www.cpwr.com • www.elcosh.org

CPWR

THE CENTER FOR CONSTRUCTION
RESEARCH AND TRAINING

Topics in Construction Safety and Health

Safety Culture and Safety Climate:

An Interdisciplinary Annotated Bibliography

CPWR - The Center for Construction Research and Training

2023

8484 Georgia Avenue
Suite 1000
Silver Spring, MD 20910

PHONE: 301.578.8500
FAX: 301.578.8572

©2023, CPWR-The Center for Construction Research and Training. All rights reserved. CPWR is the research and training arm of NABTU. Production of this document was supported by cooperative agreement OH 009762 from the National Institute for Occupational Safety and Health (NIOSH). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

Safety Culture and Safety Climate: An Interdisciplinary Annotated Bibliography

Abbe, O. O., et al. (2011). "Modeling the relationship between occupational stressors, psychosocial/physical symptoms and injuries in the construction industry." International Journal of Industrial Ergonomics 41(2): 106-117.

Injury statistics place the construction industry as a high-risk industry, making it necessary to investigate factors that influence accidents to be able to protect workers. Research was carried out to investigate the relationship existing among occupational stressors, psychological/physical symptoms and accident/injury and work days lost outcomes as experienced by manual workers engaged in a range of industrial construction occupations. Some of the occupational stressors significantly associated with self-reported and OSHA logged injuries were training, job certainty and safety climate of the company. The OSHA logged injuries were associated with the occurrence of headaches and feelings of tenseness on the job. These results imply that non-physical stressors should be included as a potential input associated with injuries in injury risk models for construction workers. Relevance to industry: Traditional approaches to workers' safety in the construction industry have focused on the physical and biomechanical aspects of work by improving tools, equipment and task completion methods. The impact of psychosocial factors, specifically stress as experienced by construction workers, is an area of growing research, which is yielding results that suggest overall work safety on the construction site should take into account psychosocial aspects of work. © 2010 Elsevier B.V.

Al-Bayati, A. J. (2021). "Firm Size Influence on Construction Safety Culture and Construction Safety Climate." Practice Periodical on Structural Design and Construction 26(4): 04021028.

Smaller construction firms represent the majority of US construction firms. The safety record of smaller construction firms indicates a lower safety performance and higher incident rates than those found in larger construction firms. Therefore, there is a need for a greater understanding of the challenges that prevent smaller construction firms from achieving higher safety performance levels. Understanding these challenges will help construction safety practitioners and policymakers provide the necessary interventions to improve overall construction site safety. Data were collected from 275 construction practitioners in the US, resulting in scores for safety culture, climate, and behavior. The results suggest a statistically significant positive correlation between firm size and construction safety culture, which represents the safety-related actions of upper management and safety personnel. Thus, interventions that aim to develop sustainable safety and health management systems for smaller construction firms are necessary. On the other hand, the study indicates no statistically significant correlation between firm size and the construction safety climate, which represents the safety-related actions of field personnel (frontline supervisors and workers). These findings contribute to the body of knowledge by providing a meaningful understanding of the interventions needed to improve the overall safety performance of smaller construction firms.

Al-Bayati, A. J. (2021). "Impact of Construction Safety Culture and Construction Safety Climate on Safety Behavior and Safety Motivation." Safety 7(2): 41.

The construction industry is known for its disappointing safety performance. Therefore, rethinking current safety management frameworks is crucial. This study assesses a newly proposed construction safety culture and climate framework that aims to overcome the present ambiguity in the definitions and measurement of construction safety culture and construction safety climate. The goal is to provide a practical construction safety culture and safety climate framework that fits the

construction industry's needs. A survey was designed to validate the proposed framework and assess its influence on safety behavior and safety motivation. The survey was completed by 275 construction practitioners. The findings suggest that the construction safety culture initiates and maintains the construction safety climate. Similarly, the construction safety culture, which is represented by the actions of upper management and safety personnel, significantly contributes to higher levels of safety behavior and safety motivation, whereas the construction safety climate does not. Accordingly, this study highlights the importance of the construction safety culture's influence on overall workplace culture. This study's contribution to the body of knowledge is critical to improving construction workplaces' overall safety performance. The findings can be strategically used by construction firms to address the construction industry's higher rates of fatal and nonfatal injuries. Finally, the results obtained support the newly proposed framework of construction safety culture and climate, which, in turn, helps the industry better manage overall site safety.

Al-Bayati, A. J., et al. (2017). "Reducing fatality rates of the Hispanic workforce in the U.S. Construction industry: Challenges and strategies." Journal of Construction Engineering and Management 143(3).

Recent government statistics have revealed a high rate of fatalities among Hispanic workers in the U.S. construction industry. This study investigates the root causes of this issue as well as the existing attempts to manage these causes effectively. Cultural barriers are one of the root causes that have not been fully explored. This detailed investigation expands into an exploration of cultural barriers and differences, variables that are directly attributable to construction site safety. A survey instrument was designed to evaluate the existence and influence of these differences at U.S. construction sites, and data were collected from construction supervisors across the United States. The results of the survey strongly suggest the existence of two differences: high power distance and collectivism cultural dimensions. Based on the survey results and feedback from construction supervisors, recommendations for best practices in workforce development that guides construction professionals and researchers are suggested. © 2016 American Society of Civil Engineers.

Albers, J. T., et al. (2014). "Residential building stakeholders' attitudes and beliefs regarding nail gun injury risks and prevention." New Solut 23(4): 577-605.

Pneumatic nail guns are ubiquitous at residential construction sites across the United States. These tools are noted for the traumatic injuries that can occur from their operation. Different trigger mechanisms on these tools are associated with different levels of risk. Residential building subcontractors and workers, both native-born and immigrant, were brought together in focus groups to discuss their attitudes and beliefs regarding risk factors for nail gun injury as well as barriers to the adoption of safer technology. Participants' comments are organized first by influences on traumatic injury occurrence or prevention and later by sociotechnical system category. Participants attributed influences on injury risk to personal and external causation factors in all sociotechnical system categories; however, participants more frequently described influences on injury prevention as related to workers' behaviors, rather than to external factors. A discussion of these influences with respect to attribution theory and sociotechnical models of injury causation is presented.

Arcury, T. A., et al. (2012). "Work safety climate and safety practices among immigrant Latino residential construction workers." Am J Ind Med 55(8): 736-745.

Background: Latino residential construction workers experience high rates of occupational fatality and injury. Work safety climate is an especially important consideration for improving the

safety of these immigrant workers. This analysis describes work safety climate among Latino residential construction workers, delineates differences in work safety climate by personal and employment characteristics, and determines associations of work safety climate with specific work safety behaviors. Methods: Data are from a cross-sectional survey of 119 Latino residential framers, roofers, and general construction workers in western North Carolina; 90 of these participants also provided longitudinal daily diary data for up to 21 days using an Interactive Voice Response (IVR) system. Measures included the Perceived Safety Climate Scale, and daily reports of five individual and five collective safety practices. Results: Work safety climate was mixed among workers, with roofers (19.9) having lower levels than framers (24.3) or general construction workers (24.3). Days reported for several individual (glove-related risks, not doing something known to be unsafe) and collective safety practices (attended daily safety meeting, not needing to use damaged equipment, not seeing coworker create an unsafe situation) were positively associated with work safety climate. Conclusions: Work safety climate predicts subsequent safety behaviors among Latino residential construction workers, with differences by trade being particularly important. Interventions are needed to improve safety training for employers as well as workers. Further research should expand the number of workers and trades involved in analyses of work safety climate. © 2012 Wiley Periodicals, Inc.

Arcury, T. A., et al. (2014). "Occupational safety beliefs among Latino residential roofing workers." Am J Ind Med 57(6): 718-725.

Background: This analysis describes beliefs about work safety and personal protective equipment (PPE) among Latino roofing workers, it delineates their perceptions of work environment characteristics that affect work safety and PPE use, and it describes how they experience work injuries and the consequences of these injuries. Methods: In-depth interviews were completed with 10 current and former Latino residential roofers. Interview transcripts were subjected to systematic qualitative analysis. Results: Participants' valued productivity over safety, and this had a negative influence on their safety behavior and reduced their PPE use. They understood that roofing was hazardous. They limited use of PPE when they felt it reduced productivity and when it was uncomfortable. Work environment characteristics that affected safety included company size, the physical demands of the job, lack of training, the need for work, general life stress, and distractions at work. An injury had to result in lost work time to be considered significant. Access to health care is limited by employers not providing Workers' compensation. Discussion: Future research is needed to substantiate these descriptive results and to delineate factors that are associated with safety behavior and use of PPE. Interventions, based on a lay health educator model, are needed to improve safety in this population. Safety regulations need to be evaluated and their enforcement needs to be improved. © 2013 Wiley Periodicals, Inc.

Arcury, T. A., et al. (2015). "Work safety climate, personal protection use, and injuries among Latino residential roofers." Am J Ind Med 58(1): 69-76.

Background: This analysis describes work safety climate, personal protective equipment (PPE) use, and injuries among Latino residential roofers, and examines the associations of work safety climate with PPE use and injuries. Methods: Eighty-nine North Carolina residential roofers completed a baseline interview and daily logs about perceptions and use of PPE, occurrence of injuries in last 12 months, and work safety climate. Results: The mean work safety climate score was 26.5 (SD=5.6). In the baseline interview, participants reported that the majority of employers provided PPE and that they used it most or all of the time; daily log data indicated that PPE was

used for half or fewer of hours worked. 39.9% reported any injury in the last 12 months. Work safety climate was significantly correlated with the provision and use of most types of PPE, and was inversely associated with injury. Conclusions: Supervisors promoting safety may increase the PPE use and decrease injuries. © 2014 Wiley Periodicals, Inc.

Boatman, L., et al. (2012). "Creating the Climate for Making Ergonomic Changes (CPWR Report)."

The purpose of this study is to learn about attitudes toward implementing ergonomic change in California construction work in the unionized sector. Our specific goal was to assess current perceptions and attitudes among construction professionals toward overcoming barriers and obstacles and voluntarily implementing ergonomic solutions.

Boatman, L., et al. (2015). "Creating a climate for ergonomic changes in the construction industry." Am J Ind Med 58(8): 858-869.

Background: Ergonomic solutions that have gained acceptance in other industries are often considered not applicable to a construction work environment, even though the industry is characterized by high physical work demands. Methods: We conducted 50 key informant interviews with 23 contractor representatives and 27 union staff, plus 4 focus groups with a total of 48 workers. Results: Many workers hold the belief that WMSDs are inevitable as part of the job, and did not consistently believe that changing the nature of the work could prevent that injury or pain. The interviewees reported limited availability and accessibility of tested and effective tools that both reduce physical demand and also get the job done efficiently and effectively. Yet for each major obstacle to implementation of ergonomics in the industry identified, the construction professionals we interviewed offered a variety of solutions. Conclusions: Contractors, unions, and workers need to work together to find actions that work within the parameters of the current economic environment. Am. J. Ind. Med. 58:858-869, 2015. © 2015 Wiley Periodicals, Inc.

Bodner, T., et al. (2014). "Safety, health, and well-being of municipal utility and construction workers." J Occup Environ Med 56(7): 771-778.

OBJECTIVE: To provide a baseline description of psychosocial workplace stressors and supports along with safety, injury, health, and well-being indicators in a sample of utility and construction workers for a National Institute for Occupational Safety and Health-funded Total Worker Health intervention study. METHODS: Survey responses and health assessments were collected from a total of 349 employees in two municipal utility departments. RESULTS: Participants demonstrated poor weight control and body mass index and provided reports of frequent poor health habits, injury, and pain. Although safety climate was good, less desirable levels of psychosocial workplace stressors and supports were observed. These stressors and supports were found to relate with many of the health, injury, and pain indicators. CONCLUSIONS: These results demonstrate the need for workplace interventions to promote and protect construction worker health and the importance of the psychosocial work environment.

Brown, G. D. and J. Barab (2007). ""Cooking the books"--behavior-based safety at the San Francisco Bay Bridge." New Solut 17(4): 311-324.

Practitioners of Behavior-Based Safety (BBS) claim dramatic reductions in worker injuries and illnesses through modifying workers' "unsafe behaviors." This case study of a BBS program implemented by KFM, a giant construction consortium rebuilding the eastern span of the San Francisco Bay Bridge in California, documents how BBS was used to suppress reporting of worker

injuries and illnesses on site. The key elements of KFM's BBS "injury prevention" strategy included: 1) cash incentives to workers and supervisors who do not report injuries; 2) reprisals and threats of reprisals against those employees who do report injuries; 3) selection and use of employer friendly occupational health clinics and workers compensation insurance administrators; 4) strict limits on the activities of contract industrial hygiene consultants; and 5) a secretive management committee that decides whether reported injuries and illnesses are legitimate and recordable. KFM reported injury and illness rates 55% to 72% lower than other bridge builders in the Bay Area, but the California Division of Occupational Safety and Health (Cal/OSHA) issued Willful citations to the consortium in June 2006 for failing to record 13 worker injuries on its "OSHA Log 300," as required by law.

