representing numerous trades and dozens of unions who participated in these studies.

There have been so many excellent people involved in getting me this far. I've mentioned some important ones and I apologize if you've been left out! As much as this is the culmination of all of my studies, this work is the result of all of your tireless efforts to support me in one way or another. Thank you so much!

We're on to Cincinnati. It's Safety Time.

INTRODUCTION

Physically demanding jobs exist in many dynamic workplaces such as healthcare and commercial construction (Hopcia, Dennerlein et al. 2012, Burdorf, Koppelaar et al. 2013, CPWR 2013). Nurses and patient care assistants as well as commercial construction workers all face temporal variability in job demands and hazards. For nurses and patient care assistants in acute-care inpatient facilities, census level and patient acuity can change from shift to shift (and even within shifts) exposing workers to a variety of ever-changing hazards. Similarly in commercial construction, the very nature of the work is to modify the physical work environment. The dynamic work environment presents workers with a constantly changing suite of hazards and controls depending on the type of work being performed as well as the programs, policies, and practices of the organization.

Organizational policies and practices (OPPs) influence the conditions of the physical work environment (i.e. the presence of hazards and controls) as well as worker proximal outcomes (i.e. safety climate and ergonomics practices). Worker outcomes (i.e. work limitations and pain) are in turn influenced by both the conditions of work and worker proximal outcomes including safety performance, knowledge, and motivation. Since the OPPs and dynamic working conditions are so influential with respect to the workers' experience of pain and injury, the ability to quantify the physical working conditions becomes extremely important for both delivery and evaluation of workplace health and safety interventions (Figure 0.1).

Safety inspections are a classic tool used to identify and anticipate hazards in the work environment, and to inform efforts designed to implement corrective action. Increased inspection rates have been associated with increased compliance with safety policies and regulations and decreased injuries in the workplace (Hinze, Hallowell et al. 2013, Mischke, Verbeek et al. 2013).

This phenomenon is the result of long-term commitment to performing inspections and providing feedback to workers and supervisors (Fang and Wu 2013, Sparer, Herrick et al. 2015).

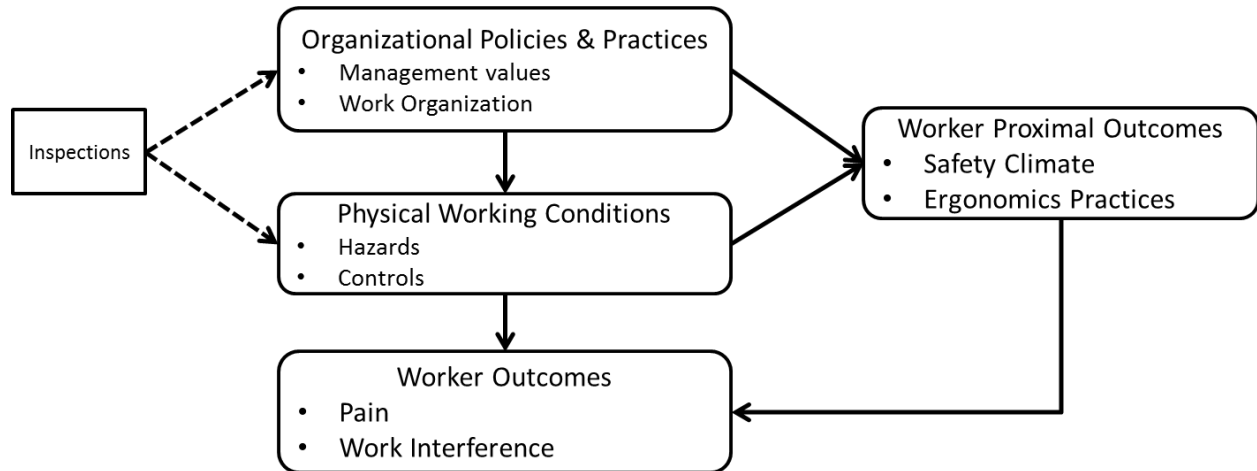


Figure 0.1. An overall conceptual model showing the relationship between organizational policies and practices, the physical working conditions, and worker outcomes. This figure also shows how inspections can be used to examine both the physical conditions of work and organizational policies and practices.

In dynamic and physically demanding hospital environments, the relationship between the physical demands of work, and workplace policies and practices and occurrence of occupational injuries, especially musculoskeletal disorders (MSDs), are well documented (Hopcia, Dennerlein et al. 2012, Burdorf, Koppelaar et al. 2013, Koppelaar, Knibbe et al. 2013). workers in acute care hospital environments in the United States experience more than 35,000 back and other injuries every year that are severe enough to result in missing work (Bureau of Labor Statistics 2013). In both acute- and long-term care settings, overexertion resulting from the need to lift and move patients accounts for the majority of these injuries (Bureau of Labor Statistics 2006). The risks are compounded by staff shortages and working long hours, often during night shifts, as well as psychosocial factors such as limited control over decisions on the job (Hopcia, Dennerlein et al. 2012, Reme, Dennerlein et al. 2012, Sembajwe, Tveito et al. 2013,

Kim, Okechukwu et al. 2014). As a result, a growing number move out of this field of work that has chronic labor shortages (Stone, Clarke et al. 2004).

Ergonomics practices aimed at reducing job demands in healthcare workers appear to be associated with healthcare worker self-reported ergonomics factors (i.e. pain, injuries, ergonomics practices, etc.) (Dennerlein, Hopcia et al. 2012). However, what is often not realized in these practices is the idea of what is modifiable in the physical environment that can be controlled through an ergonomics program targeting the prevention of work-related MSDs (Caspi, Dennerlein et al. 2013).

In addition to being very dynamic and physically demanding, commercial construction jobs are associated with high rates of musculoskeletal disorders (MSDs) and poor health behaviors among workers. In 2010, 34% of non-fatal injuries with days away from work were associated with strains and sprains, three-quarters of which were related to overexertion (CPWR 2013). Increased physical demand in construction work also increases the risk for cardiovascular disease (Holtermann, Mortensen et al. 2010). Construction workers have the highest prevalence of smoking (39%) and heavy alcohol use (17%) of all occupational groups (Lee, Fleming et al. 2007, Bush and Lipari 2015). Our pilot studies also indicate that mental distress is high (16%) among commercial construction workers (Borsting Jacobsen, Caban-Martinez et al. 2013). These health and safety challenges become more pronounced with age and as a result many construction workers retire early due to injuries or illness (de Zwart, Frings-Dresen et al. 1999, Pransky, Benjamin et al. 2005, Welch, Haile et al. 2010, CPWR 2013).

Poor health outcomes in commercial construction workers are often associated with and influenced by the conditions of work, including work organization, and job demands (Dedobbeleer and Beland 1991, Amick, Habeck et al. 2000, NRC/IOM 2001, Jorgensen, Sokas

et al. 2007, Cigularov, Chen et al. 2010, Dennerlein, Grant et al. 2016 (Submitted)).

Additionally, work organization and the hierarchical structure in construction does not follow the traditional manufacturing model; rather, workers on a given worksite are employed by different companies and move from worksite to worksite making traditional safety interventions difficult to implement and evaluate (Dunlop 1961, Weil 2014).

Controlling hazards in dynamic environments

Hazard recognition and control are essential and fundamental elements of successful injury prevention programs, especially in dynamic work environments (Cohen 1997, NIOSH 2008, OSHA 2012). The ANSI Z10 standard utilizes a Plan-Do-Check-Act model, continuously improving workplace health and safety (ANSI/AIHA 2012). This model allows programs to continue to provide timely feedback that was appropriate to the dynamic changes in the physical work environment. These successful programs utilize hazard recognition tools and practices to identify and anticipate workplace hazards.

In dynamic work settings such as acute care hospitals, new hazards can materialize quickly as patient rooms are reconfigured to fit the arrival of new patients requiring different equipment. Likewise, patient acuity and census levels can change daily, thereby changing the pace and physical demands of work.

On commercial construction sites, the inherent nature of the work is to change the physical work environment. Changes to the work environment go hand in hand with changing exposures to the workers within that environment. For example, a hole in the floor to allow ventilation ducts to pass between floors may exist at the beginning of a work shift and be completely filled with said duct just a few hours later. The hole that was a hazard at the

beginning of the shift is gone, likely replaced by additional hazards presented by other work going on in the area. Hence for such environments, regular assessments and control of hazards are often employed through a continuous improvement model for safety. Identification of modifiable ergonomic risk factors is important due to the dynamic nature of these settings (Manuele 2006).

The healthcare environment

In healthcare settings, a review of available literature and on-line resources reveals that there is a need for published methodologies and inspection tools that have a practical focus on ergonomics factors of the physical work environment. Many existing tools are extensive and cover many factors within the work environment but are extremely detailed, complex, and time consuming; often requiring trained ergonomists (OSHA , Janowitz, Gillen et al. 2006, Baumann, Holness et al. 2012, Szeto, Wong et al. 2013). For example, the OSHA Hospital eTool addresses 15 different areas of the hospital with extensive information regarding potential health and safety hazards and potential solutions (OSHA). While comprehensive, the tool requires significant time investment. Also, the tool's guidelines for improving the ergonomic risk factors at hospital settings may be too generic to allow the user to identify specific potential hazards in the physical work environment and to outline specific processes for mediating these hazards.

Other processes have utilized either sophisticated musculoskeletal injury hazard assessments (like the Rapid Entire Body Assessment) or involved extensive training of staff; both of which require advanced ergonomics training and experience (Janowitz, Gillen et al. 2006, Baumann, Holness et al. 2012, Szeto, Wong et al. 2013). Given the dynamic nature of hospital settings, simpler tools that require less time and resource commitment are needed to

allow for continuous ergonomic hazard monitoring and to plan potential abatement.

Systems approach to safety

Due to the dynamic nature of the industry, best practices to improve commercial construction worker health and safety involve ecologic system-level approaches that comprehensively integrate workplace systems relevant to the control of the hazards and worker safety, health, and wellbeing (Sorensen, McLellan et al. 2013). Approaches to improve the health and safety of construction workers have often focused on the individual worker. These approaches include targeting workers when they are enrolled in apprentice programs, (Okechukwu, Krieger et al. 2009, Sokas, Emile et al. 2009, Weinstein and Hecker 2009, Okechukwu, Nguyen et al. 2010, Kaskutas, Dale et al. 2013, Strickland, Smock et al. 2015) targeting workers through social media campaigns via posters at worksites and/or brochures sent to union members,(Strickland, Smock et al. 2015) and engineering controls for specific tasks (Rempel, Star et al. 2010).

Safety climate and inspections

The relationship between safety inspections and safety climate remains unclear. Safety climate has been linked to safety performance which is associated with organizational and environmental factors. Safety performance has been defined as the knowledge, skill, and motivation of workers with respect to performing work safely (Griffin and Neal 2000). In the petrochemical industry a positive safety climate has been shown to reduce unsafe working conditions on construction sites (Zhou, Fang et al. 2010, Wu, Chang et al. 2011). Safety climate has also been linked to safety performance in manufacturing and mining companies (Griffin and

Neal 2000). Organizational and environmental factors have been linked to safety performance on construction sites (Sawacha, Naoum et al. 1999). It follows that safety climate may be influenced by the physical work environment.

The potential impact is great for both research and the construction industry if safety climate is indeed predicted by safety inspections. The need for extensive surveying to evaluate worksite interventions can be replaced by an inspection process that occurs regularly on construction sites. This benefits researchers as well as the industry in general by reducing the burden on organizations and researchers to implement and evaluate safety interventions while returning to first principles of injury prevention with a focus on hazard identification.

Dissertation Goals

The overall goal of this dissertation is to understand the role of safety inspections in workplace interventions and associations with safety climate. It seeks to understand the utility of inspections of the physical work environment in implementing and evaluating workplace interventions in healthcare and commercial construction designed to improve worker safety, health, and wellbeing. This dissertation also tries to understand how inspections of the physical work environment are related to safety climate in commercial construction. Understanding the utility of inspections in the context of workplace interventions will help to improve the design of future workplace interventions, both in research and industry. Examining the relationship between safety inspections and safety climate will help facilitate new avenues of evaluating interventions in commercial construction through elucidating a new pathway for examining safety climate in this industry.

To accomplish these goals, an ergonomics inspection tool and process was developed for acute care hospital settings to identify modifiable aspects of the physical work environment and prioritize resource allocation. The study developed and evaluated a comprehensive worksite-based ergonomics intervention program for commercial construction sites. Finally, this dissertation explored the predictive relationship between safety inspections and safety climate on commercial construction sites. It was my overarching hypothesis that these methods would help inform the development and evaluation of interventions, to improve worker safety, health, and wellbeing in dynamic and physically demanding industries.

Chapter Overview

Chapter 1 describes an inspection tool and process identifying modifiable aspects of acute care hospital patient care units to prevent work related MSDs. There is a dearth of practical resources for evaluating ergonomic risk factors in healthcare environments. Of particular importance are tools for inspecting patient care environments for ergonomic hazards. The goal of this chapter is to describe the development and application of an inspection tool and process for identifying modifiable aspects of the physical environment, identifying ergonomic hazards and reducing injury risk to hospital workers. The process provided a structured method for recognizing hazards and reporting observations and recommendations to decision makers. The tool allows for organizations to plan and prioritize ergonomic hazard abatement (e.g. resource allocation and tracking trends).

Chapter 2 documents the successes and challenges of implementing a worksite-based ergonomics intervention on five pairs of commercial construction sites. The program developed from this research provides a step toward improving health and safety outcomes for workers on a

worksite-specific basis. It is important to understand the challenges and successes of intervention delivery in order to inform and improve future worksite-based interventions.

Chapter 3 assesses how weekly safety inspections predict weekly safety climate on six commercial construction sites. The need for extensive surveying to evaluate worksite interventions can be replaced by an inspection process that occurs regularly on construction sites. This chapter benefits researchers as well as the industry in general by providing evidence that could help reduce the burden on organizations and researchers when implementing and evaluating interventions targeting safety climate.

I expect that this dissertation will provide the reader with a comprehensive understanding of the role of safety inspections in workplace interventions. The reader will understand the advantages, limitations, and overall utility of inspections as a vital tool for hazard identification in dynamic, physically demanding workplaces. Furthermore, this dissertation should provide researchers with the rationale to further explore the predictive relationship between safety inspections and safety climate.

CHAPTER 1

An Inspection Tool and Process Identifying Modifiable Aspects of Acute Care Hospital Patient Care Units to Prevent Work Related MSDs

Major Findings

- The resulting inspection process provided a structured method for recognizing hazards in the dynamic modifiable physical work environment and reporting both observations and recommendations to decision makers.
- The development and implementation of the inspection tool provided guidance to modify the physical work environment by implementing ergonomic solutions. The tool allows for organizations to plan and prioritize ergonomic hazard abatement (e.g. resource allocation and tracking trends).
- Within a Total Worker Health® framework, this tool can measure work practices which can then be used to inform organizational programs and policies within a healthcare setting. This is useful for Total Worker Health® program evaluation since it has the ability to track trends and can provide better feedback over longer periods of time.



Figure 1.0. Be Well Work Well study logo.

ABSTRACT

Background: There is a dearth of practical resources for evaluating ergonomic risk factors in dynamic health care work environments. Of particular importance are tools for inspecting patient care environments for ergonomic hazards. The goal of this study was to describe the development and application of an inspection tool and process for identifying modifiable aspects of the physical environment in order to identify ergonomic hazards and reduce the risk of injury to hospital workers.

Methods: Through an iterative and participatory process, the tool and inspection process was developed with three purposes in mind: 1.) Create a framework for the inspection process for the dynamic physical work environment and physical conditions of work associated with injury risk (Hazards); 2.) Document the physical conditions; and 3.) Provide feedback to decision makers. The tool and its process was utilized by an ergonomics researcher on four patient care units as part of the Be Well, Work Well Total Worker Health® intervention.

Results: The resulting inspection process provided a structured method for recognizing hazards in the dynamic modifiable physical work environment and reporting both observations and recommendations to decision makers.