Bush, D., et al. (2019). "Essential Elements for Effective Safety and Health Education in Postsecondary Construction Career Technical Education." New Solut 29(1): 53-75.

Because Career Technical Education (CTE) programs at the community/technical college level are among the few places new construction workers receive training or preparation, they are an important vehicle for educating new and young workers about occupational health and safety (OSH). We developed recommendations for (1) OSH "core competencies" that all postsecondary construction students should achieve and (2) "essential elements" for OSH education in construction training programs. Based on a review of the literature, subject matter expert focus groups, and iterative engagement with an expert advisory group, we identified fourteen core competencies and a list of essential supporting elements at the school, program, and instructor levels. Knowledge and recognition of the importance of effective safety and health management systems served as the foundation for elements and competencies. Findings provide an important starting point for systematically improving the preparation of construction CTE students that can help keep them safe on the job.

Caban-Martinez, A. J., et al. (2014). "Construction workers working in musculoskeletal pain and engaging in leisure-time physical activity: Findings from a mixed-methods pilot study." Am J Ind Med 57(7): 819-825.

Background: While exercise has been shown to be beneficial for some musculoskeletal pain conditions, construction workers who are regularly burdened with musculoskeletal pain may engage less in leisure-time physical activity (LTPA) due to pain. In a small pilot study, we investigate how musculoskeletal pain may influence participation in LTPA among construction workers. Methods: A sequential explanatory mixed-methods design was employed using a jobsite-based survey (n=43) among workers at two commercial construction sites and one focus group (n=5). Results: Over 93% of these construction workers reported engaging in LTPA and 70% reported musculoskeletal pain. Fifty-seven percent of workers who met either moderate or vigorous LTPA guidelines reported lower extremity pain (i.e., ankle, knee) compared with 21% of those who did not engage in either LTPA (P=0.04). Focus group analyses indicate that workers felt they already get significant physical activity out of their job because they are "moving all the time and not sitting behind a desk." Workers also felt they "have no choice but to work through pain and discomfort [as the worker] needs to do anything to get the job done." Conclusion: Pilot study findings suggest that construction workers not only engage in either moderate or vigorous LTPA despite musculoskeletal pain but workers in pain engage in more LTPA than construction workers without pain. Am. J. Ind. Med. 57:819-825, 2014. © 2014 Wiley Periodicals, Inc.

Chávez, S. and C. E. Altman (2017). "Gambling with life: Masculinity, risk, and danger in the lives of unauthorized migrant roofers." Am J Ind Med 60(6): 537-547.

Background: This paper examines the occupational experiences of unauthorized immigrants employed in one of the most dangerous occupations in the United States: roofing. Methods: We draw on 40 in-depth interviews with return migrants in Guanajuato, Mexico, to examine how the adoption of masculinity, dangerous working conditions, the labor market structure, and absence of legal status exacerbates injuries for unauthorized roofers. Findings: Undocumented men return to Mexico injured with chronic pain, health complications, and trauma. We find that men “do gender” that is adopt masculine beliefs, when they skirt safety practices, police each other's behaviors, withhold their emotions, experience heightened stress, and engage in poor health behaviors. It is a combination of dangerous working conditions, economic insecurity, and men seeking to fulfill their masculine roles that all combine to create unsafe working conditions and lead to injuries. © 2017 Wiley Periodicals, Inc.

Chen, Q. and R. Jin (2013). "Multilevel safety culture and climate survey for assessing new safety Program." Journal of Construction Engineering and Management 139(7): 805-817.

Construction safety culture is becoming a typical proactive safety performance measurement and strategy for safety improvement. However, there is no accepted industry wide definition for safety culture. There is also no clear distinction between safety culture and safety climate. So far, little research has investigated how safety programs can be developed to improve safety culture and climate, which in turn can be used to assess the effectiveness of these programs. This paper presents a study that examined the multilevel safety culture and climate to assess a newly launched safety program. Specifically, three different questionnaires were used to survey 71 top executives, 229 site management personnel, and 350 field workers, respectively. This study found wide acceptance of the program across all three groups, strong management accountability in enforcing safety, and a positive general safety climate among workers. The results demonstrated the program's overall effectiveness in building positive safety culture and climate despite a few identified weaknesses. Based on these findings and insightful employee feedback, this paper offers generalized recommendations to help industry practitioners develop high-quality safety programs. The presented survey instruments and analysis methods can also be used to holistically assess safety programs and related safety culture and climate. © 2013 American Society of Civil Engineers.

Chen, Q. and R. Jin (2015). "A comparison of subgroup construction workers' perceptions of a safety program." Safety science 74: 15-26.

Subcontractor safety performance has become increasingly important due to the extensive use of subcontracting in construction and the elevated safety risks. Ensuring subcontractor safety has also become a major challenge of general contractors (GC). While many GCs leave the safety responsibility to individual subcontractors, others take active roles in helping them improve safety performance. To advance the understanding of how an active approach taken by the GC is received by subcontractors, a comparative study was performed to investigate subgroup workers' perceptions of a safety program implemented by a U.S. GC among all the workers on its jobsites. In this study, a 5-dimension 28-item questionnaire was administered to 350 workers on the GC's jobsites. The collected information was used to examine differences in workers' perceptions between selected subgroups, i.e., the GC and its subcontractors as well as high- and low-risk building trades. This research found more positive perceptions of the safety program (i.e., the overall perception and the awareness and acceptance dimensions) among the GC's workers than those of the subcontractors but

no difference in perceptions from high- and low-risk trades. This research also identified differences in workers' perceptions among other subgroups (e.g., based on age ranges and safety violation records) and drew insights from workers' feedback to open-ended survey questions. The findings will help contractors better understand and manage their diverse workforce to improve jobsite safety performance. © 2014.

Choi, B., et al. (2017). "Construction Workers' Group Norms and Personal Standards Regarding Safety Behavior: Social Identity Theory Perspective." Journal of Management in Engineering 33(4).

A number of researchers have proposed and demonstrated that worker behavior is one of the main factors in construction safety. Working within the parameters of worker safety awareness and behavior, many researchers have recently suggested that shared values and customs, i.e., group norms, play an important role in shaping individual workers' safety behavior. Regarding how individuals' behavior is under the influence of group norms, the social identity theory suggests that people perceive themselves as a member of a group, depersonalize the self, and base their beliefs and behavior on the norms of the group. Despite the clarity of this configuration, the extent to which construction workers' safety attitudes and behaviors are influenced by group norms, and the degree to which social identification is involved in this process, remains unclear. In particular, the transient nature of construction worker employment and multiple identities that a construction worker might hold make it difficult to understand the influence of group norms on workers' safety behavior. To address these knowledge gaps, this paper aims to identify the (1) influence of group norms on a construction worker's personal standards regarding safety behavior, (2) current status of construction workers' social identities, and (3) impact of social identification on the influence that group norms have on construction workers' personal standards regarding safety behavior. To achieve these objectives, empirical data were collected from 82 construction workers and nine project managers from three different construction sites using behavioral economic experiments along with surveys, and the data were analyzed using quantitative methods, such as correlation analysis, regression analysis, and t-tests. The analyses demonstrate that there is a measurable difference between construction workers' personal standards and the norms desired by project managers regarding safety behavior and that construction workers' personal standards regarding safety behavior are significantly influenced by their perceived group norms. The analyses also demonstrate that construction workers identify themselves with the different groups to which they belong (e.g., workgroup, trade, union, company, project) to significantly different degrees and that the salience of social identity with a group moderates the influence that the group's norms have on personal standards regarding safety behavior in construction workers. These findings suggest a new way of thinking about safety management in construction; promoting project-wide positive norms combined with improved project identity can be an effective means of improving workers' safety behavior in construction projects. © 2017 American Society of Civil Engineers.

Choi, B., et al. (2017). "Role of Social Norms and Social Identifications in Safety Behavior of Construction Workers. I: Theoretical Model of Safety Behavior under Social Influence." Journal of Construction Engineering and Management 143(5).

During the last several decades, behavior-based safety (BBS) has drawn a considerable amount of attention in the construction industry. The focus of BBS is on improving construction workers' safety behavior through feedback and increased self-awareness and motivation. Among the influencing factors of safety behavior, social norm is known to be a powerful mechanism that regulates workers' safety behavior. However, it is unclear how social norms are developed and

through which process social norms influence an individual worker's safety behavior in construction projects. Additionally, the temporary and contract-based nature of employment in construction projects makes understanding the influence of different social norms on workers' safety behavior in construction projects especially difficult. Given this background, this paper aims to better understand the process by which different social norms exert control over construction workers' safety behavior. To achieve this goal, empirical data were collected from 284 workers from eight construction sites in the United States, Korea, and Saudi Arabia using surveys, and the data were analyzed. The results demonstrate that workers' safety behavior is influenced by perceived management norm, perceived workgroup norm, and personal attitude, and perceived workgroup norm mediates the relationship between perceived management norm and safety behavior. In addition, it is shown that social identification with the project intensifies the relationship between perceived management norm and safety behavior and attenuates the relationship between perceived workgroup norm and safety behavior. These findings contribute to the body of knowledge on construction safety by providing an explicative model for how social norms influence workers' safety behavior, and suggest that a sociopsychological approach to promote project identity and reinforce favorable social norms in construction workers can be an effective means of improving construction safety. © 2016 American Society of Civil Engineers.

Choi, B. and S. H. Lee (2017). "Role of Social Norms and Social Identifications in Safety Behavior of Construction Workers. II: Group Analyses for the Effects of Cultural Backgrounds and Organizational Structures on Social Influence Process." Journal of Construction Engineering and Management 143(5).

The roles of perceived management norm, perceived workgroup norm, and project identity in construction workers' safety behavior were described in the companion paper. That paper found that workers who strongly identify with their project demonstrate a stronger association between strict perceived management norms and safety behavior and a diminished association between lenient perceived workgroup norms and safety behavior. However, it is still unclear whether the findings are stable across different cultural backgrounds and organizational structures. To address this issue, this study aims to compare the roles of perceived management norm, perceived workgroup norm, and project identity in workers' safety behavior in different cultural backgrounds and organizational structures. The surveys were conducted in the United States, Korea, and Saudi Arabia for the group analyses because the three countries are both different from and similar to each other in terms of cultural backgrounds and organizational structure. The result demonstrated a significant relationship between social norms (e.g., perceived management norms and perceived workgroup norms) and safety behavior, but cultural and organizational contexts can make a difference in the social influence processes. It was found that workers' social identification with their projects functions as an important mechanism that moderates the relationship between social norms and safety behavior in the United States and Korea. Just as the individualistic culture in the United States leads to significant direct effects of attitudes on safety behavior, the collectivistic culture in Korea brings about the significant effects of the perceived management norm and perceived workgroup norm on safety behavior. On the other hand, in Saudi Arabia, although workers already have a salient project identity due to its system of direct hiring, interactions between project identity and social norms do not have significant associations with safety behavior because perceived management norms may not be strict enough to elicit behavioral changes in improving safety behavior. The findings from this study lay a theoretical foundation for a new approach to safety management in international construction projects. Beyond the

sociopsychological aspect of safety behavior, considerations of cultural and organization context would be essential to strengthen positive social influence on workers' safety behavior in international construction projects. © 2016 American Society of Civil Engineers.

Cigularov, K. P., et al. (2013). "Measurement equivalence and mean comparisons of a safety climate measure across construction trades." Accid Anal Prev 51: 68-77.

The use of safety climate measures for needs assessment and interventions has become increasingly popular. However, no research to date has examined whether the meaning and level of safety climate may differ across different groups of interest. This study used multi-group confirmatory factor analyses to investigate the measurement equivalence of a multidimensional safety climate measure across ten construction trade groups (N=4725). In addition, observed mean differences in safety climate perceptions between trades were examined. Results revealed strong measurement equivalence of the safety climate measure across the construction trade groups. Further, significant mean differences were found between the ten trade groups on all four safety climate scales.

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

Work in the construction industry is considered inherently dangerous, despite the technological improvements regarding the safety of work conditions and equipment. To address the urgent need to identify organizational predictors of safety performance and outcomes among construction workers, the present study examined multi-level effects of two important indicators of safety climate, namely contractor error management climate and worker safety communication, on safety behavior, injury, and pain among union construction workers. Data were collected from 235 union construction workers employed by 15 contractors in Midwest and Northwest regions of the United States. Results revealed significant main effects for safety communication and error management climate on safety behaviors and pain, but not on injuries. Our findings suggest that positive safety communication and error management climate are important contributors to improving workplace safety. Specific implications of these results for organizational safety research and practice are discussed.

Cunningham, T. R. and C. J. Jacobson (2018). "Safety Talk and Safety Culture: Discursive Repertoires as Indicators of Workplace Safety and Health Practice and Readiness to Change." Ann Work Expo Health 62(suppl_1): S55-S64.