Discussion: The development and implementation of the inspection tool provided guidance to modify the physical work environment by implementing ergonomic solutions. The tool allows for organizations to plan and prioritize ergonomic hazard abatement (e.g. resource allocation and tracking trends). Within a Total Worker Health® framework, this tool can measure work practices which can then be used to inform organizational programs and policies within a healthcare setting.

INTRODUCTION

In dynamic hospital environments, the relationship between the physical demands of work, and workplace policies and practices and occurrence of occupational injuries, especially musculoskeletal disorders (MSDs), are well documented (Hopcia, Dennerlein et al. 2012, Burdorf, Koppelaar et al. 2013, Koppelaar, Knibbe et al. 2013). Moreover, ergonomics practices aimed at reducing these demands appear to be associated with healthcare worker self-reported ergonomics factors (i.e. pain, injuries, ergonomics practices, etc.) (Dennerlein, Hopcia et al. 2012). However, what is often not realized in these practices is the idea of what is modifiable in the physical environment that can be controlled through an ergonomics program targeting the prevention of work-related MSDs (Caspi, Dennerlein et al. 2013).

Hazard recognition and control are essential and fundamental elements of successful injury prevention programs (Cohen 1997, NIOSH 2008, OSHA 2012). These successful programs utilize hazard recognition tools and practices to identify and anticipate workplace hazards. In dynamic work settings such as acute care hospitals, new hazards can materialize quickly as patient rooms are reconfigured to fit the arrival of new patients requiring different equipment. Likewise, patient acuity and census levels can change daily, thereby changing the pace and physical demands of work. Hence for such environments, regular assessments of and control of hazards are often employed through a continuous improvement model for safety. Identification of modifiable ergonomic risk factors is important due to the dynamic nature of these settings (Manuele 2006).

Workplace inspections are a classic tool used to identify and anticipate hazards in the work environment, and to implement corrective action. Increased inspection rates have been associated with increased compliance with safety policies and regulations and decreased injuries

in the workplace (Hinze, Hallowell et al. 2013, Mischke, Verbeek et al. 2013). This phenomenon is the result of long-term commitment to performing inspections and providing feedback to workers and supervisors (Fang and Wu 2013, Sparer, Herrick et al. 2015).

Reviewing available literature and on-line resources reveals that there is a need for published methodologies and inspection tools that have a practical focus on ergonomics factors of the physical work environment in healthcare settings. Many existing tools are extensive and cover many factors within the work environment but are extremely detailed, complex, and time consuming; often requiring trained ergonomists (OSHA , Janowitz, Gillen et al. 2006, Baumann, Holness et al. 2012, Szeto, Wong et al. 2013). For example, the OSHA Hospital eTool addresses 15 different areas of the hospital with extensive information regarding potential health and safety hazards and potential solutions (OSHA). While comprehensive, the tool requires significant time investment. Also, the tool's guidelines for improving the ergonomic risk factors at hospital settings may be too generic to allow the user to identify specific potential hazards in the physical work environment and to outline specific processes for mediating these hazards. Other processes have utilized either sophisticated musculoskeletal injury hazard assessments (like the Rapid Entire Body Assessment) or involved extensive training of staff; both of which require advanced ergonomics training and experience (Janowitz, Gillen et al. 2006, Baumann, Holness et al. 2012, Szeto, Wong et al. 2013).

We intended to utilize a process that was comprehensive (i.e. not strictly focused on computer workstations) that could be turned over to the hospital and used easily by members of occupational health with minimal training (i.e. questions should be easy to answer without an ergonomics background so that a hospital could utilize the tool without going through a vendor or utilizing someone with extensive ergonomics training). Most hospital health and safety

inspections are performed at the unit-level and this tool was further designed to be implemented on a similar scale. Given the dynamic nature of hospital settings, simpler tools that require less time and resource commitment are needed to allow for continuous ergonomic hazard monitoring and to plan potential abatement.

METHODS

The Be Well, Work Well Study

The need for simpler ergonomic inspection tool backed by empirical analyses arose from our work in a larger proof-of-concept trial of an intervention as part of the Harvard. T.H. Chan School of Public Health Center for Work, Health, and Wellbeing. The intervention was delivered on four patient care units in a large acute-care hospital in the Greater Boston Area that participated in the Be Well, Work Well (BWW) intervention (Figure 1.0). The proof-of-concept trial is described in full elsewhere (Sorensen, Nagler et al. 2015). The units participating in BWW provided clinical care to patients formally admitted to medical, surgical, or intensive care units in the hospital. The four units that received the BWW intervention were a medical ICU, a thoracic surgery ICU, a medical oncology unit, and a Neonatal ICU.

Ergonomics Inspection Tool and Process Development

The Inspection Tool

The intent of inspection tool was to provide feedback to the units; both to the nurse directors as well as the patient care workers on ways the conditions of work could be modified to mediate ergonomic risk factors. Combining this purpose with the goal of identifying low-to-no-cost recommendations provided a useful and meaningful process for practitioners and researchers wishing to address ergonomics factors related to the physical work environment on the units.

The tool was developed using an iterative process that included the following steps: a general inspection, identifying a framework, drafting a tool, and piloting the inspection tool.

General Inspection

First, a team of experts, including three ergonomics researchers, a registered nurse, and a hospital ergonomist conducted inspections of a wide variety of unit types in two major Boston hospitals. The entire team moved from unit to unit and worked together with the goal of gaining a general understanding of the units; to observe the physical and social organization of the units, to look for visible hazards that could contribute to MSDs and acute injury, and to engage available unit staff in impromptu, short, open-ended interviews about job-specific hazards experienced in their respective working environments. The open-ended interviews with unit staff were focused on understanding the type and scope of work on each type of unit. The units observed included medical and thoracic ICUs, an orthopedics department, and an endoscopy unit, among others. All units were acute-care, inpatient units. One unit was in a building built within the last 5 years while the other three were in older buildings. Observations were made about features of the physical environment that increase the risk for injury.

One of the key aspects of our approach to developing this tool was to focus on the modifiable physical environment. The purpose of this focus was to make sure that any observations would be able to be modified. For example, we did not include items related to storage space. In the urban Boston hospital setting space is at a premium and units often do not have adequate storage space. The tool development was focused on understanding what aspects of the physical environment might be altered to make the work environment on the units safer for patient care workers.

After the inspections were completed the ergonomics researchers compiled a report outlining each of the units that were observed; including the type of care provided, observed and potential ergonomics hazards, and any other notes from the inspection or discussions with staff.

The team of experts then distilled the report into a list of common issues/themes that recur from unit to unit. These themes became the basis for creating a tool that is applicable to all hospital units in an acute-care inpatient facility.

The general inspections identified physical features that were common across all units and some features that were unique based on unit type. As part of the inspection, the team also determined to what extent the features within specific areas were modifiable. An example of identified modifiable feature is the placement of the bed in the patient rooms. Oftentimes, the placement of beds can be changed while still allowing for access for patient care. Features that were considered fixed, include aspects of the physical environment that could not be modified by the staff employed by the hospital, such as the flooring material. When aspects of these “fixed” features were found to pose ergonomic risks, they were noted in the inspection tool along with recommendation for changes to be considered as part of future renovations.

Identifying a Framework

We used OSHA's Safety and Health Program Assessment Worksheet as a framework for our tool (OSHA). The Assessment Worksheet is designed to assess organizational policies and programs pertaining to occupational safety and health. The Assessment Worksheet provided a structure that allowed for a score (0 through 5; does not apply at all, somewhat, frequently, often, almost always, fully applies) of how well each statement applies to the observation. Another beneficial aspect of the Assessment Worksheet was the inclusion of space for notes in each section. This structure allows users to provide more than a simple “yes/no” answer and provides an opportunity to track scores, and thus progress, over time.

Drafting a Tool

After choosing the structure of the tool, we began to assemble a list of the most important features and common themes of the modifiable physical work environment that were identified in the general inspection. Common features included nurses' stations, storage areas, and patient rooms. Themes from the general inspection process were grouped into the common hazard categories of manual materials handling, safe patient handling, slips trips and falls, working with your hands over your head, and excessive bending and twisting while working (Industries , Medicine and Council 2001).

After the creation of a list of modifiable risk factors based on the inspections, we obtained input from the BWWW intervention working group responsible for designing and implementing the overall intervention. The working group included a registered nurse, multiple research assistants, intervention effectiveness researchers specializing in ergonomics and wellness initiatives, and multiple health professionals from the acute-care hospital for which the tool was being designed. This team helped guide our efforts to define the modifiable aspects of the physical work environment of units and to refine the items in the tool to be more applicable to the acute care environment.

The team worked to make comments on and fine tune the original list of modifiable risk factors. Finally, we involved staff from Occupational Health at the hospital in order to further refine the tool and align our targets with hospital-wide initiatives. This step resulted in a draft of the final inspection tool that was ready to be vetted and piloted within the hospital setting.

Piloting the Inspection Tool

The tool was used by a small team consisting of two ergonomics researchers and an occupational health representative to pilot the inspection process on two units in the hospital. These units were not selected into the larger BWWW intervention and thus represented an ideal setting to understand and refine the tool and process prior to implementation as a part of the intervention. After the pilots, minor revisions related to phrasing of the statements and questions within the tool were incorporated to enhance the utility of the tool. Overall, there were no changes to the substantive content of the tool.

The Inspection Process

The inspection tool is part of a process with the goal of informing workers, managers, and in our case researchers about MSD risk factors in the physical work environment. The process involves several components including accessing and inspecting the unit, communicating immediate observations, compilation of the observations, review of inspection findings with occupational health staff, and communicating the observations back to the unit leadership and staff. These steps and processes were developed with the occupational health staff of the hospital. We wanted to ensure that the process can be easily integrated into other healthcare environments with little to no interference to existing workflow, policies, and practices on the units.

Accessing and Inspecting the Unit

Access required planning and scheduling a convenient time for the inspection to occur. The inspection process (Figure 1.1) included a member of the research team serving the role of

the inspector as well as a combination of the Nurse Director, Clinical Nursing Specialist, Resource Nurse, and assorted nurses and patient care assistants depending on staffing and availability of the particular unit during the inspection. Throughout the inspection, the tool was used to guide the inspector and document specific observations.

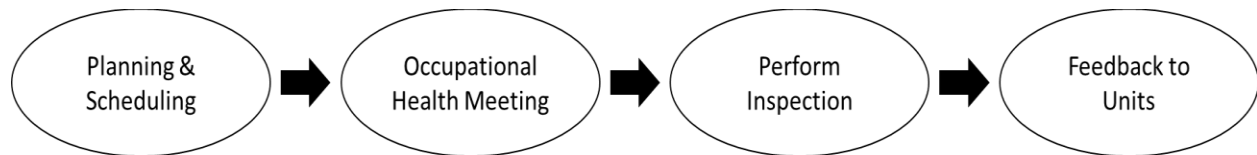


Figure 1.1. Flowchart of the inspection process including planning, meeting with occupational health, and final feedback to the units.

Communicating Immediate Observations

A key component to this process was the ability to communicate certain immediate observations to staff members. Oftentimes this came in the form of answering the questions of staff members encountered during the inspection. The inspector was able to address questions and concerns brought up by staff during the inspection. The inspector in this case was a member of the research team but inspectors in other settings would not need extensive ergonomics training to fulfill this role.

Oftentimes, the immediate feedback consisted of identifying how to adjust different equipment (i.e. office chairs or display monitors) or reminding staff that most equipment in patient rooms were on wheels (i.e. able to be maneuvered to provide better access to the patient without added strain on the workers). Providing immediate feedback was well received allowing unit leadership and staff to trust the inspection processes and sometimes resulted in immediate modifications for easy-to-change items that were identified.

Review of Inspection Findings

Working with a staff member from Occupational Health who was familiar with in-house resources, we then developed a list of recommendations to address ergonomics related issues in the work environment. The consultant aided the research team in narrowing down the list of observations to only those that were considered modifiable and able to be paired with a recommendation. All recommendations were designed to be as actionable as possible- with a description of the recommendation accompanied by appropriate contact information (i.e. phone number and contact for the office chair vendor in order to repair broken chairs covered under warranty).

Communicating Findings with Leadership and Staff

These recommendations were then communicated with the unit's Nurse Director via a feedback report consisting of the observations from the inspection and associated recommendations. This was ideally an in-person meeting which allowed the Nurse Director to ask questions about the observations and recommendations. Unit leadership was then able to disseminate results and action items to staff through various existing methodologies including staff meetings and via email.


RESULTS

The resulting inspection tool was comprised of two parts, one part was for the inspection itself (Appendix A) and one part was meant to guide a short interview with the nurse management of the unit (Appendix B). When combined, the two parts provided a complete overview of the state of the modifiable physical environment. The tool also provided a structured method for recognizing hazards in the modifiable physical work environment.

The final inspection tool encompassed three domains: housekeeping, awkward postures, and safe patient handling and mobilization. These domains were designed to address the fundamental hazards of manual materials handling, safe patient handling, slips trips and falls, working with your hands over your head, and excessive bending and twisting while working. The major component of housekeeping was cord, cable, and tubing management including placement of equipment carts. The awkward postures section was focused on accessibility of materials in storage rooms, placement of equipment (i.e. sharps boxes within patient care rooms), and computer workstations. The safe patient handling and mobilization section was of particular concern for the hospital. This section focused on ceiling lifts and the availability of slings. Virtually all patient rooms in the hospital had ceiling lifts and thus this was an important aspect to include in the process to evaluate compliance and align with hospital initiatives.

The research team generated a feedback and recommendations report that was a simple, two column table with the objective of being meaningful and actionable (Figure 1.2). The left column contained the final list of observations from the inspection and the right column contained the associated recommendations. Each recommendation was designed to include the name of a person or department to contact along with a phone number or email address. If the recommendation was something that the unit could accomplish without outside help then the

directions were very explicit and thorough in order to maintain the actionable nature of the report. If the recommendation was more along the lines of purchasing a product then the recommendations contained a website, company name, and approximate price. Wherever possible, pictures were added to increase the utility of the report and to reduce confusion over products or observations. The report was then used as a launching point for further discussions with the nurse directors in the subsequent management level of the BWWW intervention activities focusing on leadership development.



I. Office/General Findings	Recommendations
1. Sliding shelves in clean utility room	Place a sign on the shelves indicating that they should be moved one at a time. When moved singularly they are much easier to move. When workers try to move multiple shelves at once it becomes more difficult and puts unnecessary force on their bodies.
2. Computer workstation issues a) Trip Hazard from computer cords	a. Cord and Cable management at computer workstations. Contact the IT help desk at [redacted] to request cord management under desks in offices and the nursing station.

Figure 1.2. Snapshot of the inspection tool report for unit leadership. The report has two columns, the first describing the observation and the second containing the recommendation to modify and mitigate the observation.

DISCUSSION

The overall goal of this paper was to document the development and description of an inspection tool and process that could be used to guide a portion of an intervention study implemented in patient care units of an acute care hospital. Such a tool could then be used in other patient care environments to evaluate and identify areas for improvement in the modifiable physical environment.

The development and implementation of the ergonomics inspection tool showed that inspections of the modifiable physical work environment can be useful and productive. The process of performing an inspection as a part of an integrated intervention was feasible and meaningful to both intervention efforts as well as to the units involved in the intervention. We were able to identify low-to-no-cost recommendations and even utilize internal resources to address many of the findings of the inspection. One major finding was the importance of involving internal personnel with organizational knowledge. Working closely with the Occupational Health department of the hospital, users were able to quickly and efficiently identify resources across the different departments at the hospital.

There are several limitations with this study. One limitation is that the differences in work organization for different units prevents direct comparison of units. Different units might have different patient acuity and work demands. For example, a worker in the Neonatal ICU might often assume static postures at the bedside for the duration of a 12 hour work shift. While this could affect comparisons to other units without prolonged static postures (i.e. a thoracic ICU), the inspection tool was designed to examine an individual unit. A valuable strength of this tool is the ability to track the state of a unit longitudinally. Tracking the inspections can allow a

hospital to determine a unit's compliance with and the sustainability of recommendations made after an inspection.