BACKGROUND: Small construction businesses (SCBs) account for a disproportionate share of occupational injuries, days lost, and fatalities in the US and other modern economies. Owner/managers of SCBs confront risks associated with their own and workers' safety and business survival, and their occupational safety and health (OSH) related values and practices are key drivers of safety and business outcomes. Given owner/mangers are the key to understanding and affecting change in smaller firms, as well as the pressing need for improved OSH in small firms particularly in construction, there is a critical need to better understand SCB owners' readiness to improve or adopt enhanced OSH activities in their business. Unfortunately, the social expectation to support safety can complicate efforts to evaluate owners' readiness. OBJECTIVES: To get a more accurate understanding of the OSH values and practices of SCBs and the factors shaping SCB owners' readiness and intent to implement or improve safety and health programming by comparing their discourse on safety with their self-rated level of stage of change. METHODS: In-depth, semi-

structured interviews were conducted with 30 SCB owner managers. Respondents were asked to self-rate their safety program activity on a 5-point scale from unaware or ignorant ('haven't thought about it at all') to actively vigilant ('well-functioning safety and health program for at least 6 months'). They were also asked to discuss the role and meaning of OSH within their trade and company, as well as attitudes and inclinations toward improving or enhancing business safety practices. ANALYSIS AND RESULTS: Respondents' self-rating of safety program activity was compared and contrasted with results from discourse analysis of their safety talk, or verbal descriptions of their safety values and activities. Borrowing from normative and stage theories of safety culture and behavioral change, these sometimes contradictory descriptions were taxonomized along a safety culture continuum and a range of safety cultures and stages of readiness for change were found. These included descriptions of strong safety cultures with intentions for improvement as well as descriptions of safety cultures with more reactive and pathological approaches to OSH, with indications of no intentions for improvement. Some owner/managers rated themselves as having an effective OSH program in place, yet described a dearth of OSH activity and/or value for OSH in their business. CONCLUSION: Assessing readiness to change is key to improving OSH performance, and more work is needed to effectively assess SCB OSH readiness and thus enable greater adoption of best practices.

Dale, A. M., et al. (2021). "Flow-down of safety from general contractors to subcontractors working on commercial construction projects." Saf Sci 142.

Small and medium construction firms have high injury rates but lack resources to establish and maintain effective safety programs. General contractors with exemplary safety programs may serve as intermediaries to support development of smaller firm's safety programs. The purpose of this study was to examine the flow-down influence of general contractors' safety programs on the safety climate and safety behaviors among workers employed by small and medium sized subcontractors. This study collected workers' perception of safety climate and safety behaviors while working on projects with general contractors with exemplary safety programs and other general contractors. We also documented the safety program policies and practices of subcontractors, and recorded the changes in safety policies required from general contractors with exemplary programs. We examined differences in safety program changes between small and medium sized subcontractors. Results showed workers perceived general contractors with exemplary safety programs had stronger safety climates than other general contractors. Smaller subcontractors had less robust safety programs with fewer safety elements than larger subcontractors, and therefore, many of the smaller subcontractors had to adopt more safety policies and practices to work for general contractors than large subcontractors. These findings suggest that general contractors with robust safety programs can serve as intermediaries and influence the development of the safety programs of small sized firms. Future work will need to determine if smaller firms eventually adopt safety policies and practices as part of their permanent safety program.

Dale, A. M., et al. (2020). "The association between subcontractor safety management programs and worker perceived safety climate in commercial construction projects." J Safety Res 74: 279-288.

PROBLEM: Safety management programs (SMPs) are designed to mitigate risk of workplace injuries and create a safe working climate. The purpose of this project was to evaluate the relationship between contractors' SMPs and workers' perceived safety climate and safety behaviors among small and medium-sized construction subcontractors. METHODS: Subcontractor SMP

scores on 18 organizational and project-level safety items were coded from subcontractors' written safety programs and interviews. Workers completed surveys to report perceptions of their contractor's safety climate and the safety behaviors of coworkers, crews, and themselves. The associations between SMP scores and safety climate and behavior scales were examined using Spearman correlation and hierarchical linear regression models (HLM). RESULTS: Among 78 subcontractors working on large commercial construction projects, we found striking differences in SMP scores between small, medium, and large subcontractors ($p < 0.001$), related to a number of specific safety management practices. We observed only weak relationships between SMP scales and safety climate scores reported by 746 workers of these subcontractors (beta = 0.09, $p = 0.04$ by HLM). We saw no differences in worker reported safety climate and safety behaviors by contractor size. DISCUSSION: SMP only weakly predicted safety climate scales of subcontractors, yet there were large differences in the quality and content of SMPs by size of employers. SUMMARY: Future work should determine the best way to measure safety performance of construction companies and determine the factors that can lead to improved safety performance of construction firms. Practical applications: Our simple assessment of common elements of safety management programs used document review and interviews with knowledgeable representatives. These methods identified specific safety management practices that differed between large and small employers. In order to improve construction safety, it is important to understand how best to measure safety performance in construction companies to gain knowledge for creating safer work environments.

Dale, A. M., et al. (2016). "Evaluation of a participatory ergonomics intervention in small commercial construction firms." Am J Ind Med 59(6): 465-475.

BACKGROUND: Work-related musculoskeletal disorders (WMSD) among construction workers remain high. Participatory ergonomics (PE) interventions that engage workers and employers in reducing work injury risks have shown mixed results. METHODS: Eight-six workers from seven contractors participated in a PE program. A logic model guided the process evaluation and summative evaluation of short-term and intermediate impacts and long-term outcomes from surveys and field records. RESULTS: Process measures showed good delivery of training, high worker engagement, and low contractor participation. Workers' knowledge improved and workers reported changes to work practices and tools used; contractor provision of appropriate equipment was low (33%). No changes were seen in symptoms or reported physical effort. CONCLUSIONS: The PE program produced many worker-identified ergonomic solutions, but lacked needed support from contractors. Future interventions should engage higher levels of the construction organizational system to improve contractor involvement for reducing WMSD. Am. J. Ind. Med. 59:465-475, 2016. (c) 2016 Wiley Periodicals, Inc.

DeArmond, S., et al. (2011). "Individual safety performance in the construction industry: development and validation of two short scales." Accid Anal Prev 43(3): 948-954.

In the current research a short measure of safety performance is developed for use in the construction industry and the relationships between different components of safety performance and safety outcomes (e.g., occupational injuries and work-related pain) are explored within the construction context. This research consists of two field studies. In the first, comprehensive measures of safety compliance and safety participation were shortened and modified to be appropriate for use in construction. Evidence of reliability and validity is provided. Both safety compliance and safety participation were negatively related to occupational injuries, yet these two correlations were not statistically different. In the second study, we investigated the relationships

between these two components of safety performance and work-related pain frequency, in addition to replicating Study 1. Safety compliance had a stronger negative relationship with pain than safety participation. Implications for research are discussed.

Dennerlein, J. T., et al. (2021). "Associations Between Work-Related Factors and Psychological Distress Among Construction Workers." J Occup Environ Med 63(12): 1052-1057.

OBJECTIVE: Identify work-related factors associated with the mental health and well-being of construction workers. METHODS: We completed eight key informant interviews, six worker focus groups, and a survey, informed by the interviews and focus groups, of 259 construction workers on five construction sites. Negative binomial regressions examined associations between psychological distress and work-related factors including safety climate, work-to-family conflict, psychological demands, social support, harassment, and job security. RESULTS: Three themes emerged from the interviews and focus groups, job demands and structure, social support and workplace relations, and job precarity. From the survey higher psychological demands, higher work-to-family conflict, lower supervisor support, higher discrimination, and higher likelihood of losing a job were associated with higher psychological distress. When combined into a single model job demands and work-to-family conflict remained significant. CONCLUSIONS: Work-related factors were associated with high levels of distress.

Dennerlein, J. T., et al. (2020). "Associations between a safety prequalification survey and worker safety experiences on commercial construction sites." Am J Ind Med 63(9): 766-773.

BACKGROUND: While assessment of subcontractors' safety performance during project bidding processes are common in commercial construction, the validation of organizational surveys used in these processes is largely absent. METHODS: As part of a larger research project called Assessment of Contractor Safety (ACES), we designed and tested through a cross-sectional study, a 63-item organizational survey assessing subcontractors' leading indicators of safety performance. We administered the ACES Survey to 43 subcontractors on 24 construction sites. Concurrently, we captured the safety climate of 1426 workers on these sites through worker surveys, as well as injury rates, for the duration of the project. RESULTS: At the worksite level, higher average ACES scores were associated with higher worker safety climate scores ($P < .01$) and lower rates of injury involving days away ($P < .001$). Within subcontracting companies, no associations were observed between ACES and worker safety climate scores and injuries. CONCLUSIONS: These results suggest the overall and collective importance of the construction project and its worksite in mediating worker experiences, perhaps somewhat independent of the individual subcontractor level.

Dutra, L. M., et al. (2014). "Worksite safety climate, smoking, and the use of protective equipment by blue-collar building workers enrolled in the Mass BUILT smoking cessation trial." J Occup Environ Med 56(10): 1082-1087.

Objective: To assess potential contributors to high injury rates and smoking prevalence among construction workers, we investigated the association of safety climate with personal protective equipment use, and smoking behaviors. Methods: Logistic regression models estimated risk ratios for personal protective equipment use and smoking using data from participants in Mass BUILT smoking cessation intervention (n = 1725). Results: Contractor safety climate was negatively associated with the use of dust masks (rate ratio [RR], 0.88; 95% confidence interval [CI], 0.83 to 0.94), respirators (RR, 0.82; 95% CI, 0.75 to 0.89), general equipment (RR, 0.98; 95% CI, 0.95 to 1.00), and fall protection (RR, 0.94; 95% CI, 0.91 to 0.98) and positively associated with

current smoking (RR, 1.12; 95% CI, 1.01 to 1.25) but not smoking cessation. Coworker safety climate was negatively associated with the use of dust masks (RR, 0.87; 95% CI, 0.82 to 0.92), respirators (RR, 0.80; 95% CI, 0.74 to 0.87), general equipment (RR, 0.96; 95% CI, 0.94 to 0.98), fall (RR, 0.92; 95% CI, 0.89 to 0.96), and hearing protection (RR, 0.88; 95% CI, 0.83 to 0.93) but not smoking. Conclusions: Worksite safety climate may be important for personal protective equipment use and smoking, but further research is needed. Copyright © 2014 by American College of Occupational and Environmental Medicine.

Eggerth, D. E., et al. (2018). "Evaluation of toolbox safety training in construction: The impact of narratives." Am J Ind Med 61(12): 997-1004.

BACKGROUND: Construction is a dangerous industry with a large number of small businesses. Because they require minimal resources to deliver, toolbox talks may be an ideal training format for small construction contractors. METHODS: Eight toolbox talks were developed, each with two versions. One version of each toolbox talk was standard and one version included a narrative and discussion questions. Participants were randomly assigned to receive the standard or the narrative version. Pre- and post-intervention surveys measured demographics, workplace safety climate, and knowledge. The post-intervention survey also measured training impact. RESULTS: Including narratives with discussion questions significantly increased knowledge gain and led to increased training impact. Less experienced workers were more likely to gain knowledge and training impact compared to more experienced workers. There were no significant changes in workplace safety climate. CONCLUSIONS: The results suggest that including a narrative and discussion questions increases toolbox talk effectiveness.

Evanoff, B., et al. (2016). "Results of a fall prevention educational intervention for residential construction." Safety science 89: 301-307.

Falls from height remain the leading cause of fatalities in residential construction. We used results from a comprehensive needs assessment to guide changes in fall prevention training in a joint union-contractor carpenter apprenticeship program; including surveys of 1018 apprentice carpenter and observational audits at 197 residential construction sites. The revised training utilized hands-on, participatory training methods preferred by the learners to address the safety gaps in the curriculum; including ladder use, leading edge work, truss setting, and use of scaffolding and personal fall arrest. We compared apprentice surveys (n = 1273) and residential worksite audits (n = 207) 1–2 years post-training with baseline measures. Apprentices working residential construction were more likely to fall from heights (OR = 2.26, 95% CI 1.59–3.21) than those working commercial construction. The revised training resulted in improved fall safety knowledge, self-reported worksite behaviors, risk perceptions, and safety climate, even after adjusting for temporal trends. We also observed significant improvements in fall safety compliance in most domains of the worksite audit, with larger changes observed in areas emphasized in the training, demonstrating specificity of the effect. Greater effects were noted in small and medium-sized contractors, who often have limited resources to devote to safety. Self-reported falls fell from 18.2 to 14.5 per 100 person-years of work. This research supports growing evidence that worksite safety can be improved by training. This curriculum could be readily adapted to other union apprenticeship programs. Fall safety of inexperienced residential construction workers' should remain a focus of future research. © 2016 Elsevier Ltd

Fulmer, S., et al. (2006). "Factors influencing ergonomic intervention in construction: trunkman case study." New Solut 16(3): 235-247.

This case study examines factors affecting the use of equipment designed to prevent lower back strain in laborers who pour concrete on major highway construction sites. Qualitative methods of organizational analysis were used to characterize factors identified from interviews and participant observation. The major obstacles to the use of the control on site were 1. Managers placing a low priority on ergonomics. 2. Safety officers' limited power in organizational hierarchies. 3. Rationalizing, rather than challenging, resistance to change. 4. Lack of a forum to share knowledge about interventions. Several organizational factors impeded the adoption of a technically effective, low-cost safety control on the site studied. The implementation of the control ultimately resulted from actions taken by the investigators, suggesting that safety programs present at the site are not always adequate to realize feasible interventions.

Gilkey, D. P., et al. (2011). "Comparative analysis of safety culture perceptions among homesafe managers and workers in residential construction." Journal of Construction Engineering and Management 138(9): 1044-1052.

Construction workers continue to experience high rates of injury and illness compared with many other industries. Growing evidence suggests that safety culture has a direct effect on safety performance. This study investigated measures of safety culture and risk perception among a residential-home-building cohort within the HomeSafe Pilot Program in the Denver metro area of Colorado. Investigators compared group-level responses of management to frontline construction workers. Results indicate that managers appraised the overall safety culture at higher levels compared with the workers. Managers also perceived a higher level of management commitment to safety and health than that reported by workers.

Gillen, M., et al. (2002). "Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers." J Safety Res 33(1): 33-51.

PROBLEM: This study evaluated injured construction workers' perceptions of workplace safety climate, psychological job demands, decision latitude, and coworker support, and the relationship of these variables to the injury severity sustained by the workers. METHODS: Injury severity was assessed using the Health Assessment Questionnaire (HAQ), which evaluates functional limitations. Worker perceptions of workplace variables were determined by two instruments: (a) the Safety Climate Measure for Construction Sites and (b) the Job Content Questionnaire (JCQ). RESULTS: The overall model explained 23% of the variance in injury severity, with unique contributions provided by union status, the Safety Climate Score, and Psychological Job Demands. A positive significant correlation was found between injury severity and the Safety Climate Scores ($r = .183$, $P = .003$), and between the Safety Climate Scores and union status ($r = .225$, $P < .001$). DISCUSSION: There were statistically significant differences between union and nonunion workers' responses regarding perceived safety climate on 5 of the 10 safety climate items. Union workers were more likely than nonunion workers to: (a) perceive their supervisors as caring about their safety; (b) be made aware of dangerous work practices; (c) have received safety instructions when hired; (d) have regular job safety meetings; and (e) perceive that taking risks was not a part of their job. However, with regard to the 49-item JCQ, which includes Coworker Support, the responses between union and nonunion workers were very similar, indicating an overall high degree of job satisfaction. However, workers who experienced their workplace as more safe also perceived the level of management ($r = -.55$, $P < .001$) and coworker (r

= -.31, P < .001) support as being higher. IMPACT ON INDUSTRY: The findings of this study underscore the critical need for construction managers to alert workers to dangerous work practices and conditions more frequently, and express concern and praise workers for safe work in a manner that is culturally acceptable in this industry. Workplace interventions that decrease the incidence and severity of injuries, but that are flexible enough to meet a variety of potentially competing imperatives, such as production deadlines and client demands, need to be identified.

Gillen, M., et al. (2004). "Construction managers' perceptions of construction safety practices in small and large firms: a qualitative investigation." Work 23(3): 233-243.

BACKGROUND AND GOALS: Despite the institution of explicit safety practices in construction, there continue to be exceedingly high rates of morbidity and mortality from work-related injury. This study's purpose was to identify, compare and contrast views of construction managers from large and small firms regarding construction safety practices. A complementary analysis was conducted with construction workers. METHODS: A semi-structured interview guide was used to elicit information from construction managers (n = 22) in a series of focus groups. Questions were designed to obtain information on direct safety practices and indirect practices such as communication style, attitude, expectations, and unspoken messages. Data were analyzed using thematic content analysis. RESULTS: Managers identified a broad commitment to safety, worker training, a changing workplace culture, and uniform enforcement as key constructs in maintaining safe worksites. Findings indicate that successful managers need to be involved, principled, flexible, and innovative. Best practices, as well as unsuccessful injury prevention programs, were discussed in detail. Obstacles to consistent safety practice include poor training, production schedules and financial constraints. CONCLUSIONS: Construction managers play a pivotal role in the definition and implementation of safety practices in the workplace. In order to succeed in this role, they require a wide variety of management skills, upper management support, and tools that will help them instill and maintain a positive safety culture. Developing and expanding management skills of construction managers may assist them in dealing with the complexity of the construction work environment, as well as providing them with the tools necessary to decrease work-related injuries.

Gillen, M., et al. (2004). "Construction workers' perceptions of management safety practices: a qualitative investigation." Work 23(3): 245-256.

BACKGROUND AND GOALS: The purpose of this study was to identify perceptions of management safety practices from the viewpoint of union and nonunion construction workers. A complementary investigation was conducted with construction managers. METHODS: A semi-structured interview guide was used to elicit information from 64 workers (95% male) in ten focus groups. Questions were designed to elicit information about management practices that facilitate or discourage safe working conditions, including communication style, attitude, expectations, and unspoken messages. Data were analyzed using thematic content analysis. RESULTS: Workers identified management commitment to safety, concern for workers, congruence between spoken messages and practice, professionalism, and communication skills as key qualities in successful managers. Workers provided vivid examples of excellent and poor management strategies. CONCLUSIONS: Construction managers play a pivotal role in the definition and implementation of safety practices in the workplace and workers look to them for guidance and modeling. Given the high rates of injury in construction, deeply imbedded protective policies that rely on input from a broad range of stakeholders, including construction workers, should be developed.

Gittleman, J. L., et al. (2010). "[Case Study] CityCenter and Cosmopolitan Construction Projects, Las Vegas, Nevada: lessons learned from the use of multiple sources and mixed methods in a safety needs assessment." J Safety Res 41(3): 263-281.

PROBLEM: The present study describes a response to eight tragic deaths over an eighteen month times span on a fast track construction project on the largest commercial development project in U.S. history. METHODS: Four versions of a survey were distributed to workers, foremen, superintendents, and senior management. In addition to standard Likert-scale safety climate scale items, an open-ended item was included at the end of the survey. RESULTS: Safety climate perceptions differed by job level. Specifically, management perceived a more positive safety climate as compared to workers. Content analysis of the open-ended item was used to identify important safety and health concerns which might have been overlooked with the qualitative portion of the survey. DISCUSSION: The surveys were conducted to understand workforce issues of concern with the aim of improving site safety conditions. Such efforts can require minimal investment of resources and time and result in critical feedback for developing interventions affecting organizational structure, management processes, and communication. SUMMARY: The most important lesson learned was that gauging differences in perception about site safety can provide critical feedback at all levels of a construction organization. IMPACT ON THE INDUSTRY: Implementation of multi-level organizational perception surveys can identify major safety issues of concern. Feedback, if acted upon, can potentially result in fewer injuries and fatal events.

Goldenhar, L. M., et al. (2019). "Leadership skills for strengthening jobsite safety climate." J Safety Res 70: 263-271.

INTRODUCTION: Construction foremen may lack the leadership skills needed to create a strong jobsite safety climate. Many construction companies address this by sending their lead workers to the OSHA 30-h course; however the course does not include a leadership training module. This article describes the development and pilot testing of such a module and evaluation surveys designed to address this training gap. METHODS: A 17-member curriculum development team, numerous subject matter experts, and an instructional design company helped us develop a comprehensive set of teaching resources and a set of survey instruments for evaluating the materials' effectiveness on improving safety leadership and safety climate. All materials and surveys were pilot tested with representative members of the target population. RESULTS: Pilot surveys showed high reliability and data collected on the resulting Foundations for Safety Leadership (FSL) module indicated that the majority of foremen thought the training was helpful or valuable, particularly the discussion questions. The majority said they intended to use the skills on the jobsite. With the exception of the role-play activities, the trainers rated highly all other components, especially the videos and discussion questions. Modifications were made to the training materials and surveys based on pilot test findings. The most important result of the development and pilot testing efforts is that the OSHA Training Institute (OTI) included the FSL as an elective in the OSHA 30-h course. CONCLUSIONS: The FSL module fills a needed skills gap by providing safety leadership training to all foremen who might otherwise not have access to it through their company or union. The continued success of the FSL training will be ensured by dissemination via the OSHA 30-h course, an established nationwide safety training program. Practical applications: The FSL training module has already been widely accepted by the construction industry as a useful approach for providing construction foremen/See new abstract lead workers with the knowledge and skills they need to become more effective jobsite safety leaders.

Goldenhar, L. M. and P. Stafford (2015). "If you've seen one construction worksite stretch and flex program ... you've seen one construction worksite stretch and flex program." J Safety Res 55: 73-79.

BACKGROUND: Work-related Musculoskeletal Disorders (WMSD) account for approximately one-third of all injuries in the U.S. construction industry. Many companies have implemented stretch and flex (s/f) programs to reduce WMSD despite a lack of evidence showing effectiveness. METHODS: We conducted a mixed-methods study to understand (a) why employers continue devoting resources to s/f programs; (b) how programs vary; and (c) any actual or perceived benefits. RESULTS: Nineteen safety and health professionals were interviewed and 133 more (13.3% response rate) completed an on-line survey. Fifty-six percent had implemented an s/f program with the primary goal of reducing WMSDs; though most did not review data to determine goal achievement. Program structure varied in terms of duration, frequency, and type of stretches. There was strong agreement about mandating attendance but not participation, due primarily to liability issues. Cost was a factor when deciding to implement a program but not for sustaining one. The majority had not implemented other ergonomic prevention activities, but many had started conducting daily safety huddles for task and safety planning. Those reporting a reduction in WMSDs agreed that it was not due to the s/f program alone and that other benefits included increased worker camaraderie, communication, and collaboration. CONCLUSION: Although there is little to no scientific evidence showing that they work as intended, construction companies continue to implement s/f programs with the goal of reducing WMSDs. Bringing work crews together for s/f activities has prompted employers to also begin conducting daily safety huddles. Although employers may not be able to link reduced WMDS to an s/f program, the ancillary benefits may warrant the time and resources. PRACTICAL APPLICATIONS: S/f programs should be only one component of a more comprehensive ergonomics prevention program. Conducting daily safety huddles at the same time also may enhance worker communication, camaraderie, collaboration and improve safety outcomes.

Hallowell, M. R. (2012). "Safety-knowledge management in American construction organizations." Journal of Management in Engineering 28(2): 203-211.

Despite improvements in safety performance over the past 30 years, the construction industry still accounts for an injury-and-illness rate that is approximately five times greater than the all-industry average. This disproportionate injury-and-illness rate has been attributed, in part, to the complex, dynamic, and transient nature of construction projects. To address these challenges, construction organizations must be able to adapt to change by effectively identifying, capturing, storing, and transferring safety knowledge. To investigate how safety-knowledge management strategies are employed in the construction industry, 11 case studies were conducted with a geographically dispersed sample of American general contractors. The sample was stratified by experience modification rate (EMR), a relative measure of safety performance. The results of the case studies indicate that construction organizations tend to acquire safety knowledge from a variety of internal and external sources, but have ineffective knowledge storage and transfer systems, which impede the ability of the workforce to obtain critical knowledge to solve urgent safety-related problems. High-performing organizations were distinguished by their ability to manage tacit safety knowledge with formal processes such as data-entry systems that capture reactions to safety situations from experienced workers and safety mentoring. Other innovative strategies include acquiring tacit safety knowledge during safety stand-downs through interviews with workers and storing safety knowledge in proprietary training videos. © 2012 American Society of Civil Engineers.

Hallowell, M. R. and I. F. Yugar-Arias (2016). "Exploring fundamental causes of safety challenges faced by Hispanic construction workers in the US using photovoice." Safety science 82: 199-211.

The US construction industry has long been responsible for a high injury and fatality rate. Within this dangerous industry, Hispanic workers are 45% more likely to be injured or killed than their non-Hispanic counterparts. Previous researchers have examined reasons for these disproportionate injury rates but past literature is spurious, fragmented, and incomplete. To address these limitations an in-depth study was launched to explore the perceived challenges that impact the safety of Hispanic construction workers. The primary data collection method was Photovoice, a photograph-based interview process that allows each participant to be the generator of their own data. The results of Photovoice interviews with 17 Hispanic workers in Colorado indicate that, compared with non-Hispanic workers, Hispanic workers perceive that they are: (1) susceptible to an internal pressure to complete work quickly and neglect safety based on their experiences in their home country; (2) assigned more dangerous tasks because of racism and discrimination; (3) more willing to accept dangerous work for fear of losing their jobs and ability to support extended family; (4) less likely to provide feedback to their supervisors and co-workers for fear of negative personal reactions; (5) more likely to be distracted by family issues while at work because of their strong and broad family ties; (6) more likely to ignore criticism because of machismo; (7) more likely to underreport injuries for fear of losing their jobs; and (8) less likely to ask for safety assistance when it is needed because of pride. © 2015 Elsevier Ltd.