Another limitation is that the inspections were limited to a single day and time that worked well for the unit. As a result we may have missed a significant amount of the staff that works on a given unit. This is a common limitation of inspections in general and highlights the need for repeated evaluations both over time and over the course of a shift. A limitation of any inspection process is the potential for the inspector to miss certain events, activities, and even staff depending on the day and time that the inspection is taking place. One way to address this issue is to increase the frequency with which the inspections occur. This is especially important in dynamic work environments such as healthcare. Although we were limited in our access to the units during this study, our tool can be utilized as frequently as the organization desires in order to address this limitation.

One aspect of the hospital environment that is particularly difficult to quantify or overcome is the deeply engrained beliefs and attitudes surrounding environmental health and safety practices. These beliefs can impede change to policies and practices on the units with respect to many factors. In this study it was difficult to address practices related to safe patient handling and mobilization, particularly surrounding the use of mechanical patient lifts.

This study did not use one of the more sophisticated musculoskeletal injury hazard assessment tools like the Rapid Upper Limb Assessment (RULA), the Strain Index, or the NIOSH lifting equation. This was by design. The intervention intended to utilize a process that could be turned over to the hospital and used easily by members of occupational health with minimal training.

This study also has several strengths. First and foremost, the inspection protocol was designed to be a meaningful and useful evaluation tool for the units. It was not meant to be a design tool. We incorporated the needs and wants of the organization wherever possible. Occupational Health was involved with nearly every step in the process, including the design and process development, through the evaluation and feedback steps. We wanted to make sure that their needs were met and that we were focusing on issues that would benefit the hospital.

Another strength of this process is the ability to track progress over time. Basing the inspection tool off of the OSHA Form 33, we were able to assign a "score" to each unit. These metrics allow for organizations to track trends for individual units over time with an inspection protocol that includes follow up inspections at regular intervals.

An effort was made to ensure that the management on the nursing units received actionable and meaningful feedback to make it as easy as possible for them to respond to our findings. This is in part due to the busy schedule of the nurse directors as well as a concession to the limited resources available to the units. Most recommendations were in-house services from other departments of which the units were unaware.

Although intended as a component of the BWWW intervention and designed for use by an occupational health and safety professional, there are other potential users in the healthcare community. The physical environment is an often overlooked area of overall quality and safety criteria for both patient and worker safety. This tool and process could be integrated into the systematic assessments routinely performed on nursing units by nurses and other clinicians.

Dynamic work environments like healthcare benefit from strong organizational programs, policies, and practices surrounding hazard identification. Total Worker Health® is a useful framework for interventions in dynamic work environments like healthcare. The tool and process

developed in this study can measure work practices which can then be used to inform organizational programs and policies within a healthcare setting. The ergonomics inspection tool can help to identify areas for improvement in existing patient care environments to reduce the likelihood of musculoskeletal pain and injury.

CHAPTER 2

Weekly Safety Inspections Predict Weekly Safety Climate on Six Commercial Construction Sites

Major Findings

- Safety inspections by trained safety managers were significant predictors of concurrently collected safety climate reported by workers, demonstrating that safety climate captures aspects of physical work environment.
- Safety inspections were not significant predictors of safety climate measured one week later, demonstrating the ever-changing conditions of work in construction.
- Since physical working conditions (the presence of hazards and controls) are associated with safety climate, this study indicates that both physical work conditions and safety climate are an important to assess and also critical to improving health and safety of workers in the dynamic commercial construction environment.



Figure 2.0. B-SAFE study logo.

ABSTRACT

Objective: To test the ability of safety inspections to predict safety climate within the dynamic setting of commercial construction sites.

Methods: We utilized weekly safety inspection scores from safety manager walkthroughs and safety climate scores from worker surveys from six commercial construction sites (20,000 sq ft to 485,000 sq ft) for 4 to 5 months. Safety inspections focused on working conditions (the presence of hazards and controls). The safety inspection scores were a ratio of the number of safe conditions to the total number of observations. Linear mixed effects models estimated weekly safety climate scores from the weekly safety inspections.

Results: Concurrent weekly safety inspections were significant predictors of safety climate in our unadjusted analysis as well as when controlling for treatment status ($p < 0.0001$). Safety inspections were not significant ($p = 0.9426$) predictors of safety climate measured one week after the inspection demonstrating the ever-changing conditions of work in construction.

Conclusions: These findings support the associations between the physical conditions of work (in terms of the presence of both controls and hazards) and safety climate indicating that these physical working conditions are an important aspect of improving safety climate in the dynamic commercial construction environment.

INTRODUCTION

The composition of the construction workforce on a given worksite is constantly changing depending on the phase of construction as well as the needs of the individual subcontractors (Ringen and Stafford 1996, Sparer, Okechukwu et al. 2015). Worksites rely on individual workers to provide and maintain safe working conditions while they are on site (Haro and Kleiner 2008, McDonald, Lipscomb et al. 2009). The extent to which safe working conditions are maintained on a worksite depends on the organizational policies and practices of both the general contractor as well as that of the subcontractor and can be measured using the construct of safety climate (Manu, Ankrah et al. 2013).

Additionally, work organization and the hierarchical structure in construction does not follow the traditional manufacturing model; rather, workers on a given worksite are employed by different companies and move from worksite to worksite (Dunlop 1961, Weil 2014). Therefore, comprehensive safety inspections may be used to quantify the physical work environment which can be used to examine the link between conditions of work and safety climate.

Safety climate represents the set of attitudes, beliefs, values, and priorities held by managers and employees, and directly influences the development, implementation, performance, oversight, and enforcement of health and safety in the work environment (NORA 2008). Safety climate is a valuable measurement tool that can be used to evaluate the effect of a worksite intervention, as it has been found to be predictive of safety related outcomes such as numbers of safety incidents (Colley, Lincolne et al. 2013).

Within the context of the conceptual model of Griffin and Neal 2000, Safety climate is a result of organizational policies, programs, and practices, which then in turn has been linked to safety performance of individual workers and eventually their outcomes. Safety performance has

been defined as the knowledge, skill, and motivation of workers with respect to performing work safely (Griffin and Neal 2000). However, many critics of initiatives to improve safety climate question the application of safety climate and its associations with physical hazards in the workplace (Clarke 2000, Myers, Nyce et al. 2014). It is indeed the presence of physical hazards (energy) are the immediate cause of injuries (Gibson 1961). Organizational policies, programs, and practices are also associated with the physical work environment and hence the control of workplace hazards (Figure 2.1).

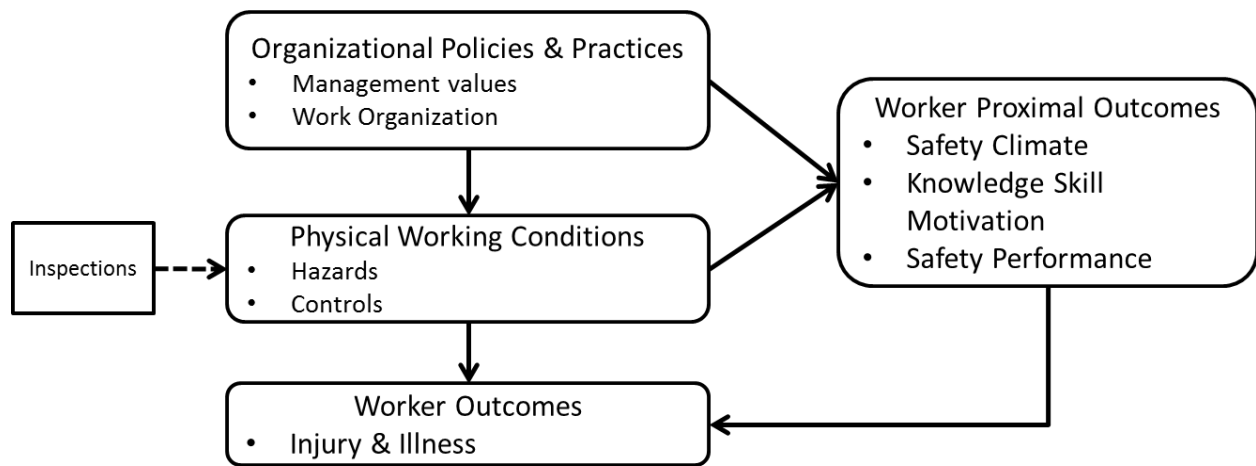


Figure 2.1. Conceptual model displaying the relationship between physical working conditions and safety climate. The right branch is adapted from Neil and Griffith, 2000. Inspections focusing on existing hazards and associated controls provide a quantifiable measurement of the physical working conditions. The conditions of work (presence of hazards and controls) are influenced by organizational policies and practices and, in turn, influence the safety climate of the workers on the worksite.

There is some evidence that there are associations between safety climate and the working conditions. In the petrochemical industry, a positive safety climate has been associated with unsafe working conditions (Zhou, Fang et al. 2010, Wu, Chang et al. 2011). Safety climate has also been linked to safety performance in manufacturing and mining companies (Griffin and

Neal 2000).

In the dynamic environment of commercial construction sites, the relationship between physical working conditions and safety climate is unknown. We expect that this relationship may itself also be dynamic. While work has been done to measure and characterize antecedents and consequences of safety climate, how much safety climate changes over time and the relationship between these changes and physical work environment is another important, but unexplored question.

METHODS

For this study we utilized longitudinal data collected as part of the B-SAFE study (Figure 2.0), (www.northeastern.edu/b-safe)(Sparer, Herrick et al. 2015) that evaluated an intervention recognizing safe physical working conditions and practices from safety inspections and provided feedback to workers. The study was a clustered randomized control trial where sites were recruited through the Harvard University Construction Safety Group and other general contracting companies and industry partners in the Boston area. Of the 8 commercial construction sites enrolled in the B-SAFE study, six had weekly concurrent measures of safety climate and safety inspection scores.

Survey Description

Weekly safety climate scores were determined from follow up surveys collected as part of the B-SAFE study. Each week research staff identified and surveyed workers on site for whom it had been 4 weeks since they had completed base line survey (when they came on site) or a previous follow up survey. Therefore, the weekly sample of workers was a subset of workers on site and the workers sampled varied week to week depending upon their tenure on site. Surveys were collected only from workers who had been on site for more than four-weeks and had completed previous baseline surveys. The weekly safety climate score for the site was calculated as the average score from the workers sampled that week.

The follow up survey contained a nine-item safety climate scale (Dedobbeleer and Béland 1991) as well as other questions regarding recent injuries and musculoskeletal pain, and demographics such as age, gender, race/ethnicity, education, trade, title, and tenure. In 1991, Dedobbeleer and Beland applied a safety climate model to construction workers and found a

nine-item scale provided an efficient fit to the data (Appendix C) (Dedobbeleer and Béland 1991). This scale was developed for the construction industry and can therefore address elements of safety specific to construction workers.

An exploratory factor analysis using principal component analysis to assess the internal validity of the scale. Factor analysis of the nine-item baseline data indicated that the items grouped together in two factors, a five item (scale items 1-3, 6-7) and a four item (scale items 4-5, 8-9). Therefore, we did not include these items in our final safety climate scale. The Cronbach's alphas for the two scale configurations were 0.71 and 0.78 for the 9-item and 5-item, respectively. Additionally, based on inspection of the nine items, it became apparent that some items appeared to represent safety performance constructs such as safety training (items 6-7) and risk perception (items 8-9) rather than safety climate. Given the empirical and theoretical strength of the five item scale, we selected the five item scale for our data analysis. The five-item safety climate scale was used to generate a single value, a safety climate score, for an individual worker. Each of the five questions is given a point value based on the response. The values are summed to generate a score, which can range from 0 to 50, with higher values representing a more positive safety climate. Follow up surveys, used in the analysis for this study, asked workers to refer to the entire scope of their experience on the current worksite when responding to questions pertaining to their work environment.

Safety Inspections

Safety inspections were conducted by a trained safety manager from the general contractor. These safety inspections provided weekly safety inspection scores for the worksite through Predictive Solutions, an online data inspection management program (Industrial

Scientific, Oakdale, PA, <http://www.predictivesolutions.com/solutions/SafetyNet/>). During the inspection, the inspector classified each observation into one of 22 categories (such as Hand and Power Tools or Hazard Communication) and denoted them as “safe” or “unsafe”. All unsafe conditions were then characterized as “low,” “medium,” “high,” or “life threatening”, based on a severity-likelihood risk matrix (HarvardConstructionSafetyGroup 2010). From this inspection data, we calculated a weighted safety score (a ratio of the number of safe conditions to the total number of observations) for each site that accounts for the severity of the unsafe observation and the category of the safe observation (Griffin and Neal 2000, Sparer, Herrick et al. 2015). This weighted safety score ranged from 0 to 100, with 100 representing 100% safe. Although each site had a different inspector, all followed the same guidelines and all sites used Predictive Solutions prior to study initiation.

Statistical Analysis

We generated four repeated measures linear regression models where the dependent variable was the weekly safety climate. For model 1, concurrent safety climate and safety inspection scores were included as repeated measures, over time (weeks), within each site. Model 2 had the same predictors as model 1. Since four of the six sites had an intervention program we added a variable for treatment status (intervention or control) to model 2 to control for potential differences between the intervention and control sites. Model 3 tested for the association of working conditions of this week (inspections) with safety climate measured next week. Model 4 had the same predictors as model 3 with an added variable for treatment status. Finally, to ensure that the model was robust given the small number of sites we completed a sensitivity analysis of running the models with only five sites six times, removing one of sites

each time. All analyses were performed using the SAS software package version 9.4 (SAS Institute, Cary, NC).

RESULTS

The six commercial sites varied in size from approximately 20,000 square feet to 485,000 square feet (Table 2.1). Data collection occurred over a period of approximately six months on each worksite. Four sites were new construction while two were renovations. Each worksite had data available for 10 to 16 weeks. Average weekly safety climate on these sites ranged from 24 to 50 out of a total of 50 possible points. Weekly safety inspection scores ranged from 88 to 99 out of a total of 100 possible points.

The relationship between weekly safety inspections and weekly safety climate scores shows an overall positive association, with increased safety climate associated with increased safety inspections (Figure 2.2). Sites B and C have less variability in weekly safety inspections ($sd = 0.85$ and 0.72 , respectively), which can be seen in the tighter clusters of inspection scores compared to other sites. Sites B and F have less variability in weekly safety climate ($sd = 1.54$ and 1.07 , respectively), which can be seen in the tighter clusters of safety climate scores compared to other sites. Sites D and E have a wider range of values for safety inspections ($sd = 4.72$ and 4.19 , respectively).

Weekly safety inspections were significant predictors of weekly safety climate in our unadjusted analysis (model 1; $p < 0.0001$) as well as when controlling for B-SAFE treatment status (model 2; $p < 0.0001$) (Table 2.2). A one point increase in inspection score is associated with a 0.56 point increase in safety climate in both model 1 and model 2. Treatment was not significant in the adjusted model 2 ($p = 0.1812$) suggesting that B-SAFE treatment status does not affect the relationship between weekly inspection scores and weekly safety climate.

Table 2.1. Description of selected study site characteristics.

Site	Size (sq. ft.)	Construction Project length	Time of year of data collection	Scope of work	Bsafe Treatment type	Weeks ^b	Mean (sd) Safety Climate (0-50)	Mean (sd) safety Inspection Score (0-100)
A	20,600	8 months	August-February	Renovation	Intervention	10	44.5 (3.29)	97.3 (2.02)
B	200,000	48 months	May-October	Renovation + new construction	Intervention	14	44.3 (1.54)	97.1 (0.85)
C	375,000	33 months	January-June	New construction	Control	13	42.1 (4.84)	99.4 (0.72)
D	390,000	35 months	July-December	New construction	Intervention	16	39.5 (2.97)	88.6 (4.72)
E	19,000	10 months	July-December	Renovation	Control	12	41.1 (2.95)	92.4 (4.19)
F	485,000	13 months	February-June	New construction	Intervention	16	42.2 (1.07)	95.5 (2.59)

^aNumber reflects the number of followup surveys used in analysis.

^bNumber of weeks of observations used in analysis.

Table 2.2. Results of repeated measures analysis.

	Effect Estimate	N	Standard Error	p-value
Model 1 - Unadjusted ^a	0.3477	79	0.0736	< 0.0001*
Model 2 - Adjusted ^b	0.3689	79	0.0704	< 0.0001*
Model 3 – Lagged ^c	0.0339	73	0.0916	0.7124
Model 4 - Adjusted Lagged ^d	0.0311	73	0.0925	0.7376

^aModel 1: Dependent variable is weekly safety climate. Independent variable is weekly safety inspection. Subject is Site and repeated measure is week.

^bModel 2: Same parameters as Model 1. Also adjusted for worksite treatment status.

^cModel 3: Dependent variable is lagged weekly safety climate (next week). Independent variable is weekly safety inspection (this week). Subject is Site and repeated measure is week.

^dModel 4: Same parameters as Model 3. Also adjusted for worksite treatment status.

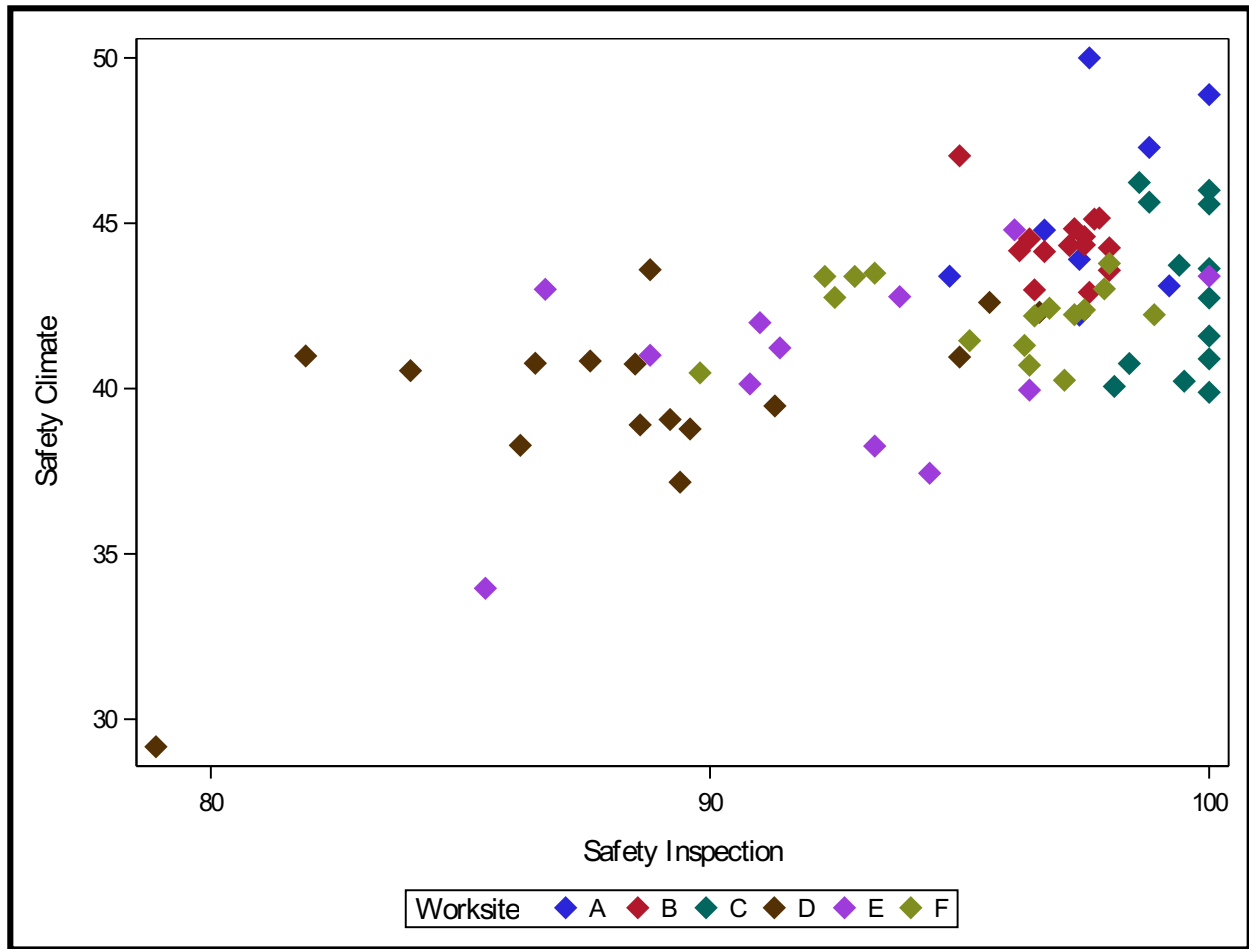


Figure 2.2. Relationship between weekly safety inspection score (Safety Inspection) and weekly safety climate (Safety Climate) across the six sites included in the study. Safety climate was measured on a scale of 0-50 and safety inspections on a scale of 0-100.

Weekly inspections remain highly significant as predictors during the sensitivity analysis with p-values ranging from <0.0001 to 0.0229 . In the adjusted models, p-values for B-SAFE treatment status ranged from 0.1062 to 0.4152 . There was a range of changes in effect estimates for weekly inspections. The largest change occurred with the removal of Site D ($\Delta=0.09$) from the analysis. While Site D may be considered an influential point in our dataset, the relationship between weekly inspections and weekly safety climate remains significant in this sensitivity analysis so we kept it in the dataset and select model 1 and 2 as our final models. In

the lagged models, the previous week's safety inspections were not significant predictors of the current week's safety climate in either Model 3 ($p=0.7124$) or Model 4 ($p=0.7376$). Treatment was not significant in Model 4 ($p=0.5319$), further suggesting that B-SAFE treatment status does not affect the relationship between weekly inspection scores and weekly safety climate.

DISCUSSION

The goal of this study was to examine the relationship between safety climate and safety inspections. This study found that weekly safety inspections predict weekly safety climate on these six commercial construction sites. The associations between weekly inspections and weekly safety climate data were seen when using data collected concurrently but not when comparing safety climate data collected one week after the safety inspections.

This concurrent relationship demonstrates that indeed the commercial construction worksite is a very dynamic work environment and that the ever-changing conditions of work are reflected in the safety climate of the workers on a given worksite for a given week. The presence of hazards and associated controls on commercial construction sites are dynamic and may change week to week. Our results indicate that safety climate on these sites also changes weekly, depending on the presence of hazards and controls on the worksite (measured through the comprehensive inspections).

These data support the hypothesis that safety climate is associated with the physical work environment, utilizing objectively collected inspections of the physical work environment to predict safety climate. Many critics of initiatives to improve safety climate question whether safety climate is associated with physical hazards in the work place many critics of initiatives to improve safety climate question the application of safety climate and its associations with physical hazards in the workplace (Clarke 2000, Myers, Nyce et al. 2014), perhaps owing to the history of safety climate studies focusing on workers' safety behavior, rather than the physical work environment in order to improve safety-related outcomes (Zohar 1980, Griffin and Neal 2000, Neal and Griffin 2006).

The B-SAFE intervention was designed to provide feedback about the weekly inspections

to worksites receiving the intervention, leading to concern that B-SAFE treatment status (intervention vs. control) could influence weekly safety climate in the week following the feedback to workers. In the commercial construction workplace, the physical environment is very dynamic and the workforce is essentially transient given movements of different trades on and off sites (Ringen and Stafford 1996, CPWR 2013, Sparer, Okechukwu et al. 2015). However, modeling both the concurrent and lagged data suggests that treatment status does not affect the relationship between weekly inspection scores and weekly safety climate.

Maintaining a behavior-based safety program in the dynamic commercial construction environment is extremely difficult (Lingard and Rowlinson 1998) and the transient nature of the workforce prevents the long-term exposure to individual workers required by behavior-based programs (DePasquale and Geller 2000). A focus on safety behaviors moves away from the traditional continuous improvement model described by American National Standard for Occupational Health and Safety Management Systems (ANSI Z10-2012) used to identify, evaluate, and control hazards in the workplace. It is a strength of this study to focus on the comprehensive inspections of the dynamic physical work environment and acknowledging the importance of the identification and control of workplace hazards.

Additionally, the analysis revealed that treatment status did not have an effect on the relationship between weekly safety inspections and safety climate (Table 2.2). The data collected in the B-SAFE study was not intended to be used for this analysis when the intervention was designed so the effect of treatment status was a concern. Modeling the relationship as both concurrent and lagged showed no significant treatment effects allaying all concerns about the B-SAFE treatment status. Furthermore, our sensitivity analysis revealed that removing single sites from our dataset did not appreciably change the modeling results. Large values of Cook's

Distance are likely due to the small number of sites included in this model. This further illustrates the ability of weekly safety inspections to predict weekly safety climate on these construction sites and rules out the possibility of a single site having undue influence on our models.

This study involves worksites in commercial construction only. The results of our study may not be generalizable to other types of construction (i.e. residential or industrial). However, commercial construction accounts for a large portion of construction activities across the United States and represents an important area for injury prevention research. Similarly, the B-SAFE study was performed in the Greater Boston Area which may not be representative of commercial construction nationwide with respect to workforce composition or organizational policies and practices.

Further study is needed into the predictive nature of safety inspections and safety climate. The innovative research presented here makes an important contribution to the study of safety interventions and safety climate research. The potential impact is great for both research and the construction industry if safety climate is indeed predicted by safety inspections. The need for extensive surveying to evaluate worksite interventions can be replaced by an inspection process that occurs regularly on construction sites. This benefits researchers as well as the industry in general by reducing the burden on organizations and researchers to implement and evaluate safety interventions while returning to first principles of injury prevention with a focus on hazard identification and control.

CHAPTER 3

Successes and Challenges of Implementing a Worksite-based Ergonomics Intervention on Five Pairs of Commercial Construction Sites

Major Findings

- We were able to successfully develop and evaluate a worksite-based ergonomics intervention on five pairs of commercial construction sites providing a step toward improving health outcomes for construction workers.
- Key challenges to intervention implementation were competing safety and production priorities and break practices leading to inconsistencies in intervention delivery.
- An overall barrier to intervention implementation and data collection was the capability of subcontractor companies to make changes to their worksite. Subcontractors did not have the systems in place or the available tools to assist in changing their working conditions.



Figure 3.0. All the Right Moves study logo.

ABSTRACT

Introduction: Our objective was to complete a cluster randomized control trial on five pairs of commercial construction sites to evaluate a work-site based ergonomics intervention.

Methods: The ergonomics intervention program consisted of a pre-intervention site assessment, pre-task planning protocol, foremen training, and an inspection and communication protocol. We randomly assigned treatment status to pairs of sites recruited from general contractors. We utilized a mixed methods approach to evaluation; obtaining baseline and follow-up survey data from 211 commercial construction workers in addition to focus group and key informant interviews of workers and safety managers.

Results: We observed very non-significant intervention effect estimates on ergonomic practices ($p=0.502$), pain severity ($p=0.454$), and work interference due to pain ($p=0.894$). Qualitative findings indicate that key challenges to intervention implementation were competing safety and production priorities and break practices leading to inconsistencies in intervention delivery. A key barrier was the capability of subcontractor companies to make changes.

Conclusions: We were able to successfully develop and evaluate a worksite-based ergonomics intervention on five pairs of commercial construction sites. Best practices to improve the health and safety of construction workers involve ecologic system-level approaches that comprehensively address workplace systems relevant to the control of hazards and worker safety, health, and well-being.

INTRODUCTION

Commercial construction work is a highly dynamic industry with physically demanding jobs associated with high rates of musculoskeletal disorders (MSDs) and poor health behaviors that affect worker health and productivity (Forde, Punnett et al. 2005, Lee, Fleming et al. 2007, Okechukwu, Krieger et al. 2009, Holtermann, Mortensen et al. 2010, CPWR 2013, Dennerlein, Grant et al. 2016 (Submitted)). In 2010, 34% of non-fatal injuries with days away from work were associated with strains and sprains, three-quarters of which were related to overexertion (CPWR 2013). Increased physical demand in construction work also increases the risk for cardiovascular disease (Holtermann, Mortensen et al. 2010). These health and safety challenges become more pronounced with age and as a result many construction workers retire early due to injuries or illness (de Zwart, Frings-Dresen et al. 1999, Pransky, Benjamin et al. 2005, Welch, Haile et al. 2010, CPWR 2013).

Approaches to improve the health and safety of construction workers have often focused on the individual worker, however best practices involve ecologic system-level approaches that comprehensively address workplace systems relevant to the control of hazards and worker safety, health, and well-being (Sokas, Emile et al. 2009, Weinstein and Hecker 2009, Rempel, Star et al. 2010, Kaskutas, Dale et al. 2013, Sorensen, McLellan et al. 2013, Strickland, Smock et al. 2015).

An important partner for implementing ecologic system-level approaches to improving occupational health among construction workers is the general contractor. The general contractor sets the norms and stands that determine worksite-wide policies and practices regarding health and safety given that construction sites have diverse groups of workers under different sub-contractors flowing in and out of worksites.

This chapter evaluated Phase I of the “All the Right Moves” (ARM) intervention study (Figure 3.0) through a cluster randomized control trial on five pairs of commercial construction sites in the Boston Area. ARM developed and evaluated an a work-site based ergonomics intervention that was specifically developed to be delivered to commercial construction workers through the general contractor at the worksite-level. ARM was delivered in two phases. Phase 1 implemented a comprehensive ergonomics program for the construction worksite. Phase II of ARM focused on promoting change in risky health behaviors through telephone based health coaching. Our hypothesis was that workers on worksites receiving the ARM intervention would show improvements in ergonomics practices, pain severity, and work interference due to pain compared to workers on worksites that did not receive the ARM intervention.

METHODS

Study sites and population

The ARM intervention study was conducted at the Harvard T.H. Chan School of Public Health, Center for Work, Health and Wellbeing, in collaboration with industry partners from the Boston area: Suffolk Construction Company, Shawmut Design and Construction, Gilbane Building Company, and John Moriarty and Associates. We worked with the general contractors to identify pairs of worksites of similar size and phase of construction project, and one of each pair was randomly assigned to intervention or control condition using a random number generator. All study protocols and processes were approved by the Harvard Chan School's Institutional Review Board.

The All the Right Moves Intervention

The conceptual model (Figure 3.1) used to guide development of the All the Right Moves (ARM) intervention was adapted from the Center's overarching conceptual framework (Sorensen, McLellan et al. in review). Intervention components were delivered on intervention sites, while control sites only experienced data collection. The main component to Phase 1 of the ARM intervention was an ergonomics program which was delivered over an approximately eight week period, targeting organizational practices and physical job demands by creating a process to identify and control hazards on the job. The process consisted of several activities aimed at developing and reinforcing work practices: a pre-intervention site assessment, pre-task planning protocol, foremen training, and an inspection and communication protocol.