Han, S., et al. (2014). "Toward an understanding of the impact of production pressure on safety performance in construction operations." Accid Anal Prev 68: 106-116.

It is not unusual to observe that actual schedule and quality performances are different from planned performances (e.g., schedule delay and rework) during a construction project. Such differences often result in production pressure (e.g., being pressed to work faster). Previous studies demonstrated that such production pressure negatively affects safety performance. However, the process by which production pressure influences safety performance, and to what extent, has not been fully investigated. As a result, the impact of production pressure has not been incorporated much into safety management in practice. In an effort to address this issue, this paper examines how production pressure relates to safety performance over time by identifying their feedback processes. A conceptual causal loop diagram is created to identify the relationship between schedule and quality performances (e.g., schedule delays and rework) and the components related to a safety program (e.g., workers' perceptions of safety, safety training, safety supervision, and crew size). A case study is then experimentally undertaken to investigate this relationship with accident occurrence with the use of data collected from a construction site; the case study is used to build a System Dynamics (SD) model. The SD model, then, is validated through inequality statistics analysis. Sensitivity analysis and statistical screening techniques further permit an evaluation of the impact of the managerial components on accident occurrence. The results of the case study indicate that schedule delays and rework are the critical factors affecting accident occurrence for the monitored project. © 2013 Elsevier Ltd.

Hoffmeister, K., et al. (2014). "The differential effects of transformational leadership facets on employee safety." Safety science 62: 68-78.

Transformational and transactional leadership have been associated with numerous positive safety outcomes, such as improved safety climate, increased safety behaviors, and decreased

accidents and injuries. However, leadership is a complex, multidimensional construct, and there is reason to suspect that different facets of leadership may affect safety in different ways and for different reasons. Yet little research to date has considered the relationships between individual facets of transformational and transactional leadership and safety outcomes. The present study addressed this gap by using relative weights analysis to examine the unique influences of leadership facets on five employee safety outcomes. In a survey of 1167 construction pipefitters and plumbers, idealized attributes and behaviors accounted for the most variance in each of the safety outcomes, whereas individualized consideration and active management-by-exception frequently accounted for the least amount of variance. These results suggest that leadership development programs in construction should address multiple individual elements of leadership, such as core values, as well as concrete skills and behaviors. © 2013 Elsevier Ltd.

Huang, Y. H., et al. (2006). "Safety climate and self-reported injury: assessing the mediating role of employee safety control." Accid Anal Prev 38(3): 425-433.

To further reduce injuries in the workplace, companies have begun focusing on organizational factors which may contribute to workplace safety. Safety climate is an organizational factor commonly cited as a predictor of injury occurrence. Characterized by the shared perceptions of employees, safety climate can be viewed as a snapshot of the prevailing state of safety in the organization at a discrete point in time. However, few studies have elaborated plausible mechanisms through which safety climate likely influences injury occurrence. A mediating model is proposed to link safety climate (i.e., management commitment to safety, return-to-work policies, post-injury administration, and safety training) with self-reported injury through employees' perceived control on safety. Factorial evidence substantiated that management commitment to safety, return-to-work policies, post-injury administration, and safety training are important dimensions of safety climate. In addition, the data support that safety climate is a critical factor predicting the history of a self-reported occupational injury, and that employee safety control mediates the relationship between safety climate and occupational injury. These findings highlight the importance of incorporating organizational factors and workers' characteristics in efforts to improve organizational safety performance.

Jorgensen, E., et al. (2007). "An English/Spanish safety climate scale for construction workers." Am J Ind Med 50(6): 438-442.

BACKGROUND: Workers in the construction trades experience high rates of traumatic injury. An increasing number of workers in this industry speak only Spanish, including members of construction trade unions. This brief communication reports a dual language safety climate scale developed during a larger training intervention study. METHODS: Construction workers in two unions self-completed a previously validated 6-item safety climate scale modified for the construction trades. A seventh item was developed midway through the study and incorporated into the version completed by half of the respondents. For one union with a sizeable number of Spanish-speaking members, a dual-language (Spanish/English) version was administered. Follow-up telephone interviews conducted 3 months after the self-completed survey also included the safety climate scale. RESULTS: Cronbach's coefficient alpha was 0.85 for the 6-item scale and 0.85 for the 7-item scale. Similar coefficient alpha scores were found for the subgroup of Spanish-speakers on the 6- and 7-item scales. Spanish speakers with low education were less likely to respond to the scale when self-completing but not when it was administered by telephone in Spanish. CONCLUSION: This safety climate scale elicits consistent and reliable response from unionized

construction workers when administered in English or in Spanish. Spanish literacy may be a consideration for the use of this scale among foreign-born Hispanic workers.

Kaskutas, V., et al. (2016). "Foremen's intervention to prevent falls and increase safety communication at residential construction sites." Am J Ind Med 59(10): 823-831.

Background: This research aimed to improve residential construction foremen's communication skills and safety behaviors of their crewmembers when working at heights. Methods: Eighty-four residential construction foremen participated in the 8-hr fall prevention and safety communication training. We compared pre- and post-intervention surveys from foremen and their crewmembers to measure the effect of training. Results: Foremen and crewmembers' ratings showed improvements in fall prevention knowledge, behaviors, and safety communication and were sustained 6-months post-training, with emphasized areas demonstrating larger increases. Ratings were similar between foremen and crewmembers, suggesting that the foremen effectively taught their crew and assigned accurate ratings. Based upon associations between safety behaviors and reported falls observed in prior research, we would expect a 16.6% decrease in the one year cumulative incidence of self-reported falls post-intervention. Conclusions: This intervention improved safety knowledge and behaviors of a large number of workers by training construction foremen in fall prevention and safety communication skills. Am. J. Ind. Med. 59:823–831, 2016. © 2016 Wiley Periodicals, Inc. © 2016 Wiley Periodicals, Inc.

Kaskutas, V., et al. (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.

PROBLEM: Falls from heights account for 64% of residential construction worker fatalities and 20% of missed work days. We hypothesized that worker safety would improve with foremen training in fall prevention and safety communication. METHOD: Training priorities identified through foreman and apprentice focus groups and surveys were integrated into an 8-hour training. We piloted the training with ten foremen employed by a residential builder. Carpenter trainers contrasted proper methods to protect workers from falls with methods observed at the foremen's worksites. Trainers presented methods to deliver toolbox talks and safety messages. Results from worksite observational audits (n=29) and foremen/crewmember surveys (n=97) administered before and after training were compared. RESULTS: We found that inexperienced workers are exposed to many fall hazards that they are often not prepared to negotiate. Fall protection is used inconsistently and worksite mentorship is often inadequate. Foremen feel pressured to meet productivity demands and some are unsure of the fall protection requirements. After the training, the frequency of daily mentoring and toolbox talks increased, and these talks became more interactive and focused on hazardous daily work tasks. Foremen observed their worksites for fall hazards more often. We observed increased compliance with fall protection and decreased unsafe behaviors during worksite audits. DISCUSSION: Designing the training to meet both foremen's and crewmembers' needs ensured the training was learner-centered and contextually-relevant. This pilot suggests that training residential foremen can increase use of fall protection, improve safety behaviors, and enhance on-the-job training and safety communication at their worksites. IMPACT ON INDUSTRY: Construction workers' training should target safety communication and mentoring skills with workers who will lead work crews. Interventions at multiple levels are necessary to increase safety compliance in residential construction and decrease falls from heights.

Kaskutas, V., et al. (2010). "Fall prevention among apprentice carpenters." Scand J Work Environ Health 36(3): 258-265.

OBJECTIVES: Falls from heights are a leading cause of mortality and morbidity in the construction industry, especially among inexperienced workers. We surveyed apprentice carpenters to identify individual and organizational factors associated with falls from heights. METHODS: We developed a 72-item survey on fall prevention with multiple domains including fall experience, fall-prevention knowledge, risk perceptions, confidence in ability to prevent falls, training experience, and perceptions of the safety climate and crew safety behaviors. We administered the questionnaire to apprentice carpenters in this cross-sectional study. RESULTS: Of the 1025 respondents, 51% knew someone who had fallen from a height at work and 16% had personally fallen in the past year, with ladders accounting for most of the falls. Despite participation in school-based and on-the-job training, fall-prevention knowledge was poor. Ladders were perceived as low risk and ladder training was rare. Apprentices reported high levels of unsafe, fall-related behaviors on their work crews. Apprentices in residential construction were more likely to fall than those in commercial construction, as were apprentices working on crews with fewer senior carpenters to provide mentorship, and those reporting more unsafe behaviors among fellow workers. CONCLUSIONS: Despite participation in a formal apprenticeship program, many apprentices work at heights without adequate preparation and subsequently experience falls. Apprenticeship programs can improve the timing and content of fall-prevention training. This study suggests that organizational changes in building practices, mentorship, and safety practices are also necessary to decrease worker falls from heights.

Kim, S. S., et al. (2014). "Contractor-, steward-, and coworker-safety practice: Associations with musculoskeletal pain and injury-related absence among construction apprentices." Int Arch Occup Environ Health 87(5): 493-500.

Objectives: This paper sought to assess organizational safety practices at three different levels of hierarchical workplace structure and to examine their association with injury outcomes among construction apprentices. Methods: Using a cross-sectional sample of 1,775 construction apprentices, three measures of organizational safety practice were assessed: contractor-, steward-, and coworker-safety practice. Each safety practice measure was assessed using three similar questions (i.e., on-the-job safety commitment, following required or recommended safe work practices, and correcting unsafe work practices); the summed average of the responses ranged from 1 to 4, with a higher score indicating poorer safety practice. Outcome variables included the prevalence of four types of musculoskeletal pain (i.e., neck, shoulder, hand, and back pain) and injury-related absence. Results: In adjusted analyses, contractor-safety practice was associated with both hand pain (OR: 1.27, 95 % CI: 1.04, 1.54) and back pain (OR: 1.40, 95 % CI: 1.17, 1.68); coworker-safety practice was related to back pain (OR: 1.42, 95 % CI: 1.18, 1.71) and injury-related absence (OR: 1.36, 95 % CI: 1.11, 1.67). In an analysis that included all three safety practice measures simultaneously, the association between coworker-safety practice and injury-related absence remained significant (OR: 1.68, 95 % CI: 1.20, 2.37), whereas all other associations became non-significant. Conclusions: This study suggests that organizational safety practice, particularly coworker-safety practice, is associated with injury outcomes among construction apprentices. © 2013 Springer-Verlag Berlin Heidelberg.

Kincl, L. D., et al. (2016). "Safety voice for ergonomics (SAVE) project: Protocol for a workplace cluster-randomized controlled trial to reduce musculoskeletal disorders in masonry apprentices." BMC Public Health 16: 362.

Background: Masons have the highest rate of overexertion injuries among all construction trades and rank second for occupational back injuries in the United States. Identified ergonomic solutions are the primary method of reducing exposure to risk factors associated with musculoskeletal disorders. However, many construction workers lack knowledge about these solutions, as well as basic ergonomic principles. Construction apprentices, as they embark on their careers, are greatly in need of ergonomics training to minimize the cumulative exposure that leads to musculoskeletal disorders. Apprentices receive safety training; however, ergonomics training is often limited or non-existent. In addition, apprenticeship programs often lack "soft skills" training on how to appropriately respond to work environments and practices that are unsafe. The SAVE program - SAfety Voice for Ergonomics - strives to integrate evidence-based health and safety training strategies into masonry apprenticeship skills training to teach ergonomics, problem solving, and speaking up to communicate solutions that reduce musculoskeletal injury risk. The central hypothesis is that the combination of ergonomics training and safety voice promotion will be more effective than no training or either ergonomics training alone or safety voice training alone. Methods/design: Following the development and pilot testing of the SAVE intervention, SAVE will be evaluated in a cluster-randomized controlled trial at 12 masonry training centers across the U.S. Clusters of apprentices within centers will be assigned at random to one of four intervention groups (n = 24 per group): (1) ergonomics training only, (2) safety voice training only, (3) combined ergonomics and safety voice training, or (4) control group with no additional training intervention. Outcomes assessed at baseline, at the conclusion of training, and then at six and 12 months post training will include: musculoskeletal symptoms, general health perceptions, knowledge of ergonomic and safety voice principles, and perception and attitudes about ergonomic and safety voice issues. Discussion: Masons continue to have a high rate of musculoskeletal disorders. The trade has an expected increase of 40 % in the number of workers by 2020. Therefore, a vetted intervention for apprentices entering the trade, such as SAVE, could reduce the burden of musculoskeletal disorders currently plaguing the trade. © 2016 Kincl et al.

Lipscomb, H. J., et al. (2008). "Challenges in residential fall prevention: insight from apprentice carpenters." Am J Ind Med 51(1): 60-68.