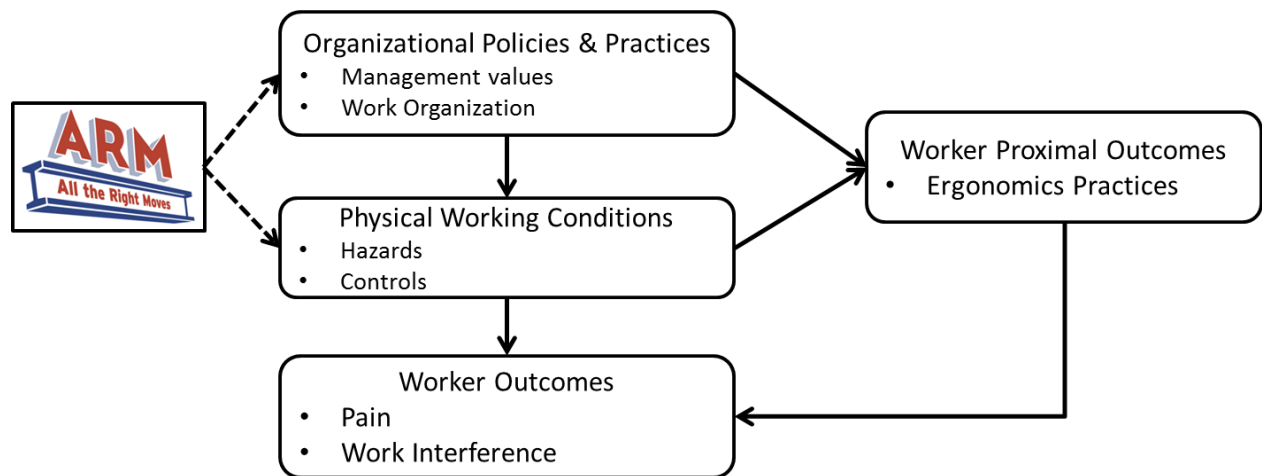


Figure 3.1. All the Right Moves intervention conceptual model. The intervention targets both the conditions of work and the proximal outcomes through a variety of intervention activities.

Pre-intervention site assessment: A walkthrough of the worksite was conducted by an ergonomics researcher, a research assistant, and the safety manager from the general contractor approximately one week prior to the kickoff of intervention activities. The purpose of the assessment was to identify the site-specific ergonomics hazards and solutions seen during the assessment. Pictures of hazards and solutions (e.g. correct workstation setup) were taken during the walk-through assessments. Having identified hazards and solutions from the worksites was important during the latter phase of foremen training because it enabled trainers to populate training materials with “real-time” photos of the worksite.

Pre-task planning protocol: Working with the general contractor’s safety manager, the intervention team then identified pre-task planning protocols that were used on site in order to incorporate them into the foremen training. Pre-task planning tools are commonly used in construction safety to assist in the planning and implementation of hazard controls (Liska, Goodloe et al. 1993, Abdelhamid 2000). The intervention team identified the existing pre-task planning tools on each worksite in order to use it as part of the foremen training. Specific worker

training was delivered through “tool box talks” or “safety stand-downs” (OSHA 2015) (full company break in normal work activities to discuss a safety concern).

Foremen training: The foremen training targeted the subcontractor company foremen and utilized pictures and examples that were observed during the pre-intervention site assessment. The curriculum consisted of training on ergonomics hazards and solutions and what to expect for the duration of the intervention. Training occurred during a portion of the mandatory weekly foremen meeting that was common among all sites involved in this study.

Inspection and communication protocol: To encourage the adoption of the identified ergonomic solutions, we employed a standard worksite walkthrough inspection and communication protocol that was based on the inspection protocol of our previous successful B-SAFE Program for construction sites that was an augmentation of the existing safety inspection and feedback process (Figure 3.2) (Sparer and Dennerlein 2013, Sparer, Herrick et al. 2015). The ARM intervention added specific ergonomics-related observations and formalized weekly feedback to the foremen.

Inspections were conducted weekly by the general contractor safety manager for a six week period following kickoff, documenting instances in which solutions were in place, noting better working conditions as well as instances when solutions were not in place, and reporting the results of the inspection to the foremen and workers. The inspection was documented through an internet-based inspection tool with the ability to aggregate and print a report with all observations for a given date range. Foremen received these reports and feedback at weekly foremen meetings and workers received feedback through posters placed in high-visibility areas on the worksite (i.e. on the wall near the hoist). The feedback posters included space for a “Tip of the Week” and other observations “Seen Onsite”. The “Tip of the Week” was one of the better

ergonomics solutions observed during the previous week. Two more observations were placed in the “Seen Onsite” section of the poster.

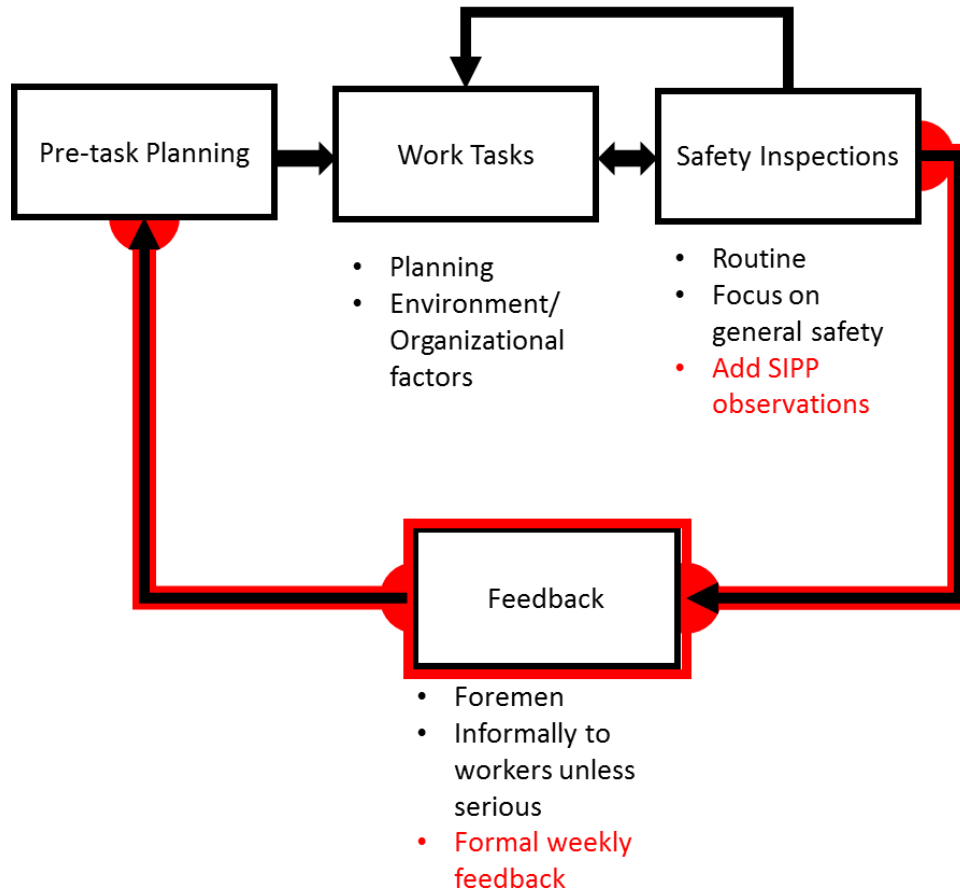


Figure 3.2. A flowchart of the ARM inspection and feedback process. This feedback loop is a part of usual practice for General Contractor safety managers. Everything in black could be considered usual practice for safety walkthroughs. The red depicts where ARM sought to add ergonomics observations to safety walkthroughs as well as a formal weekly feedback component during weekly foremen meetings.

Data collection

Data collection consisted of a baseline and a one month follow-up survey of workers, post-intervention focus groups with workers, and post-intervention key informant interviews with safety managers. All data collection occurred on site and all construction workers employed

on recruited worksites at the kickoff of the data collection period were eligible to participate in the study. Collection on all matched pairs occurred within three weeks of each other.

Baseline data collection: At each site, the general contractor's safety manager held a safety stand-down where the study and research team members were introduced to the entire worksite. Any workers who wished to enroll in the study were provided the opportunity to take the baseline survey at this time as well as at new worker safety orientations. These orientations are frequently held at commercial construction sites to accommodate the continuous flow of new workers. Data collection lasted for a six week time period following study kickoff.

Follow-up data collection: One month after baseline survey collection, we administered follow-up surveys to workers who filled out the baseline survey. Workers who did not take the follow-up survey were noted to be within one of three categories; left the site, refused participation, or could not be located.

Post-intervention focus groups: we conducted focus group interviews at seven of the ten worksites, involving 6 to 8 individuals per worksite. The objectives of the focus group interviews were to understand: 1) worker and foremen perceptions of health and safety on their worksites; 2) worker and foremen perceptions of intervention activities as they relate to them individually and as they related to the workplace; and 3) how safety and health were treated between and within general contractors as workers moved from site to site.

Post-Intervention interviews with general contractor safety managers: Key informant interviews were conducted with safety managers from the general contractors for seven of ten worksites. The objective was to identify barriers and facilitators to worker participation in the intervention and intervention delivery and to investigate ways that foremen

and site management were able to support worker participation, explore perceptions of the intervention, and identify areas for improvement for future interventions.

Outcome measures

Ergonomics practices were assessed using a modified organizational policies and practices questionnaire, developed to address organizational context in relation to injury claims and disability management (Amick, Habeck et al. 2000). Factor analysis revealed that the three items loaded onto one factor with a Cronbach's Alpha of 0.78 with an eigenvalue of 1.45. Responses were on a five point scale from "1 = strongly agree" to "5 = strongly disagree" and averaged to provide a measure of ergonomics practices. Responses were flipped so that higher ergonomics practices measures were representative of better ergonomics practices. Pain was assessed using multiple constructs, including recent (past three months) and current (last seven days) pain using a modified question from the Pro-Care Survey (NordicQ) (Kuorinka, Jonsson et al. 1987) and the adapted DASH questionnaire, (Hudak, Amadio et al. 1996) respectively. For both pain constructs, respondents were asked to indicate which body parts were in pain. Responses were recorded as either "yes" or "no" for each of six body parts unless respondents indicated "none of the above". Work interference due to pain was measured by the question, "In general how much did this pain interfere with your normal work?" which had five possible responses ranging from "not at all" to "extremely". Work interference was considered present when the individual responded "moderately", "quite a bit", or "extremely", rather than "not at all" or "a little bit". Musculoskeletal pain severity was also assessed during the past week using an adapted DASH questionnaire (Hudak, Amadio et al. 1996) based on pain location (i.e., in the low back; arm, shoulder, or hand pain; tingling in their arm, shoulder, or hand; pain in their legs

or knees; and pain in their feet); responses were on a five point scale from “0 = none” to “4 = extreme” and summed to provide a measure of pain severity during the past week with greater numbers indicating more pain. The surveys also collected a number of worker demographic characteristics including worker age, gender, race/ethnicity, trade, job status (e.g., foreman, journeyman), and years worked in current trade.

Statistical analyses

As a result of self-selection into the study, baseline differences between the intervention and control sites may have arisen, possibly leading to confounding. Therefore, we first compared worker demographics between control and intervention sites using Chi-squared tests of homogeneity for categorical variables and *t*-tests for continuous variables. We checked for baseline differences between intervention and control group in age, gender, job title, trade, race, and education. We then generated two fixed-effects linear regression models where the dependent variable was the difference in outcome measure between baseline and the one month follow-up surveys. Treatment status (intervention or control) was the independent variable. For the first model general contractor pair was included as a fixed effect, controlling for the differences between general contractors. For the second model, we used the same predictors as the first one but expanded the model to include worker age and trade. First-order interaction terms were used to assess effect modification, the validity of the multivariate models, and their assumptions. All quantitative analysis was performed using the SAS software package (SAS Institute, Cary, NC).

RESULTS

Study participation

At baseline, we surveyed all interested workers employed on the worksite who either attended new worker safety orientation or were present at the intervention kickoff (response rates: Intervention: 73% (n=227/307); Control: 80% (n=272/337)). Site C had the lowest kickoff participation rate 25% (n=10)) which was reflected by the poor break practices and the site having no centralized area for workers to take breaks. This site often worked straight through breaks in order to address production pressures and thus, workers and foremen were unable to participate in various aspects of the intervention. Site A had the highest kickoff participation rate (93% (n=74)) which can be attributed to each subcontractor having a private area for breaks. Kickoff consisted of individual safety stand-downs for each subcontractor within their private break areas. For comparison, Site B had a traditional safety stand-down where the whole site gathered in a common break area and had an 87% (n=20) kickoff participation (Table 3.1).

Table 3.1. Intervention delivery tracking.

Site	# of foremen at ergonomics training	Foremen training length (minutes)	# of ergonomics ^a observations	Baseline Participation (% and N)	
				Kickoff	Orientation
A	25	45	14	93% (74)	97% (30)
B	7	45	15	87% (20)	80% (20)
C	6	20	19	25% (10)	79% (15)
D	5	30	18	42% (8)	87% (26)
E	5	25	0	45% (9)	75% (15)

^aThe number of observations made by safety managers as part of the soft tissue injury prevention program.

Ergonomics program training and inspections

Ergonomics training was delivered to the foremen of the subcontractor companies that were on site at kickoff. Safety managers made approximately 4 observations per week for the duration of the ergonomics program and four of five intervention sites fully participated in the inspection and feedback process (Table 3.1). Site E did not have a single ergonomics observation and had the shortest amount of time allocated for foremen training, indicative of a lack of follow through from safety managers after kickoff.

Commercial construction worker survey results

We observed no significant differences between demographics on the intervention and control sites at baseline (Table 3.2). Our study population tended to be white males with an average age of 39.7 years. They were predominantly foremen or journeymen and roughly half went to vocational school while the other half went to at least some high school. The majority of workers were either in the mechanical trades or laborers.

Using fixed effects linear regression models, there was no significant intervention effect on the primary outcomes (Table 3.3). The first model adjusted only for general contractor pair to control for variability between general contractors. The second model includes trade and age in addition to general contractor pair.

Table 3.2. Selected characteristics of survey respondents by intervention condition: Frequency (and %) or mean (\pm standard deviation).

DEMOGRAPHICS	N	Intervention (N=128)	N	Control (N=91)	p-value
Age	127	39.7 (\pm 10.6)	91	39.7 (\pm 11.2)	0.9836
Gender					0.9188
Male	128	122 (95.3%)	91	87 (95.6%)	
Female	128	6 (4.7%)	91	4 (4.4%)	
Job Title					0.4064
General Foreman/Foreman	127	24 (18.9%)	90	15 (16.7%)	
Journeyman	127	67 (52.8%)	90	54 (60%)	
Apprentice	127	31 (24.4%)	90	15 (16.7%)	
Other	127	5 (3.9%)	90	6 (6.6%)	
Trade					0.2008
Laborer	127	36 (28.4%)	89	37 (41.6%)	
Mechanical	127	64 (50.4%)	89	40 (44.9%)	
Operator	127	0 (0%)	89	1 (1.1%)	
Finishing	127	10 (7.8%)	89	3 (3.4%)	
Ironworker	127	8 (6.3%)	89	3 (3.4%)	
Unknown/Other	127	9 (7.1%)	89	5 (5.6%)	
Race					0.1092
White	125	113 (90.4%)	91	75 (82.4%)	
Black	125	8 (6.4%)	91	7 (7.7%)	
Unknown/Other	125	4 (3.2%)	91	9 (9.7%)	
Education					0.9592
Some high school/High school or GED	127	71 (55.9%)	90	50 (55.6%)	
Vocational school/ Associate's degree or more	127	56 (44.1%)	90	40 (44.4%)	

Table 3.3. Results of fixed effects linear regression models.

Dependent Variable ^a	n	Model 1 ^b			Model 2 ^c		
		Estimate	Standard Error	p-value	Estimate	Standard Error	p-value
Ergonomics Practices	219	0.0855	0.1271	0.502	0.0847	0.1313	0.519
Pain Severity	209	0.0684	0.0911	0.454	0.0752	0.0942	0.426
Work Interference	193	-0.0099	0.0737	0.894	-0.0089	0.0761	0.907

^aDependent variable is the difference in outcome between baseline and the one month follow-up surveys.

^bModel 1: Independent variable is treatment status (control or intervention). Model also adjusted for General Contractor pairing.

^cModel 2: Same predictors as model 1. Also adjusted for trade and age.

Qualitative findings

Intervention implementation and data collection: Workers were happy to participate in intervention activities as long as their supervisors approved the time and it was during paid, working hours. They were generally less likely to complete surveys before the workday begins or during lunch or coffee break. Common reasons for difficulty administering surveys were the short time allotted for breaks and the necessity for relaxation during a strenuous work shift. One worker's perception on taking surveys:

“... the big difference is whether or not we can fill that survey out on company time or if you say take this home and do it yourself. Because that's going to bring your return way down. But if you give the guys a couple minutes...”

Making changes in the workplace: A key barrier was the capability of subcontractor companies to make changes. While the program trained the foreman of the subcontractors with a focus on pre-task planning, the subcontractors did not have the systems in place or the available

tools to assist in changing the working conditions. For example one safety manager observed that production pressure could be a driving factor:

“I think it’s the schedules... Because they rush around, it’s hard for them to take a step back and really evaluate how they’re doing things. They’re just trying to do it as quickly as possible.”

Buy-in and management support: Focus group participants and key informants all reported that programs needed buy-in and support from upper management for interventions to be successful. This was especially true with respect to training and data collection which, by necessity, must be conducted on the worksite during working hours. For instance, General Contractors could allow for extra training related to the ARM program and build it into the contracts of the subcontractors. To illustrate this point, one safety manager noted:

“A health and safety program would have a lot more buy-in and success on a site if it was written into the contract... An owner or GC would have to financially support the program running on their site.”

DISCUSSION

We developed and evaluated a worksite-based ergonomics intervention, implementing the intervention and collecting data on five pairs of commercial construction sites. We observed very non-significant intervention effect estimates on ergonomic practices ($p=0.502$), pain severity ($p=0.454$), and work interference due to pain ($p=0.894$).

Qualitative findings indicate that key challenges to intervention implementation were competing safety and production priorities and break practices leading to inconsistencies in intervention delivery. Production pressure and competing safety priorities would supersede the intervention delivery efforts. For example, smoking on worksites is often allowed up until the building is enclosed. When the worksite bans smoking inside of the structure, there are often instances where workers are found to be smoking inside the structure, incurring stiff penalties in the form of fines or shut downs of the worksite from the city fire department. On certain sites the break practices were more informal or possibly ignored in the face of mounting production pressure. On other sites, the breaks were taken at exact times and occurred in centralized locations on the worksite facilitating intervention delivery and data collection.

An overall barrier to intervention implementation and data collection was the capability of subcontractor companies to make changes to their worksite. Subcontractors did not have the systems in place or the available tools to assist in changing their working conditions, highlighting the need for ecologic system-level approaches that comprehensively address workplace systems relevant to the control of hazards and worker safety, health, and well-being.

We incorporated a strong focus on components from the ANSI Z10 standard, utilizing a Plan-Do-Check-Act model into the ergonomics program (ANSI/AIHA 2012). In this fashion, the ergonomics program sought to provide weekly feedback to foremen on the state of the physical

work environment. This feedback was informed by the inspections and the cycle was repeated on a weekly basis. This system allowed the program to continue to provide timely feedback that was appropriate to the dynamic changes in the physical work environment.

Additionally, wherever possible our protocol was designed to be flexible in order to accommodate the dynamic nature of the commercial construction industry. For example, our method for baseline surveying included attending new worker safety orientations to enroll interested workers in the study. These orientations were unpredictable and worksites did not know if there would be new workers until the workday started. As a consequence, study staff was on site every single work day in anticipation of these orientations, avoiding undue pressure on safety managers to provide advanced notice of safety orientations. Additionally, we designed the program to be able to address all trades on site at one time rather than a single trade or a single task within a trade allowing ARM to benefit more workers on a given worksite.

All intervention materials and activities were designed to utilize existing policies and practices wherever possible. For example, our inspection and feedback process augmented existing inspection and feedback activities that regularly occur on construction worksites adding specific ergonomics-related observations and formalized weekly feedback to the foremen (Figure 3.2). Additionally, all materials and activities were designed to be simple and easy to implement and understand. For example, the ergonomics inspection tool was internet-based so that safety managers would be able to upload inspections on smart phones and/or tablets from the field.

One limitation of this study is that our intervention depended on the participation of the general contractor safety managers, whose involvement and dedication to the study varied across sites and between general contractors. This aspect of the intervention was by design, it was important to design the intervention such that the ergonomics inspections were performed by the

safety managers. Giving the safety managers latitude to decide how invested they were in the program allowed order to assess the feasibility of the intervention being adopted without the aid of study staff. This would ensure that our observations were realistic and representative of barriers and facilitators to intervention delivery by non-study staff.

Another limitation is that this study involved worksites in commercial construction only. The results of our study may not be generalizable to other types of construction (i.e. residential or industrial). However, commercial construction accounts for a large portion of U.S. construction activities, and represents an important area for injury prevention research. Similarly, the construction workforce in the Boston Area may not be representative of commercial construction workers in other parts of the country or world where work practices, demographics, and union membership differ.

This study has several strengths, most notably the study design and the wide variety of general contractors and sites recruited into the study. The cluster randomized control trial design is a novel approach in commercial construction. Typically, approaches to improve the health and safety of construction workers have often focused on the individual worker, targeting workers when they are enrolled in apprentice programs,(Sokas, Emile et al. 2009, Weinstein and Hecker 2009) targeting workers through social media campaigns via posters at worksites and/or brochures sent to union members,(Strickland, Smock et al. 2015) and engineering controls for specific tasks(Rempel, Star et al. 2010). However, best practices involve system-level approaches that comprehensively address workplace systems relevant to the control of hazards and worker safety, health, and well-being (Sorensen, McLellan et al. 2013). This study was fortunate to be able to recruit four major general contractors operating in the Boston Area and gain access to ten different construction sites for the purpose of evaluating the ARM

intervention. Furthermore, delivering the intervention through mid-level managers (through a combination of the general contractor safety managers and subcontractor foremen) was a strength of the study. This focused intervention efforts on those who were in the best positions to make changes to the conditions of work.

The ergonomics inspection and communication protocol provides a method to identify broad areas for improving ergonomics in the dynamic construction work environment. It is important to understand the challenges and successes of intervention delivery in order to inform and improve future worksite-based interventions. It appears that the largest barriers to the success of the intervention was the inability of subcontractors to make changes to their worksite and the variability in the involvement and dedication to the study across different worksites and general contractors. Subcontractors did not have the systems in place or the available tools to assist in changing their working conditions and competing safety and production priorities influenced the level of management commitment to the study. Additionally, construction safety research may have broader implications for an increasing number of industries that are becoming as dynamic and variable as construction, as more services once housed in a single facility are outsourced to multiple employers (Weil 2014).

DISCUSSION

Major Findings:

- The inspection tool and process developed in Chapter One provided a structured method for recognizing hazards in the modifiable physical work environment and reporting both observations and recommendations to decision makers.
- Key challenges to the implementation of ergonomics interventions in commercial construction were competing safety and production priorities and break practices leading to inconsistencies in intervention delivery. A key barrier was the capability of subcontractor companies to make changes. It is important to understand the challenges and successes of intervention delivery in order to inform and improve future worksite-based interventions.
- Concurrent weekly safety inspections were significant predictors of safety climate while Safety inspections were not significant predictors of safety climate measured one week after the inspection demonstrating the ever-changing conditions of work in construction.

The overall goal of this dissertation was to understand the role of safety inspections in workplace interventions and associations with safety climate in dynamic and physically demanding industries. It sought to understand the utility of inspections of the physical work environment in implementing and evaluating workplace interventions in the dynamic settings of healthcare and commercial construction designed to improve worker safety, health, and wellbeing. This dissertation also wanted to understand how inspections of the physical work environment are related to safety climate in commercial construction. Understanding the utility of inspections in the context of workplace interventions will help to improve the design of future workplace interventions, both in research and industry. Examining the relationship between safety inspections and safety climate will help facilitate new avenues of evaluating interventions in commercial construction through elucidating a new pathway for examining safety climate in this industry.

The inspection process detailed in Chapter One provided a structured method for recognizing hazards in the modifiable physical work environment and reporting both observations and recommendations to decision makers. The tool and process examined each patient care unit and generated a detailed report that was shared with occupational health and safety staff and unit leadership. Overall, the development and implementation of the inspection tool provided guidance to modify the physical work environment implementing ergonomic solutions. The tool allows for organizations to plan and prioritize ergonomic hazard abatement (e.g. resource allocation and tracking trends). Chapter One is a clear example that inspections of the physical work environment in an acute care hospital setting is a very feasible method for examining the physical work environment in a dynamic and physically demanding workplace.

In Chapter Two we observed positive, however, non-significant intervention effect estimates on ergonomic practices, pain severity, and work interference. Qualitative findings indicate that key challenges to intervention implementation were competing safety and production priorities and break practices leading to inconsistencies in intervention delivery. A key barrier was the capability of subcontractor companies to make changes. We were able to successfully develop, implement, and test a worksite-based ergonomics intervention on five pairs of commercial construction sites. The intervention developed from this research provides a step toward improving health outcomes for construction workers on a worksite-specific basis. It is important to understand the challenges and successes of intervention delivery in order to inform and improve future worksite-based interventions.

Chapter Three found that concurrent weekly safety inspections were significant predictors of safety climate in our unadjusted analysis as well as when controlling for B-SAFE treatment status. Safety inspections were not significant predictors of safety climate measured one week after the inspection demonstrating the ever-changing conditions of work in construction. These findings support the associations between the physical conditions of work (in terms of the presence of both controls and hazards) and safety climate indicating that these physical working conditions are an important aspect of improving safety climate in dynamic work environments. The innovative research presented here makes an important contribution to the study of safety interventions and safety climate research. The potential impact is great for both research and the construction industry if safety climate is indeed predicted by safety inspections. The need for extensive surveying to evaluate worksite interventions can be replaced by an inspection process that occurs regularly on construction sites. This benefits researchers as well as the industry in general by reducing the burden on organizations and researchers to

implement and evaluate safety interventions while returning to first principles of injury prevention with a focus on hazard identification.

The dynamic work environment

The importance of the dynamic nature of the work environment with respect to understanding the utility of inspections in workplace interventions cannot be understated. This dissertation has shown that there are a number of factors that change over time in both healthcare and commercial construction. These worksites see changes in terms of the composition of the workforce, the hazards and controls present in the workplace, and the safety climate of the workers on these worksites.

Weekly safety inspections and concurrent weekly safety climate measurements were the key to understanding that commercial construction is very dynamic and that safety climate is highly related to the physical work environment. Inspections were essential in this process in order to quantify the presence of controls on commercial construction sites. The dynamic nature of construction requires nearly continuous monitoring of the physical work environment.

Similarly, when it comes to ergonomics interventions in commercial construction, due diligence is required in order to effectively and sustainably implement ergonomics solutions on the worksite. Given the dynamic nature of the hazards, workers should be encouraged to change their workstations often. In fact, workers need to continually reassess their surroundings in order to perform any of their day to day work, planning for safety and productivity.

Ergonomics in healthcare

The developed inspection tool and process identifying modifiable aspects of acute care hospital patient care units to prevent work related MSDs will contribute to the lack of practical resources for evaluating ergonomic risk factors in dynamic, physically demanding healthcare jobs. The process can be utilized by other acute-care hospitals in order to recognizing hazards in the modifiable physical work environment and reporting both observations and recommendations to decision makers. The process allows for organizations to plan and prioritize ergonomic hazard abatement (e.g. resource allocation and tracking trends). This process can also aid in new intervention research by providing a method for evaluating and modifying the ergonomics of the physical work environment in physically demanding and dynamic healthcare settings.

Break practices in construction

The lessons learned from the successes and challenges of implementing a worksite-based ergonomics intervention on commercial construction sites will aid in generating new research questions in commercial construction safety and health research. Although we did not see a significant intervention effect for any of our primary outcomes, the barriers to implementation included inconsistent break practices and competing safety and production priorities. On certain sites the break practices were more informal or possibly ignored in the face of mounting production pressure. On other sites, the breaks were taken at exact times and occurred in centralized locations on the worksite.

One downfall of the intervention was that it was attempting to deliver programmatic activity to workers during their break times. Heading into the project our piloting and vetting process did not reveal that sites would have different break practices depending on site specific

characteristics. What is, in hindsight, glaringly obvious is that the specific characteristics of the worksite play a large role in how and where breaks are taken. Some sites had space for workers to congregate before work and during breaks. This was ideal for implementation given that almost all workers would be in this area during break times. Other sites had individual “shacks” set up for each individual subcontracting company. This was less ideal because it segregated the individual trades and forced study staff to have to cover more ground in the pursuit of data collection and intervention delivery. The least desirable break setup was when sites had neither a common area nor individual “shacks”. These sites often had workers simply taking breaks wherever they were in the building. This led to small pockets of workers scattered across the entire worksite which is not conducive to intervention delivery.

The ideal solution would be to leverage the general contractor to allow workers to participate in intervention activities and take surveys on company time. This was something that we heard from workers in focus groups as well as anecdotally throughout the entire project on virtually every worksite – most workers were not turning down the opportunity to participate due to any reason other than that the data collection or activity was happening during break time. The job itself is so physically demanding and dynamic that workers cherish their break time and are reluctant to give it up even when they report that they understand and agree that the purpose of the research is important and valuable.

Competing priorities

Similarly, competing safety and production priorities were another reason that intervention activities (including data collection) were interrupted or impeded. In this case there was something important to the general contractor that was superseding the efforts to deliver the

intervention. For example, smoking on worksites is often allowed up until the building is enclosed. Many worksites start as empty lots and are essentially an outdoor workplace for much of the beginning of a project. When the worksite bans smoking inside of the structure, there are often instances where workers are found to be smoking inside the structure. The rationale for this behavior is irrelevant in this case. What is important to note is that smoking violations carry hefty penalties from organizations like the Boston Public Health Commission. It was reported informally to study staff that the Boston Public Health Commission along with the Boston Fire Department were able to levy fines and even shut down a construction site when violations were reported or discovered. A fire can also be catastrophic at that stage since the majority of the building envelope is complete. A fire would destroy progress made as well as force demolition and re-building of certain parts of the structure.

The solution here is unclear at this time. Perhaps, similar to the break practice solution, there is a way to cement the intervention into the policies of the worksite. If there is scheduled time where workers are required to participate in intervention activities (data collection would still have to be voluntary) then there would be very little chance that competing priorities would interfere. Making the intervention activities a priority on the worksite would effectively combat the tendency to side step intervention activities when other priorities emerged.

Changing intervention focus

Another way to utilize the lessons learned from the All the Right Moves intervention is to adjust the scope and focus of this type of intervention. A key barrier to intervention implementation and adoption was the capability of subcontractor companies to make changes in the workplace. This was attributable to a number of factors including the timing of the

intervention, break practices, and management buy-in. In order to work for a particular general contractor on a jobsite, subcontractors must bid on the project. That is, individual subcontractors place competitive bids on how much they would charge to complete the identified scope of the project. At the time that the intervention was implemented, bidding for the subcontractors had ended which did not allow subcontractor companies to change their work practices. Bids typically take into account the cost of labor and equipment.

Some of the ergonomics solutions proposed by the intervention would take time to implement and could potentially involve purchasing new equipment. Even though the solutions were designed to be easy and cheap to implement, some companies were hesitant to take even a small amount of extra time to reconfigure a workstation. Thus, the strategy moving forward would be to run this type of an intervention through the individual subcontracting companies rather than the general contractors. This would allow the research team to provide trade-specific recommendations to the subcontractors and allow the companies to adjust their bids according to their new work practices in order to account for extra time (if any) and additional equipment to help alleviate the MSD burden placed on workers in this industry.

Safety climate in commercial construction

It is clear from the results of this dissertation that the physical conditions of work are associated with safety climate. This relationship was shown on six commercial construction sites and addresses one of the major criticisms of initiatives to improve safety climate – that safety climate is not associated with the physical hazards in the workplace and is more likely associated with worker safety performance, knowledge, and motivation. The dynamic setting of commercial construction allowed us to test whether there was an association between the physical hazards in

the workplace (presence of hazards and controls) with safety climate. Since the commercial construction worksite is so dynamic and the hazards and controls are essentially constantly changing, our analyses allowed us to examine the relationship as well as the effect of lagging the data. We were able to show that safety climate was associated with the conditions of the physical work environment. Future direction with this work should include researchers and practitioners alike returning to first principles of injury prevention with a focus on hazard identification and control.