BACKGROUND: Falls remain a serious source of morbidity and mortality in residential construction despite considerable knowledge of risk factors and prevention strategies. While training is universally viewed as positive, we know little about its effectiveness in preventing residential falls. METHODS: A series of focus groups were conducted with union apprentice carpenters (n = 36) at varied levels of training to elicit input on factors that might influence the effectiveness of residential fall prevention training, including hazard awareness, timing of elements of formal instruction, jobsite mentoring, and workplace norms. RESULTS: While apprentices identified many residential fall hazards, they voiced little concern about work near unprotected vertical or horizontal openings such as stairwells, window openings or leading edges. On residential jobs, apprentices worked at heights immediately and were often exposed to hazards they had not yet been trained to handle. The quality of mentoring varied tremendously, and things they had been taught in school were often not the norm on these small worksites. Use of fall arrest equipment was uncommon. Job insecurity in this fast-paced work environment influenced behaviors even when apprentices reported knowledge of safe procedures; this was more of a problem for less experienced

apprentices. CONCLUSIONS: These data provide compelling evidence that apprentices often do not apply safety principles they have been taught in school in the actual work environment, illuminating how attempts to empower workers through training alone can fall short. The findings have policy implications and demonstrate the importance of measuring more than knowledge when evaluating effectiveness of training.

Lipscomb, H. J., et al. (2011). "Buyer beware: personnel selling nail guns know little about dangerous tools." Am J Ind Med 54(8): 571-578.

BACKGROUND: Nail gun use is ubiquitous in wood frame construction. Accessibility and decreasing costs have extended associated occupational hazards to consumers. Compelling evidence documents decreased injury risk among trained users and those with tools with sequential triggers. To prevent inadvertent discharge of nails, this safer trigger requires the nose be depressed before the trigger is pulled to fire. The sequential trigger is not required by the Consumer Product Safety Commission (CPSC) or the Occupational Safety and Health Administration (OSHA) nor are there any guidelines for training. METHODS: We collected data from personnel at 217 points of sale/rental of framing nail guns in four areas of the country. RESULTS: Sales personnel had little understanding of risks associated with use of framing nail guns. Individuals who had used the tool and those working in construction outlets were more likely to be knowledgeable; even so, less than half understood differences in trigger/actuation systems. CONCLUSIONS: Consumers, including contractors purchasing for workers, cannot count on receiving accurate information from sales personnel regarding risks associated with use of these tools. The attitudes and limited knowledge of some sales personnel regarding these potentially deadly tools likely contributes to a culture accepting of injury. The findings demonstrate how influences on the culture of construction are not limited to workers, employers, or the places construction gets done.

Lipscomb, H. J., et al. (2015). "Non-reporting of work injuries and aspects of jobsite safety climate and behavioral-based safety elements among carpenters in Washington state." Am J Ind Med 58(4): 411-421.

Background: Declining work injury rates may reflect safer work conditions as well as under-reporting. Methods: Union carpenters were invited to participate in a mailed, cross-sectional survey designed to capture information about injury reporting practices. Prevalence of non-reporting and fear of repercussions for reporting were compared across exposure to behavioral-based safety elements and three domains of the Nordic Safety Climate Questionnaire (NOSACQ-50). Results: The majority (>75%) of the 1,155 participants felt they could report work-related injuries to their supervisor without fear of retribution, and most felt that the majority of injuries on their jobsites got reported. However, nearly half indicated it was best not to report minor injuries, and felt pressures to use their private insurance for work injury care. The prevalence of non-reporting and fear of reporting increased markedly with poorer measures of management safety justice (NOSACQ-50). Conclusions: Formal and informal policies and practices on jobsites likely influence injury reporting. Am. J. Ind. Med. 58:411-421, 2015. © 2015 Wiley Periodicals, Inc.

Liu, K. H., et al. (2019). "The Gap Between Tools and Best Practice: An Analysis of Safety Prequalification Surveys in the Construction Industry." New Solut 28(4): 683-703.

This study characterizes safety prequalification surveys currently in use in the construction industry to identify approaches that include leading indicators of worker safety performance. We collected prequalification surveys available in the public domain from internet searches,

construction company websites, published literature, and construction industry partners. We utilized a conceptual framework, based on safety theory and best practices, to categorize survey questions. Fifty-two prequalification surveys were identified containing 112 unique questions. Most included questions related to lagging indicators (83 percent), safety management leadership (75 percent), and worker training (60 percent). Safety management system elements such as hazard prevention and control, program evaluation and improvement, and coordination and communication were notably absent in 90 percent of the surveys. There was little consistency in the surveys available concerning leading indicators of safety. Only a small number of surveys currently in use incorporate all the elements of best practices associated with robust safety management systems.

Manjourides, J. and J. T. Dennerlein (2019). "Testing the associations between leading and lagging indicators in a contractor safety pre-qualification database." Am J Ind Med 62(4): 317-324.

BACKGROUND: Safety prequalification assessing contractors' safety management systems and safety programs lack validation in predicting construction worker injuries. METHODS: Safety assessments of leading indicators from 2198 construction contractors, including Safety Management Systems (SMS), Safety Programs (e.g., falls, hearing protection), and Special Elements (drug testing, return to work) scales as well as the history of citations from the Occupational Safety and Health Administration (OSHA) were compared to contractors' lagging indicators of recordable injury case rates (RC) and rates of injuries involving days away, restricted, or transferred (DART). RESULTS: Increased SMS scores were related to lower injury rates. Each one-point increase in SMS values was associated with 34% reduced odds of a recordable case rate greater than zero (Odds ratio (OR): 0.66, 95% Confidence Interval (CI): (0.57, 0.79)), and a 9% reduced recordable case rate, if one occurs (Risk Ratio (RR): 0.91, 95% CI: (0.88, 0.94)). A one-point increase in SMS was associated with 28% reduced odds of a DART (OR = 0.72, 95%CI (0.56, 0.91)), and 9% reduced DART rate, if one occurs (RR = 0.91, 95%CI (0.87, 0.95)). Safety programs did not show consistent associations with injury outcomes. Having additional Special Elements related to drug and alcohol programs was associated with lower injury rates while the Special Element related to return to work showed no consistent associations with injury. Having more OSHA Citations was associated with lower injury rates for companies with injuries. CONCLUSIONS: These results support pre-qualification methods based on SMS and suggest the need for safety management systems in contractors.

Manjourides, J., et al. (2018). "The Effect of Workforce Mobility on Intervention Effectiveness Estimates." Ann Work Expo Health 62(3): 259-268.

BACKGROUND: Little is known about how mobile populations of workers may influence the ability to implement, measure, and evaluate health and safety interventions delivered at worksites. METHODS: A simulation study is used to objectively measure both precision and relative bias of six different analytic methods as a function of the amount of mobility observed in the workforce. Those six methods are then used to reanalyze a previously conducted cluster-randomized control trial involving a highly mobile workforce in the construction industry. RESULTS: As workforce mobility increases, relative bias in treatment effects derived from standard models to analyze cluster-randomized trials also increases. Controlling for amount of time exposed to the intervention can greatly reduce this bias. Analyzing only subsets of workers who exhibit the least amount of mobility can result in decreased precision of treatment effect estimates. We demonstrate a 59% increase in the treatment effect size from the reanalysis of the previously conducted trial. CONCLUSIONS: When evaluating organizational interventions implemented at

specific worksites by measuring perceptions and outcomes of workers present at those sites, researchers should consider the effects that the mobility of the workforce may have on the estimated treatment effects. The choice of analytic method can greatly affect both precision and accuracy of estimates.

Marin, L. S., et al. (2015). "Results of a community-based survey of construction safety climate for Hispanic workers." Int J Occup Environ Health 21(3): 223-231.

BACKGROUND: Hispanic construction workers experience high rates of occupational injury, likely influenced by individual, organizational, and social factors. OBJECTIVES: To characterize the safety climate of Hispanic construction workers using worker, contractor, and supervisor perceptions of the workplace. METHODS: We developed a 40-item interviewer-assisted survey with six safety climate dimensions and administered it in Spanish and English to construction workers, contractors, and supervisors. A safety climate model, comparing responses and assessing contributing factors was created based on survey responses. RESULTS: While contractors and construction supervisors' (n = 128) scores were higher, all respondents shared a negative perception of safety climate. Construction workers had statistically significantly lower safety climate scores compared to supervisors and contractors (30.6 vs 46.5%, $P<0.05$). Safety climate scores were not associated with English language ability or years lived in the United States. CONCLUSIONS: We found that Hispanic construction workers in this study experienced a poor safety climate. The Hispanic construction safety climate model we propose can serve as a framework to guide organizational safety interventions and evaluate safety climate improvements.

Marín, L. S., et al. (2019). "Perceptions of safety climate across construction personnel: Associations with injury rates." Safety science 118: 487-496.

While there is a growing body of literature on assessing perceptions of safety climate, many of these studies report a company’s safety climate as a worker-based phenomenon. Discrepancies in perceptions of safety across different hierarchical groups in an organization may increase barriers to the development and implementation of effective ways to mitigate workplace hazards. This study examines and compares the perceptions of safety climate among three groups of construction personnel: (1) construction workers, (2) field supervisors, and (3) site managers; as well as evaluating the relationships among discrepancies in perceptions of safety and reported injury rates. The Nordic Occupational Safety Climate Questionnaire (NOSACQ-50), which consists of 50 items across seven dimensions, was used to assess safety climate perceptions across construction site personnel. In total, 266 workers, 55 supervisors and 32 site managers from 26 Colombian construction companies were surveyed. Results confirmed differences in overall perceptions as well as across safety climate dimensions. Managers reported higher safety climate scores than supervisors and construction workers. There were no statistically significant relationships between each group’s perceptions of safety climate and the company’s 3-year injury rate. However, worker-manager discrepancies in perceptions of safety were positively correlated with the 3-year injury rate of construction companies. Better understanding of the differences in perceptions of safety climate across construction personnel, may make it possible to design comprehensive safety interventions that involve managers, supervisors, and workers. Targeting each group with initiatives customized to bridge their particular gaps can identify opportunities to improve workplace safety and health.

Marín, L. S. and C. Roelofs (2017). "Promoting Construction Supervisors' Safety-Efficacy to Improve Safety Climate: Training Intervention Trial." Journal of Construction Engineering and Management 143(8): 04017037.

Hispanic workers may be more likely to experience a deficient safety climate on construction worksites and it may account for their disproportionate injury rates. As part of a large study, the authors developed and implemented a 5-h training program to improve construction supervisors' safety-efficacy, in order to enhance the safety climate on construction worksites. The training program covered fall prevention, silica exposure, leadership, communication, and safety planning. This study evaluated pretraining and posttraining changes and safety-efficacy six months posttraining. A total of 118 supervisors, contractors, and workers from more than 50 construction firms in Massachusetts attended the training. Statistically significant improvements were observed in participants' safety knowledge, skills, and attitudes. Six-months postintervention, 58% of supervisors, contractors, or both, perceived that the training contributed "a lot" to their ability to communicate effectively with Spanish-speaking workers, to take on a safety leadership role (52%), and to conduct effective training (62%). This study determined that when supervisors perceive that they have the knowledge, skills, and confidence to make changes, they may better fulfill their role as a safety leader. Construction supervisor training courses might be revised to include leadership and effective communication topics. - See more at: http://ascelibrary.org/doi/full/10.1061/%28ASCE%29CO.1943-7862.0001330#sthash.bOwqmOhn.dpuf

McDonald, M. A., et al. (2009). ""Safety is everyone's job:" the key to safety on a large university construction site." J Safety Res 40(1): 53-61.

PROBLEM: Construction risk management is challenging. METHOD: We combined data on injuries, costs, and hours worked, obtained through a Rolling Owner-Controlled Insurance Program (ROCIP), with data from focus groups, interviews, and field observations, to prospectively study injuries and hazard control on a large university construction project. RESULTS: Lost-time injury rates (1.0/200,000 hours worked) were considerably lower than reported for the industry, and there were no serious falls from height. Safety was considered in the awarding of contracts and project timeline development; hazard management was iterative. A top-down management commitment to safety was clearly communicated to, and embraced by, workers throughout the site. DISCUSSION AND IMPACT: A better understanding of how contracting relationships, workers' compensation, and liability insurance arrangements influence safety could shift risk management efforts from worker behaviors to a broader focus on how these programs and relationships affect incentives and disincentives for workplace safety and health.

Molenaar, K. R., et al. (2009). "Framework for measuring corporate safety culture and its impact on construction safety performance." Journal of Construction Engineering and Management 135(6): 488-496.

This paper presents the results of a structural equation model (SEM) that describes and quantifies the relationships between corporate culture and safety performance. The SEM is estimated using 196 individual questionnaire responses from three companies with better than average safety records. A multiattribute analysis of corporate safety culture characteristics resulted in a hierarchical description of corporate safety culture comprised of three major categories: people, process, and value. These three major categories were decomposed into 54 measurable questions and used to develop a questionnaire to quantify corporate safety culture. The SEM identified five

latent variables that describe corporate safety culture: (1) a company's safety commitment; (2) the safety incentives that are offered to field personal for safe performance; (3) the subcontractor involvement in the company culture; (4) the field safety accountability and dedication; and (5) the disincentives for unsafe behaviors. These characteristics of company safety culture serve as indicators for a company's safety performance. Based on the findings from this limited sample of three companies, this paper proposes a list of practices that companies may consider to improve corporate safety culture and safety performance. A more comprehensive study based on a larger sample is recommended to corroborate the findings of this study.