Safety climate may be a more global, all-encompassing metric that is influenced by many factors in the workplace. These factors include various OPPs (including the use of inspections), hazards and controls on the worksite, individual worker behaviors, knowledge, and motivation. Rather than targeting safety climate itself, perhaps companies should be instead targeting the factors that influence the construct of safety climate. Based on this dissertation, it appears that one of the ways in which safety climate is articulated is through the presence of hazards on the worksite. OSHA's General Duty Clause states that employers "shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees". The primary directive of health and safety personnel should be to uphold that clause. By identifying and controlling hazards in the workplace we can control some of the many factors that influence safety climate (OPPs and hazard identification and control). Programs like Predictive Solutions, an online data inspection management program (Industrial Scientific, Oakdale, PA, <http://www.predictivesolutions.com/solutions/SafetyNet/>) measure controls and inform employers when they are doing things right by controlling hazards on the worksite. An inspection protocol like Predictive Solutions gives the user a quantifiable number about how well

a site is controlling hazards. Overall, this process is much simpler and easier to implement in dynamic work environments than trying to target safety climate. Safety climate is more proximal to the real cause of workplace injuries – the presence of hazards.

APPENDIXES

APPENDIX A

Appendix A: Ergonomics Inspection Tool.

Ergonomics Inspection Tool

Unit: _____ **Date Completed:** _____ **Inspector:** _____

After reading each location and the hazard description, select the number in the corresponding cell that most accurately represents how the hazard applies to the area of the unit. Specific notes can and should be added for each location, including room numbers and description of issues for each observation.

I. Housekeeping

Location	Hazard Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
Patient Rooms	Patient rooms should be free of slip, trip, and fall (STF), struck by/against, and collision hazards. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> <i>Cables, straps and cords (electrical, telephone, medical, etc) should be organized and managed to appropriately mitigate STF hazards.</i> 						
	<ul style="list-style-type: none"> <i>Equipment (patient handling equipment, trash/linen boxes, sharps containers, biohazard boxes, etc) should be out of the way of the PCW (against the wall, moved to a storage area, etc) to reduce STF and struck by/ against and collision hazards.</i> 						
	<ul style="list-style-type: none"> <i>The floor should be clear of debris (pens, paper, screws, small equipment like syringes, caps, etc) to reduce STF hazards.</i> 						
Notes							

Location	Hazard Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
Storage Areas	Storage Areas should be free of slip, trip, and fall (STF), struck by/against, and collision hazards. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> Equipment is stored in demarcated areas (out of the way on the sides of the hallway or in a designated area) to reduce struck by/against and collision hazards. 						
	<ul style="list-style-type: none"> Equipment (patient handling equipment, trash/linen boxes, sharps containers, biohazard boxes, etc) should be out of the way of the PCW (against the wall, on shelving, etc) to reduce STF and struck by/ against and collision hazards. 						
	<ul style="list-style-type: none"> Cables, Straps and cords for equipment should be secured or tucked away to reduce STF hazards. 						
	<ul style="list-style-type: none"> The floor should be clear of debris (pens, paper, screws, small equipment like syringes, caps, etc) to reduce STF hazards. 						
Notes							
Nurses' Workstations	Nurses' Workstations should be free of slip, trip, and fall (STF), struck by/against, and collision hazards. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> Cables, straps and cords (electrical, telephone, medical, etc) should be organized and managed to appropriately mitigate STF hazards. 						
	<ul style="list-style-type: none"> Equipment (patient handling equipment, trash/linen boxes, sharps containers, biohazard boxes, etc) should be out of the way of the 						

Location	Hazard Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
	<p><i>PCW (against the wall, moved to a storage area, etc) to reduce STF and struck by/ against and collision hazards.</i></p> <ul style="list-style-type: none"> <i>The floor should be clear of debris (pens, paper, screws, small equipment like syringes, caps, etc) to reduce STF hazards.</i> 						
Notes							
Other	<p>When performing the assessment, were there any additional housekeeping hazards/concerns noticed on the unit?</p> <ul style="list-style-type: none"> 						

II. Awkward Postures

Location	Hazard Description	Does not apply at	Somewhat	Frequently	Often	Almost Always	Fully Applies
Patient Rooms	Patient rooms should be free of Musculoskeletal Disorder (physical) hazards involving posture, lifting, pushing and pulling. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> • <i>Sharps boxes should be within easy reaching access and between knee and shoulder height for PCW to avoid MSD posture related injuries.</i> 						
	<ul style="list-style-type: none"> • <i>Equipment heavier than a gallon of milk should be within shoulder to knee height to reduce MSD lifting hazards.</i> 						
	<ul style="list-style-type: none"> • <i>Supplies should be readily accessible and within knee to shoulder height whenever possible to reduce MSD posture hazards.</i> 						
	<ul style="list-style-type: none"> • <i>Electrical outlets should be between knee and shoulder height and not at floor level if they are used more frequently than once a week to reduce MSD posture hazards.</i> 						
	<ul style="list-style-type: none"> • <i>A good footstool or other height assistance with good tread and locking wheels should be available to reach overhead work to help keep movements within shoulder to knee area.</i> 						
Notes							
Hallways	Hallways should be free of Musculoskeletal Disorder (physical) hazards involving posture, lifting, pushing and pulling. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> • <i>Equipment is regularly maintained to promote easier pushing and pulling to reduce MSD push/pull hazards.</i> 						
	<ul style="list-style-type: none"> • <i>A step stool or other height assistance should be available to reach cabinet storage to reduce overhead work and help keep movements within shoulder to knee area.</i> 						

Location	Hazard Description	Does not apply at	Somewhat	Frequentl y	Often	Almost Always	Fully Applies
Notes							
Storage Areas	<p>Storage Areas should be free of Musculoskeletal Disorder (physical) hazards involving posture, lifting, pushing and pulling. This includes but is not limited to:</p> <ul style="list-style-type: none"> • <i>Equipment heavier than a gallon of milk should be within shoulder to knee height to reduce MSD lifting hazards.</i> • <i>Supplies should be readily accessible and within knee to shoulder height whenever possible to reduce MSD posture hazards.</i> • <i>Electrical outlets should be between knee and shoulder height and not at floor level to reduce MSD posture hazards.</i> • <i>A safe step stool or other height assistance should be available to reach higher storage to reduce overhead work and help keep movements within shoulder to knee area.</i> • <i>The lightest items should be stored below and above the knee to shoulder zone to reduce MSD posture and lifting hazards.</i> 	0	1	2	3	4	5
Notes							
Computer Workstations	<p>Nurses' Workstations should be free of Musculoskeletal Disorder (physical) hazards involving posture, lifting, pushing and pulling. This includes but is not limited to:</p>	0	1	2	3	4	5
Computer workstations can	<ul style="list-style-type: none"> • <i>Chairs should be adjustable with arm rest supports to reduce MSD posture hazards.</i> 						

Location	Hazard Description	Does not apply at	Somewhat	Frequentl y	Often	Almost Always	Fully Applies
be anywhere – patient rooms, halls, central nursing stations, medication rooms	<ul style="list-style-type: none"> • <i>Workstations should be adjustable wherever possible (computers, height of workstation, space to move keyboard and mouse, etc) to reduce MSD posture hazards.</i> 						
	<ul style="list-style-type: none"> • <i>Equipment should be easily accessible to reduce MSD posture hazards.</i> 						
	<ul style="list-style-type: none"> • <i>Electrical outlets that are frequently accessed should be between knee and shoulder height and not at floor level to reduce MSD posture hazards.</i> 						
	<ul style="list-style-type: none"> • <i>The mouse is located next to the keyboard.</i> 						
	<ul style="list-style-type: none"> • <i>The leg wells are clear.</i> 						
	<ul style="list-style-type: none"> • <i>The monitor is directly in front of the user.</i> 						
	<ul style="list-style-type: none"> • <i>Workstations on wheels have designated recharging stations with outlets between knee and shoulder height.</i> 						
Notes							
Other	When performing the assessment, were there any additional awkward posture hazards/concerns noticed on the unit? <ul style="list-style-type: none"> • 						

III. Safe Patient Handling and Mobilization

Location	Hazard Description	Does not apply at	Somewhat	Frequently	Often	Almost Always	Fully Applies
Patient Rooms	Patient rooms should be free of MSD (physical) hazards related to lifting, pushing, pulling, and twisting during SPH and mobilization activities. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> • <i>There are ceiling lifts in the rooms to reduce MSD lifting, push/pull, and twisting hazards.</i> 						
	<ul style="list-style-type: none"> • <i>There is patient access on both sides of the bed to reduce awkward postures.</i> 						
Notes							
Storage Areas	Storage Areas will not have SPH and Mobilization tasks. This section should focus on the availability of SPH and Mobilization equipment. The purpose for all of the following equipment is to MSD lifting, push/pull, and twisting hazards. This includes but is not limited to:	0	1	2	3	4	5
	<ul style="list-style-type: none"> • <i>Adequate numbers, types, and sizes of slings for ceiling lifts to reduce MSD lifting, push/pull, and twisting hazards associated with SPH and mobilization.</i> 						
	<ul style="list-style-type: none"> • <i>Adequate numbers of slide boards with attached guidelines indicating proper usage to reduce MSD push/pull, and twisting hazards associated with SPH and mobilization.</i> 						
	<ul style="list-style-type: none"> • <i>Sit to stand, walking aids, etc to reduce MSD lifting, push/pull, and twisting hazards associated with SPH and mobilization.</i> 						
Notes							

Location	Hazard Description	Does not apply at	Somewhat	Frequentl y	Often	Almost Always	Fully Applies
Other	When performing the assessment, were there any additional SPH and Mobilization hazards/concerns noticed on the unit? <ul style="list-style-type: none"> • <i>Slings and types clearly labeled?</i> • <i>Storage easily accessible?</i> 						

APPENDIX B

Appendix B: Unit Management Interview Guide.

Unit Management Interview Guide

Unit: _____ **Date Completed:** _____ **Inspector:** _____

This guide is meant to be used on the day of the inspection during a pre-walkthrough meeting. Notes regarding effectiveness, utility, and general feelings about each statement should be taken. After reading each statement/description, select the number in the corresponding cell that most accurately represents how the statement applies to the unit.

I. Programmatic Activities

Statement/Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
The unit has effective policies to manage safe patient handling and mobilization. This can refer to a written or unwritten policy on the unit that leads to avoiding safe patient handling (SPH) injuries and incidents. Might be a policy requiring the use of SPH assist devices or a culture within the unit of commitment to injury-free SPH and Mobilization.	0	1	2	3	4	5
Notes						
Mesh repositioning slings under all patients that cannot boost, turn, or sit-up without assistance (unless it is medically contraindicated).	0	1	2	3	4	5
Notes						
Room types do not change across the unit. Private vs. semi private, shape, layouts are similar in the unit. Please explain if they're different and how. Include numbers if possible.	0	1	2	3	4	5
Notes						
How often does a customer service call need to be made from the unit to material management because a sling is not available?	0	1	2	3	4	5
Notes						

Statement/Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
Patient care workers (PCWs) feel comfortable and knowledgeable about reporting injuries. Ideally the PCWs should know where and how to report their injuries. Management should encourage them to	0	1	2	3	4	5
Notes						
The unit performs a needs assessment to determine SPH and M needs. For each patient, there is a pre-handling/mobilization assessment performed by the PCW to determine the appropriate handling and mobilization techniques should be applied for a given situation.	0	1	2	3	4	5
Notes						
There are effective training practices on the unit. This refers to overall perception of training on the unit. PCWs should feel knowledgeable of policies and procedures on the unit.	0	1	2	3	4	5
Notes						
Cord and cable management is not an issue on the unit. This is getting at whether there are any concerns regarding cable management from the point of view of the PCWs. Ideally, the PCWs would feel comfortable that cables are appropriately managed to avoid STF injuries. Management of cables includes streamlining the cables and keeping them against the wall, out of the areas frequented by PCWs, patients, and other personnel.	0	1	2	3	4	5
Notes						
The unit has an effective policy surrounding spill cleanup. This can refer to a written or unwritten policy on the unit that leads to avoiding incidents related to spills. An effective policy would involve immediate cleanup of spills and include a positive attitude of management when work stops to clean up spills.	0	1	2	3	4	5
Notes						
Do any of your answers vary by time of day (shift)?	0	1	2	3	4	5
Notes						

Statement/Description	Does not apply at all	Somewhat	Frequently	Often	Almost Always	Fully Applies
Do you have any concerns regarding injuries and work limitations for new and/or temporary employees?	0	1	2	3	4	5
Notes						
What would you say is the most physically demanding job? Not necessarily heavy lifting- could also be repetitive or fine motor focused.	0	1	2	3	4	5
Notes						
Other concerns raised by Occupational Health/PCWs	0	1	2	3	4	5
Notes						

APPENDIX C

Appendix C: Nine item safety climate scale modified from Dedobbeleer and Beland (1991).

1. How important do you think workers' safety practices are to this site's general contractor/construction management company?
 - a. 0 = Not at all important
 - b. 3.33 = Somewhat important
 - c. 6.67 = Very important
 - d. 10 = Extremely important

2. How much do supervisors and other top management seem to care about your safety?
 - a. 0 = None
 - b. 2.5 = A little
 - c. 5 = Some
 - d. 7.5 = A good amount
 - e. 10 = A great deal

3. As a foreman, how much emphasis does your immediate supervisor place on safety practices on the job?
 - a. 0 = None
 - b. 2.5 = A little
 - c. 5 = Some
 - d. 7.5 = A good amount
 - e. 10 = A great deal

4. When you started at this worksite, were you given instructions on the safety policy and safety requirements of this site's general contractor/construction management company
 - a. 0 = No
 - b. 10 = Yes

5. How often are job safety meetings held at this worksite?
 - a. 0 = Never
 - b. 2.5 = Only when there had been an accident
 - c. 5 = Once a week
 - d. 7.5 = Several times a week
 - e. 10 = Everyday

6. How often is the proper equipment for your tasks available at this worksite?
 - a. 0 = Never
 - b. 2.5 = Rarely
 - c. 5 = Sometimes
 - d. 7.5 = Usually
 - e. 10 = Always

7. How much control do feel you have over what happens to your safety on the job?
 - a. 0 = None
 - b. 2.5 = A little
 - c. 5 = Some
 - d. 7.5 = A good amount
 - e. 10 = A great deal
8. How often do you feel you have to take risks to get the job done?
 - a. 0 = Always
 - b. 2.5 = Usually
 - c. 5 = Sometimes
 - d. 7.5 = Rarely
 - e. 10 = Never
9. How likely do you think it is that you might be injured on the job in the next 12 months?
 - a. 0 = Very likely
 - b. 3.33 = Somewhat likely
 - c. 6.67 = Not very likely
 - d. 10 = Not at all likely

BIBLIOGRAPHY

Abdelhamid, J. G. (2000). "Identifying root causes of construction accidents " Journal of Construction Engineering and Management **126**(1): 52-60.

Amick, B. C., R. V. Habeck, A. Hunt, A. H. Fossel, A. Chapin, R. B. Keller and J. N. Katz (2000). "Measuring the impact of organizational behaviors on work disability prevention and management." Journal of Occupational Rehabilitation **10**(1): 21-38.

ANSI/AIHA (2012). Z10 Occupational Health and Safety Management Systems. Falls Church.

Baumann, A., D. L. Holness, P. Norman, D. Idriss-Wheeler and P. Boucher (2012). "The Ergonomic Program Implementation Continuum (EPIC): Integration of health and safety-A process evaluation in the healthcare sector." Journal of safety research **43**(3): 205-213.

Borsting Jacobsen, H., A. Caban-Martinez, L. C. Onyebeke, G. Sorensen, J. T. Dennerlein and S. Endresen Reme (2013). "Construction Workers Struggle With a High Prevalence of Mental Distress, and This Is Associated With Their Pain and Injuries." J Occup Environ Med.

Burdorf, A., E. Koppelaar and B. Evanoff (2013). "Assessment of the impact of lifting device use on low back pain and musculoskeletal injury claims among nurses." Occupational and environmental medicine **70**(7): 491-497.

Bureau of Labor Statistics (2006) "Occupational Injuries, Illnesses, and Fatalities among Nursing, Psychiatric, and Home Health Aides, 1995-2004." <http://www.bls.gov/opub/mlr/cwc/occupational-injuries-illnesses-and-fatalities-among-nursing-psychiatric-and-home-health-aides-1995-2004.pdf>."

Bureau of Labor Statistics. (2013). "Number, incidence rate, and median days away from work for nonfatal occupational injuries and illnesses involving days away from work and musculoskeletal disorders by selected worker occupation and ownership, 2013." <http://www.bls.gov/news.release/osh2.t18.htm>."

Bush, D. M. and R. N. Lipari (2015). Substance Use and Substance Use Disorder by Industry. The CBHSQ Report: Short Report. Washington, DC, Substance Abuse and Mental Health Services Administration.

Caspi, C. E., J. T. Dennerlein, C. Kenwood, A. M. Stoddard, K. Hopcia, D. Hashimoto and G. Sorensen (2013). "Results of a Pilot Intervention to Improve Health and Safety for Health Care Workers." Journal of Occupational and Environmental Medicine **55**(12): 1449-1455
1410.1097/JOM.1440b1013e3182a1447e1465a.

Cigularov, K. P., P. Y. Chen and J. Rosecrance (2010). "The effects of error management climate and safety communication on safety: a multi-level study." Accid Anal Prev **42**(5): 1498-1506.

Clarke, S. (2000). "Safety culture: under-specified and overrated?" International Journal of Management Reviews **2**(1): 65-90.

Cohen, A. (1997). "Elements of ergonomics programs: a primer based on workplace evaluations of musculoskeletal disorders." DHHS (NIOSH) publication (USA).

Colley, S. K., J. Lincolne and A. Neal (2013). "An examination of the relationship amongst profiles of perceived organizational values, safety climate and safety outcomes." Safety science **51**(1): 69-76.

CPWR (2013). The Construction Chart Book. Silver Springs, MD, The Center for Construction Research and Training.

de Zwart, B. C., M. H. Frings-Dresen and J. C. van Duivenbooden (1999). "Senior workers in the Dutch construction industry: a search for age-related work and health issues." Exp Aging Res **25**(4): 385-391.

Dedobbeleer, N. and F. Beland (1991). "A Safety Climate Measure for Construction Sites." Journal of Safety Research **22**(2): 97-103.

Dedobbeleer, N. and F. Béland (1991). "A safety climate measure for construction sites." Journal of Safety Research **22**(2): 97-103.

Dennerlein, J. T., M. P. Grant, J. Rodgers, J. Manjourides and C. A. Okechukwu (2016 (Submitted)). Physical Job demands are associated with smoking and pain in construction workers. PREMUS 2016 -- International Conference on the prevention of work related musculoskeletal disorders, Toronto, International Commission on Occupational Health. .

Dennerlein, J. T., K. Hopcia, G. Sembajwe, C. Kenwood, A. M. Stoddard, T. H. Tveito, D. M. Hashimoto and G. Sorensen (2012). "Ergonomic practices within patient care units are associated with musculoskeletal pain and limitations." American journal of industrial medicine **55**(2): 107-116.

DePasquale, J. P. and E. S. Geller (2000). "Critical success factors for behavior-based safety: A study of twenty industry-wide applications." Journal of Safety Research **30**(4): 237-249.

Dunlop, J. T. (1961). The Industrial Relations System in Construction. The Structure of Collective Bargaining. A. Weber. Chicago, IL, University of Chicago Press: 255-277.

Fang, D. and H. Wu (2013). "Development of a Safety Culture Interaction (SCI) model for construction projects." Safety science **57**: 138-149.

Forde, M. S., L. Punnett and D. H. Wegman (2005). "Prevalence of musculoskeletal disorders in union ironworkers." J Occup Environ Hyg **2**(4): 203-212.

Gibson, J. J. (1961). "The contribution of experimental psychology to the formulation of the problem of safety—a brief for basic research." Behavioral approaches to accident research: 77-89.

Griffin, M. A. and A. Neal (2000). "Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation." Journal of occupational health psychology **5**(3): 347.

Haro, E. and B. M. Kleiner (2008). "Macroergonomics as an organizing process for systems safety." Applied Ergonomics **39**(4): 450-458.

HarvardConstructionSafetyGroup (2010). "Harvard University Owner's Manual: Predictive Solutions."

Hinze, J., M. Hallowell and K. Baud (2013). "Construction-Safety Best Practices and Relationships to Safety Performance." Journal of Construction Engineering and Management **139**(10): 04013006.

Holtermann, A., O. S. Mortensen, H. Burr, K. Sogaard, F. Gyntelberg and P. Suadicani (2010). "Physical demands at work, physical fitness, and 30-year ischaemic heart disease and all-cause mortality in the Copenhagen Male Study." Scand J Work Environ Health **36**(5): 357-365.

Hopcia, K., J. T. Dennerlein, D. Hashimoto, T. Orechia and G. Sorensen (2012). "Occupational injuries for consecutive and cumulative shifts among hospital registered nurses and patient care associates: a case-control study." Workplace Health Saf **60**(10): 437-444.

Hudak, P. L., P. C. Amadio and C. Bombardier (1996). "Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG)." Am J Ind Med **29**(6): 602-608.

Industries, W. S. D. o. L. "Evaluation Tools." Training & Prevention - Sprains & Strains, from <http://www.lni.wa.gov/safety/SprainsStrains/tools/default.asp>.

Janowitz, I. L., M. Gillen, G. Ryan, D. Rempel, L. Trupin, L. Swig, K. Mullen, R. Rugulies and P. D. Blanc (2006). "Measuring the physical demands of work in hospital settings: Design and implementation of an ergonomics assessment." Applied ergonomics **37**(5): 641-658.

Jorgensen, E., R. K. Sokas, L. Nickels, W. Gao and J. L. Gittleman (2007). "An English/Spanish safety climate scale for construction workers." Am J Ind Med **50**(6): 438-442.

Kaskutas, V., A. M. Dale, H. Lipscomb and B. Evanoff (2013). "Fall prevention and safety communication training for foremen: report of a pilot project designed to improve residential construction safety." J Safety Res **44**: 111-118.

Kim, S. S., C. A. Okechukwu, J. T. Dennerlein, L. I. Boden, K. Hopcia, D. M. Hashimoto and G. Sorensen (2014). "Association between perceived inadequate staffing and musculoskeletal pain among hospital patient care workers." Int Arch Occup Environ Health **87**(3): 323-330.

Koppelaar, E., J. Knibbe, H. Miedema and A. Burdorf (2013). "The influence of individual and organisational factors on nurses' behaviour to use lifting devices in healthcare." Applied ergonomics **44**(4): 532-537.

Kuorinka, I., B. Jonsson, A. Kilbom, H. Vinterberg, F. Biering-Sorensen, G. Andersson and K. Jorgensen (1987). "Standardized Nordic Questionnaires for the analysis of musculoskeletal symptoms." Applied Ergonomics **18**: 233-237.

Lee, D. J., L. E. Fleming, K. L. Arheart, W. G. LeBlanc, A. J. Caban, K. Chung-Bridges, S. L. Christ, K. E. McCollister and T. Pitman (2007). "Smoking rate trends in U.S. occupational groups: the 1987 to 2004 National Health Interview Survey." J Occup Environ Med **49**(1): 75-81.

Lingard, H. and S. Rowlinson (1998). "Behavior-based safety management in Hong Kong's construction industry." Journal of Safety Research **28**(4): 243-256.

Liska, R. W., D. Goodloe and R. Sen (1993). Zero accident techniques: A report to the Construction Industry Institute. Austin, Texas, Construction Industry Institute.

Manu, P., N. Ankrah, D. Proverbs and S. Suresh (2013). "Mitigating the health and safety influence of subcontracting in construction: The approach of main contractors." International Journal of Project Management **31**(7): 1017-1026.

Manuele, F. A. (2006). "ANSI/AIHA Z10-2005: The new benchmark for safety management systems." Professional Safety **51**(2): 25.

McDonald, M. A., H. J. Lipscomb, J. Bondy and J. Glazner (2009). "'Safety is everyone's job:' The key to safety on a large university construction site." Journal of Safety Research **40**(1): 53-61.

Medicine, I. o. and N. R. Council (2001). Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington, DC, The National Academies Press.

Mischke, C., J. Verbeek, J. Job, T. Morata, A. Alvesalo-Kuusi, K. Neuvonen, S. Clarke and R. Pedlow (2013). "Inspections to prevent occupational diseases and injuries."

Myers, D. J., J. M. Nyce and S. W. Dekker (2014). "Setting culture apart: Distinguishing culture from behavior and social structure in safety and injury research." Accident Analysis & Prevention **68**: 25-29.

Neal, A. and M. A. Griffin (2006). "A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels." Journal of applied psychology **91**(4): 946.

NIOSH (2008) "Essential Elements of Effective Workplace Programs and Policies for Improving Worker Health and Wellbeing." Worklife: A NIOSH Initiative.

NORA (2008). "National Occupational Research Agenda (NORA) Construction Sector Council." National Construction Agenda. Washington DC, National Institute for Occupational Safety and Health.

NRC/IOM, N. R. C. a. I. o. M. (2001). Musculoskeletal Disorders and the workplaces: Low Back and Upper Extremities. Washington, D.C, National Academy Press.

Okechukwu, C., N. Krieger, G. Sorensen, L. Yi and E. M. Barbeau (2009). "Massbuilt: Effectiveness of an Apprenticeship Site-Based Smoking Cessation Intervention for Unionized Building Trades Workers." Cancer Causes and Control **20**(6): 887-894.

Okechukwu, C. A., N. Krieger, G. Sorensen, Y. Li and E. M. Barbeau (2009). "MassBuilt: effectiveness of an apprenticeship site-based smoking cessation intervention for unionized building trades workers." Cancer Causes Control **20**(6): 887-894.

Okechukwu, C. A., K. Nguyen and N. J. Hickman (2010). "Partner smoking characteristics: Associations with smoking and quitting among blue-collar apprentices." Am J Ind Med **53**(11): 1102-1108.

OSHA. "Hospital eTool." eTools, 2015, from <https://www.osha.gov/SLTC/etools/hospital/>.

OSHA. "Safety & Health Management Systems eTool." Safety and Health Program Assessment Worksheet Retrieved 06 March 2014, from <https://www.osha.gov/SLTC/etools/safetyhealth/form33i.html>.

OSHA. (2012). "Injury and Illness Prevention Program: White Paper." Retrieved 7 December 2014, from <https://www.osha.gov/dsg/topics/safetyhealth/OSHAwhite-paper-january2012sm.pdf>.

OSHA. (2015). "National Safety Standdown -- Preventing Falls in Construction." from <https://www.osha.gov/StopFallsStandDown/faqs.html>.

Pransky, G. S., K. L. Benjamin and J. A. Savageau (2005). "Early retirement due to occupational injury: who is at risk?" Am J Ind Med **47**(4): 285-295.

Reme, S. E., J. T. Dennerlein, D. Hashimoto and G. Sorensen (2012). "Musculoskeletal pain and psychological distress in hospital patient care workers." J Occup Rehabil **22**(4): 503-510. PMID 3671916.

Rempel, D., D. Star, A. Barr and I. Janowitz (2010). "Overhead drilling: comparing three bases for aligning a drilling jig to vertical." J Safety Res **41**(3): 247-251.

Ringen, K. and E. J. Stafford (1996). "Intervention research in occupational safety and health: examples from construction." American journal of industrial medicine **29**(4): 314-320.

Sawacha, E., S. Naoum and D. Fong (1999). "Factors affecting safety performance on construction sites." International journal of project management **17**(5): 309-315.

Sembajwe, G., T. H. Tveito, K. Hopcia, C. Kenwood, E. T. O'Day, A. M. Stoddard, J. T. Dennerlein, D. Hashimoto and G. Sorensen (2013). "Psychosocial stress and multi-site

musculoskeletal pain: a cross-sectional survey of patient care workers." Workplace health & safety **61**(3): 117-125.

Sokas, R. K., J. Emile, L. Nickels, W. Gao and J. L. Gittleman (2009). "An intervention effectiveness study of hazard awareness training in the construction building trades." Public Health Rep **124 Suppl 1**: 160-168.

Sorensen, G., D. McLellan, J. Dennerlein, E. Nagler, D. Hurtado, N. Pronk, E. Sabbath and G. Wagner (in review). "Integrating Worksite Health Protection and Health Promotion: A Conceptual Model for Intervention and Research." Am J Public Health.

Sorensen, G., D. McLellan, J. T. Dennerlein, N. P. Pronk, J. D. Allen, L. I. Boden, C. A. Okechukwu, D. Hashimoto, A. Stoddard and G. R. Wagner (2013). "Integration of health protection and health promotion: rationale, indicators, and metrics." J Occup Environ Med **55**(12 Suppl): S12-18.

Sorensen, G., E. Nagler, D. Hashimoto, J. Dennerlein, J. Theron, A. Stoddard, O. Buxton, L. Wallace, C. Kenwood, C. Nelson, S. Tamers, M. Grant and G. Wagner (2015). "Implementing an integrated health protection/health promotion intervention in the hospital setting: Lessons learned from the Be Well, Work Well Study. ." J Occup Environ Med (**in press**).

Sparer, E. H. and J. T. Dennerlein (2013). "Determining safety inspection thresholds for employee incentives programs on construction sites." Safety Science **51**(1): 77-84.

Sparer, E. H., R. F. Herrick and J. T. Dennerlein (2015). "Development of a safety communication and recognition program for construction." New Solut **25**(1): 42-58.

Sparer, E. H., C. A. Okechukwu, J. Manjourides, R. F. Herrick, J. N. Katz and J. T. Dennerlein (2015). "Length of time spent working on a commercial construction site and the associations with worker characteristics." Am J Ind Med **58**(9): 964-973.

Stone, P. W., S. P. Clarke, J. Cimiotti and R. Correa-de-Araujo (2004). "Nurses' Working Conditions: Implications for Infectious Disease." Emerging Infectious Diseases **10**(11): 1984-1989.

Strickland, J. R., N. Smock, C. Casey, T. Poor, M. W. Kreuter and B. A. Evanoff (2015). "Development of targeted messages to promote smoking cessation among construction trade workers." Health Educ Res **30**(1): 107-120.

Szeto, G., T. Wong, R. Law, E. Lee, T. Lau, B. So and S. Law (2013). "The impact of a multifaceted ergonomic intervention program on promoting occupational health in community nurses." Applied ergonomics **44**(3): 414-422.

Weil, D. (2014). The fissured workplace : why work became so bad for so many and what can be done to improve it. Cambridge, MA, Harvard University Press.

Weinstein, M. and S. Hecker. (2009). "Diffusing Ergonomic Innovations in Construction." Retrieved 31 October 2010, from <http://orcehs.org/wiki/display/orcehs/Construction+Ergonomics>.

Welch, L. S., E. Haile, L. I. Boden and K. L. Hunting (2010). "Impact of musculoskeletal and medical conditions on disability retirement-a longitudinal study among construction roofers." Am J Ind Med **53**(6): 552-560.

Wu, T.-C., S.-H. Chang, C.-M. Shu, C.-T. Chen and C.-P. Wang (2011). "Safety leadership and safety performance in petrochemical industries: The mediating role of safety climate." Journal of Loss Prevention in the Process Industries **24**(6): 716-721.

Zhou, Q., D. Fang and S. Mohamed (2010). "Safety climate improvement: Case study in a Chinese construction company." Journal of Construction Engineering and Management **137**(1): 86-95.

Zohar, D. (1980). "Safety climate in industrial organizations: theoretical and applied implications." Journal of applied psychology **65**(1): 96.