Namian, M., et al. (2022). "Are Construction Managers from Mars and Workers from Venus? Exploring Differences in Construction Safety Perception of Two Key Field Stakeholders." Int J Environ Res Public Health 19(10).

Persisting high rates of worksite accidents and injuries in construction projects indicate the urge to investigate the root causes and revisit safety practices in this industry. Consonance in perceptions and safety approaches has been identified as a fundamental factor in boosting projects' safety. Discrepancies between how different elements of construction safety are perceived and handled by the key stakeholders, namely managers and workers, could be detrimental to worksite safety. This research studied how, if at all, the perception of four key construction safety components, including 33 sets of pairwise questions, is different in the lens of managers from workers. To explore safety perceptions, 133 construction professionals in the United States participated in the study and expressed their perceptions toward their own and counterparts' (1) safety knowledge, (2) safety culture and commitment, (3) safety performance, and (4) safety support and communication. The results indicated that massive gaps in safety perceptions do exist between the construction managers and workers (26 out of 33 areas), and the magnitude varies for different safety elements. In all four categories, both managers and workers perceived a superior safety position for themselves and inferior for their counterparts. Further investigations revealed that the common ground between managers and workers is their consensus on proper communication and safety training as the key solutions to address such discrepancies. Construction safety professionals and practitioners can benefit from the results of this study to establish and implement strategies to foster communication and provide more effective safety training to bridge the existing gaps in the perception of safety by managers and workers.

Pandit, B., et al. (2020). "Developing construction hazard recognition skill: leveraging safety climate and social network safety communication patterns." Construction Management and Economics 38(7): 640-658.

Poor hazard recognition skill is a widespread issue in the construction industry. Therefore, an understanding of factors that influence the development of hazard recognition skill among workers is fundamental to effective safety management. Based on social learning theory which suggests that individuals learn efficiently by observing, interacting, and emulating others in workplaces, the current article reports findings from a larger study that examined the effect of safety climate and social-network safety communication patterns on the hazard recognition skill demonstrated by workers. More specifically, building upon previously reported findings presented in Pandit et al. which suggests that maintaining a more positive safety climate can lead to superior hazard recognition levels, the current article presents additional results examining the effect of safety climate and social-network safety communication patterns?maintained by workers?on the demonstrated hazard recognition skill. The study involved recruiting construction crews from 57

projects in the United States where safety climate and social-network safety communication data were gathered using questionnaire surveys?which was then followed by a hazard recognition activity. The results suggest that, apart from the safety climate, social-network safety communication patterns are positively related to the demonstrated hazard recognition skill. In addition, evidence of an interaction effect was found?suggesting that establishing a positive safety climate and maintaining higher levels of safety communication can yield synergistic benefits.

Pandit, B., et al. (2018). "Fostering Safety Communication among Construction Workers: Role of Safety Climate and Crew-Level Cohesion." Int J Environ Res Public Health 16(1).

Safety communication among construction workers is fundamental to effective safety management. However, evidence suggests that poor safety communication is a common problem in construction workplaces. In fact, previous research has unveiled a number of systemic barriers to effective safety communication in the construction industry. When workers do not sufficiently communicate relevant safety hazards and appropriate injury prevention measures, unexpected injuries can follow. Therefore, research examining factors that promote or impede effective safety communication is necessary. Towards achieving this goal, the purpose of the current research was to evaluate the effect of safety climate and crew cohesion on the demonstrated safety communication levels. The goal was achieved by gathering empirical data from 57 construction workplaces in the United States. More specifically, the participating construction workplaces were visited, and data pertaining to the safety climate and crew-level cohesion were first collected using questionnaire surveys. Next, a safety communication survey instrument was administered, and the data necessary to compute network density-a social network metric that is indicative of safety communication levels was gathered. The analysis of the data suggested that a positive relationship exists between safety climate and safety communication levels. Likewise, construction crews that demonstrated higher levels of cohesion exhibited superior safety communication levels. Finally, evidence also suggested that a synergetic effect exists between safety climate and crew cohesion in improving safety communication levels.

Perry, M. J., et al. (2015). "Evaluating Fall Safety Compliance among Skilled Trades in Construction (CPWR Report)."

Pinion, C., et al. (2018). "North American Engineering, Procurement, Fabrication and Construction Worker Safety Climate Perception Affected by Job Position." Safety 4(2): 14.

Understanding and implementing the results of Safety Climate surveys can assist in decreasing occupational injuries and illnesses. The following article presents findings of a cross-sectional study that assessed the relationship between safety climate perceptions and job position among engineering, procurement, fabrication and construction (EPFC) employees using a 15-item survey. Descriptive statistics (means and frequencies) and an ANACOVA (analysis of covariance) were performed on a saturated model. The study had a 62% response rate. Results indicate a statistically significant in mean safety climate scores between job position among EPFC employees when controlling for years in industry and location type (i.e., construction versus fabrication) [$F(9, 603) = 5.28$, $p < 0.0001$, adjusted R-square = 0.07]. Employee perception of safety climate differed based on the employee's job position (i.e., laborer, foreman, etc.). Project management reported the highest safety climate scores (0.91), followed by supervisors (0.86), technical support employees and foremen (0.84) and laborers (0.81).

Probst, T. M., et al. (2008). "Organizational injury rate underreporting: the moderating effect of organizational safety climate." J Appl Psychol 93(5): 1147-1154.

The goals of this study were (a) to assess the extent to which construction industry workplace injuries and illness are underreported, and (b) to determine whether safety climate predicts the extent of such underreporting. Data from 1,390 employees of 38 companies contracted to work at a large construction site in the northwestern United States were collected to assess the safety climate of the companies. Data from the Occupational Safety and Health Administration (OSHA) logs kept by the contractors allowed for calculation of each company's OSHA recordable injury rate (i.e., the reported injury rate), whereas medical claims data from an Owner-Controlled Insurance Program provided the actual experienced rate of injuries for those same companies. While the annual injury rate reported to OSHA was 3.11 injuries per 100 workers, the rate of eligible injuries that were not reported to OSHA was 10.90 injuries per 100 employees. Further, organizations with a poor safety climate had significantly higher rates of underreporting (81% of eligible injuries unreported) compared with organizations with a positive safety climate (47% of eligible injuries unreported). Implications for organizations and the accuracy of the Bureau of Labor Statistics's national occupational injury and illness surveillance system are discussed.

Probst, T. M., et al. (2019). "The Safety Climate Assessment Tool (S-CAT): A rubric-based approach to measuring construction safety climate." J Safety Res 69: 43-51.

INTRODUCTION: This paper presents the development and validation of a new rubric-based Safety Climate Assessment Tool (S-CAT). The S-CAT gives companies the opportunity to use rubric descriptors, rather than traditional Likert scale responses, to self-assess their level of safety climate maturity and receive a composite score benchmarked against others in the S-CAT database. METHOD: The S-CAT is composed of 37 separate indicators of 8 safety climate factors identified by construction industry subject matter experts. The eight factors have between three and six indicators each with its own rubric-based response-scale. The scales comprise descriptors for five levels of safety climate maturity ranging from "inattentive" to "exemplary." Nine hundred and eighty-five respondents working in the construction industry completed the S-CAT via our online safety climate website. We used company recordable incident rates (RIR) to assess the S-CAT's criterion-related validity. RESULTS: Cronbach alphas for each factor ranged from 0.77 to 0.90 and a confirmatory factor analysis supported the hypothesized eight factor structure with a higher-order safety climate factor. Seven of the eight factor scores, as well as the overall S-CAT score, were significantly negatively correlated with RIR. Moreover, a relative weights analysis indicated that a weighted combination of the eight safety climate factors explained 27% of the variance in organizational RIR. CONCLUSIONS: These findings provide evidence that the S-CAT is a reliable tool allowing construction companies to self-assess their safety climate along eight different factors. Moreover, the S-CAT was significantly associated with organizational injury rates. Practical applications: We discuss how companies can use the rubric descriptors to strengthen their safety management systems and improve their safety climate maturity.

Puerto, C. L. d., et al. (2014). "Exploratory Study to Identify Perceptions of Safety and Risk among Residential Latino Construction Workers as Distinct from Commercial and Heavy Civil Construction Workers." Journal of Construction Engineering and Management 140(2): 04013048.

Latino workers in residential construction currently suffer disproportionately high rates of injuries and fatalities compared to Latino workers in commercial and heavy civil construction. The aim of this study is to investigate possible differences in safety culture and risk perception among

Latino construction workers across residential, commercial, and heavy civil construction sectors. Analysis was conducted using 218 survey responses from Latino construction workers collected in the Denver metro and northern Colorado areas. Results suggest that Latino workers in commercial and heavy civil construction share more similar perceptions of safety culture and risk than those in residential construction. Specifically, Latino workers in residential construction were more likely to agree with the statements that (1) work productivity and quality have a higher priority than safety and (2) safety rules and safety procedures are difficult to understand and that dangers present on construction sites cannot cause death. This study enhances the knowledge about the safety culture and risk perceptions of Latino construction workers in all three sectors. Study findings support the hypothesis that differences in safety culture perceptions among Latinos may contribute to differences in injury rates across the three sectors. Specifically, perceptions of a less-supportive safety culture may correlate to higher rates of miscommunication and incorrect assumptions that influence decision making, resulting in disproportionately higher rates of injuries and fatalities in residential construction compared to commercial and heavy civil construction. Such research findings are important because they provide a meaningful context and basis for effective construction worker safety interventions in the future.

R. Kaufman and, B., et al. (2014). "Interactive effects of leader justice and support for safety on safety performance." Journal of Organizational Effectiveness: People and Performance 1(3): 296-315.

Ringen, K., et al. (2018). "Construction Safety and Health in the USA: Lessons From a Decade of Turmoil." Ann Work Expo Health 62(suppl_1): S25-S33.

The construction industry is one of the largest and also most hazardous industries in the USA. It is affected more severely by the business cycle than most other industries. We examined industry trends during the last decade including the severe recession. During 2008 to 2010, as a result of the recession, 2.7 million workers and 20% of all employers left the industry. By 2010, the number and rate of traumatic fatalities had reached its lowest point ever, only to gradually increase again as the industry recovered from the recession. The risks of a fatality were disproportionate with employer size. The small employers (<20 employees), which account for 37.5% of employment, were responsible for 57% of all fatalities. These small employers are less likely to embrace essential safety culture practices and are slow to adopt new approaches to occupational safety and health. These employers-especially those which hire immigrant workers and self-employed workers-lag far behind in terms of adopting even essential elements of good safety cultures and management practices. Currently, there are no restrictions on going into business as a construction contractor or seeking employment as a construction worker. There is a great need to find ways to establish minimum qualifications for becoming a construction contractor and for becoming a construction worker. Some jurisdictions have established minimum occupational safety and health training. This is a good start, but qualifications must include greater emphasis on minimum skills requirements. State and local jurisdictions have good policy tools which could be deployed for this purpose but which have largely been neglected: licensing of both companies and workers could include skills qualifications; construction permits could include requirements for occupational safety and health; and greater use of criminal prosecution could be pursued where it is obvious that basic requirements for safety and health have been ignored.

Rojas, E. M. (2013). "Identifying, recruiting, and retaining quality field supervisors and project managers in the electrical construction industry." Journal of Management in Engineering 29(4): 424-434.

Productivity depends upon many factors including motivation, symmetry between assignments and skills, anticipation of technical challenges during tasks, precise instructions, availability of materials and equipment, coordination with other trades, creativity, and emphasis on safety and quality. Good field supervisors and project managers foster such productivity. Over 100 participants ranging from electricians to company owners informed a modified 360 assessment of field supervisors and project managers within the unionized electrical contracting community. Focus group discussions and interviews assessed the beneficial characteristics of field supervisors and project managers. Analysis of these characteristics yielded consistent themes, which became the 12 pillars of successful supervision. Based upon these pillars, effective recruitment and retention strategies for both field supervisors and project managers were developed. © 2013 American Society of Civil Engineers.

Sa, J., et al. (2009). "Comparison of risk factors for falls from height between commercial and residential roofers." J Safety Res 40(1): 1-6.

INTRODUCTION: The purpose of this investigation was to compare commercial roofers and residential roofers in terms of their behaviors, beliefs, working conditions, and attitudes toward the use of fall protection devices, which could lead to fall accidents. METHODS: A cross-sectional sample of 252 roofers participated in the survey in the Midwest (Wisconsin, Illinois, Michigan, Indiana, and Iowa). RESULTS: Residential roofers were more likely to fall (prevalence ratio = 2.28, 95% CI = 1.58, 3.29) [corrected] than commercial roofers. Race/ethnicity, company size, work type, existence [corrected] of fall protection programs, enforcement of fall protection device use, actual use of fall protection devices, years of experience as a roofer, and perceived level of safety at roofing sites were [corrected] significantly associated with fall accidents. IMPACT ON INDUSTRY: This study adds insight into fall accidents from roofs in the construction industry and provides industry-specific cautions against fall accidents that can be reflected in regulatory agency implementation.

Salas, R., et al. (2020). "Safety Risk Tolerance in the Construction Industry: Cross-Cultural Analysis." Journal of Construction Engineering and Management 146(4): 04020022.

Disparities in worker risk tolerance may create barriers to implementing safety management systems and improving safety performance. At present, it is unclear if and to what extent construction safety risk tolerance vary across broad geographic regions. To better understand patterns in these sociocultural constructs, a survey of building trade contractors and subcontractors was administered. Using principal component analysis and K-means clustering, the determinants of risk tolerance were analyzed for 11,997 construction workers from 17 countries via controlled sampling for equal representation. The analysis showed that risk tolerance is influenced and linked by individual and sociocultural determinants, i.e., affective associations, control beliefs, safety culture, and risk-taking attitudes. Differences and distinct groupings were observed when the derived global risk tolerance scores were compared to country-specific risk-tolerance scores. This study contributes to the literature by empirically identifying determinants of risk tolerance and quantifying cross-cultural disparities in risk tolerance. It was found that the natural grouping of countries, based on their risk-tolerance determinants, coincides with their ancestral heritage and socioeconomic systems. The results can be used to inform policymakers, stakeholders, safety

professionals, and industry leaders to improve safety decisions in the workplace, promote strong situational awareness, design structural policies, and implement safety programs.

Sampson, J. M., et al. (2014). "Role of safety stressors and social support on safety performance." Safety science 64: 137-145.

Saunders, L. W., et al. (2017). "Developing an inter-organizational safety climate instrument for the construction industry." Safety science 98: 17-24.

In the construction industry, recent literature has promoted a design for safety approach that discusses the benefits of considering safety from the very start of the project lifecycle. With this approach, non-construction personnel, such as owners and designers, need to work alongside constructors and subcontractors to consider safety during design and procurement stages of a project. This is a difficult process, particularly with the degree of fragmentation in the industry. Safety climate survey instruments have been developed to identify these sources of fragmentation among stakeholder groups, but most of these tools are directed toward on-site construction personnel. This paper describes the development of an inter-organizational safety climate instrument for measuring attitudes toward safety of construction industry stakeholders including owners, designers, construction managers, and subcontractors. Overall, the measurement model demonstrated a good fit with the data based on a confirmatory factor analysis. Therefore, the survey instrument provides a useful tool for researchers and practitioners to identify the sources of fragmentation in attitudes of construction project personnel toward worker safety that can affect occupational health and safety within the industry. © 2017

Schwatka, N. V., et al. (2020). "Change in frontline supervisors' safety leadership practices after participating in a leadership training program: Does company size matter?" J Safety Res 74: 199-205.

INTRODUCTION: The majority of construction companies are small businesses and small business often lack the resources needed to ensure that their supervisors have the safety leadership skills to build and maintain a strong jobsite safety climate. The Foundations for Safety Leadership (FSL) training program was designed to provide frontline leaders in all sized companies with safety leadership skills. This paper examines the impact of the FSL training by size of business. METHODS: Leaders, defined as foremen or other frontline supervisors, from small, medium, and large construction companies were recruited to participate in a study to evaluate the degree to which the FSL changed their understanding and use of the leadership skills, safety practices and crew reporting of safety-related conditions. We used linear mixed modeling methods to analyze pre-post training survey data. RESULTS: Prior to the training, leaders from small and medium sized companies reported using safety leadership skills less frequently than those from large ones. After the training, regardless of business size, we observed that the FSL training improved leaders understanding of safety leadership skills from immediately before to immediately after the training. Additionally, leaders reported greater use of safety leadership skills, safety practices, and crew reporting of safety-related conditions from before to two-weeks after the training. However, those from small and medium sized companies reported the greatest improvement in their use of safety leadership skills. CONCLUSIONS: The FSL training improves safety leadership outcomes regardless of the size company for which the leader worked. However, the FSL may be even more effective at improving the safety leadership skills of leaders working for smaller sized construction companies or those with lower baseline levels of safety leadership skills. Practical applications: The

majority of construction companies employ a small number of employees and therefore may not have the resources to provide their frontline leaders with the leadership training they need to be effective leaders who can create a strong jobsite safety climate. The Foundations for Safety Leadership (FSL) training can help fill this gap.

Schwatka, N. V., et al. (2019). "A training intervention to improve frontline construction leaders' safety leadership practices and overall jobsite safety climate." J Safety Res 70: 253-262.

INTRODUCTION: The 2.5 h Foundations for Safety Leadership (FSL) training program teaches construction supervisors the leadership skills they need to strengthen jobsite safety climate and reduce adverse safety-related outcomes. METHODS: Using a quasi-experimental prospective switching replications study design, we examined (1) if FSL-trained jobsite safety leaders would report improved understanding and practice of the FSL leadership skills, safety practices and crew reporting of safety related conditions, and (2) if their crew perceived a change in (a) their supervisors' practices, (b) their own safety practices and reporting of safety-related conditions, and (c) overall jobsite safety climate. Twenty construction sub-contracting companies were recruited and randomly assigned to either an early or lagged-control training group. Participating supervisors and workers completed surveys at multiple time points before and after the FSL training. We used linear mixed modeling to test changes over time. RESULTS: Only supervisors in the early group reported a statistically significant improvement in their understanding and practice of the leadership skills as well as safety practices from before to 2- and 4-weeks post-training. Overall, no significant change was detected in crew-reported outcomes from before to after their supervisors' participated in the FSL training. CONCLUSIONS: These results provide evidence that the FSL training can, at least in the short-term, improve construction frontline leaders' jobsite leadership skills. Future research could include an evaluation of FSL refresher activities and a longer-term follow-up. Practical applications: The Foundations for Safety Leadership (FSL) program fills an identified need for construction frontline supervisors to learn and practice critical safety leadership skills on the jobsite. It has already reached over 60,000 leaders and has the potential to reach over 100,000 each year during either an OSHA 30-h or a stand-alone course.

Schwatka, N. V., et al. (2016). "Defining and Measuring Safety Climate: A Review of the Construction Industry Literature." Ann Occup Hyg 60(5): 537-550.

Safety climate measurements can be used to proactively assess an organization's effectiveness in identifying and remediating work-related hazards, thereby reducing or preventing work-related ill health and injury. This review article focuses on construction-specific articles that developed and/or measured safety climate, assessed safety climate's relationship with other safety and health performance indicators, and/or used safety climate measures to evaluate interventions targeting one or more indicators of safety climate. Fifty-six articles met our inclusion criteria, 80% of which were published after 2008. Our findings demonstrate that researchers commonly defined safety climate as perception based, but the object of those perceptions varies widely. Within the wide range of indicators used to measure safety climate, safety policies, procedures, and practices were the most common, followed by general management commitment to safety. The most frequently used indicators should and do reflect that the prevention of work-related ill health and injury depends on both organizational and employee actions. Safety climate scores were commonly compared between groups (e.g. management and workers, different trades), and often correlated with subjective measures of safety behavior rather than measures of ill health or objective safety and health outcomes. Despite the observed limitations of current research, safety climate has been

promised as a useful feature of research and practice activities to prevent work-related ill health and injury. Safety climate survey data can reveal gaps between management and employee perceptions, or between espoused and enacted policies, and trigger communication and action to narrow those gaps. The validation of safety climate with safety and health performance data offers the potential for using safety climate measures as a leading indicator of performance. We discuss these findings in relation to the related concept of safety culture and offer suggestions for future research and practice including (i) deriving a common definition of safety climate, (ii) developing and testing construction-specific indicators of safety climate, and (iii) focusing on construction-specific issues such as the transient workforce, subcontracting, work organization, and induction/acculturation processes.

Schwatka, N. V. and J. C. Rosecrance (2016). "Safety climate and safety behaviors in the construction industry: The importance of co-workers commitment to safety." Work 54(2): 401-413.

BACKGROUND: There is growing empirical evidence that as safety climate improves work site safety practice improve. Safety climate is often measured by asking workers about their perceptions of management commitment to safety. However, it is less common to include perceptions of their co-workers commitment to safety. While the involvement of management in safety is essential, working with co-workers who value and prioritize safety may be just as important. OBJECTIVE: To evaluate a concept of safety climate that focuses on top management, supervisors and co-workers commitment to safety, which is relatively new and untested in the United States construction industry. METHODS: Survey data was collected from a cohort of 300 unionized construction workers in the United States. The significance of direct and indirect (mediation) effects among safety climate and safety behavior factors were evaluated via structural equation modeling. RESULTS: Results indicated that safety climate was associated with safety behaviors on the job. More specifically, perceptions of co-workers commitment to safety was a mediator between both management commitment to safety climate factors and safety behaviors. CONCLUSIONS: These results support workplace health and safety interventions that build and sustain safety climate and a commitment to safety amongst work teams. © 2016 - IOS Press and the authors.

Shrestha, P. P. and N. N. Menzel (2014). "Hispanic construction workers and assertiveness training." Work 49(3): 517-522.

BACKGROUND: Hispanic (Latino) construction workers experience disparities in occupational death and injury rates in the United States. The cultural value of respect for those in authority may hinder these workers from requesting safe working conditions from supervisors. OBJECTIVE: To evaluate whether Hispanic construction workers in Las Vegas, Nevada found assertiveness training more useful than non-Hispanic trainees and whether or not they practiced this behavior at work after the training. METHODS: An assertiveness training simulation was part of fall prevention classes offered to area construction workers. Eight weeks after the training, participants were interviewed by telephone about class topics they found most useful and whether or not they had made any subsequent behavior changes at work. RESULTS: More than half of the 760 fall prevention trainees completed telephone interviews. A smaller proportion of Hispanic trainees found assertiveness training to be useful (11%) than non-Hispanics (28%) ($p \leqslant 0.001$). Only 2% of both groups identified practicing assertiveness at work. CONCLUSIONS: A large proportion of Hispanic trainees valued other knowledge more highly. They may weigh job security as more important than speaking up about safety issues, which might threaten their employment.

Interventions to improve safety should focus instead on improving work safety climate and engineering controls.

Silver, K., et al. (2011). "Genetic susceptibility testing for beryllium: worker knowledge, beliefs, and attitudes." Am J Ind Med 54(7): 521-532.

BACKGROUND: We sought to gain insight into workers' knowledge, beliefs, and attitudes on the subject of testing for genetic susceptibility to beryllium. METHODS: Five focus groups were held with 30 current and former beryllium workers and nine family members. Audio recordings were transcribed and assessed by hierarchical coding using an inductive approach. RESULTS: Some workers were unclear about the distinction between genotoxicity and heritability. A key finding is that they perceived the benefits of a positive test result to be related to enhanced autonomous decision-making. The major concern cited by participants was potential abuse of genetic information by employers. Complete financial separation of a prospective testing entity from the employer was seen as crucial. CONCLUSIONS: A window of opportunity exists to create regional partnerships for translational research on genetic susceptibility testing. Such partnerships would involve labor, management, public health scientists, primary care professionals, and other stakeholders. They would be critical to identifying testing strategies that maximize worker autonomy along with the public health advantages of genetic testing.

Sinyai, C. and S. Choi (2020). "Fifteen years of American construction occupational safety and health research." Safety science 131: 104915.

The researchers reviewed construction occupational safety and health research published in high-impact, peer-reviewed academic journals between 2002 and 2016 to assess whether research in the field is efficiently targeted to produce evidence-based interventions addressing the industry’s most serious occupational hazards. Unlike most previous surveys of the field, this interdisciplinary literature search captured research published in the construction management and engineering literature as well as that in public health and medicine journals. The researchers found 741 articles by US-based lead authors, with falls the most-studied safety hazard (89 articles) and airborne silica exposure the most-studied health hazard (51), both among the deadliest current hazards in construction occupational safety and health, but much asbestos research was sponsored by companies involved in litigation, generating few findings useful for protecting today’s workers. The review described important trends in the literature, including increased attention to noise and hearing loss, a growing number of intervention studies, and greater concern for populations at disproportionate risk (e.g., small/residential, Latino/immigrant, younger/older workers, & women working in construction). The National Institute for Occupational Safety and Health (NIOSH) directly or indirectly funded a majority of the published research. Policymakers should understand that most occupational safety and health research depends on NIOSH funding.

Sokas, R. K., et al. (2009). "An intervention effectiveness study of hazard awareness training in the construction building trades." Public Health Rep 124 Suppl 1: 160-168.

OBJECTIVE: We evaluated knowledge, attitudes, and self-reported work practices among apprentice and journeyman trainees in two construction trades at baseline and three months after participation in two training sessions as part of a 10-hour Occupational Safety and Health Administration hazard awareness training program. We developed preliminary assessment of prior and current training impact, accounting for demographics, trade, and construction site safety climate. METHODS: Participants were recruited prior to union-delivered safety training, self-

completed a baseline survey prior to class, and completed a follow-up interviewer-administered telephone survey three months later. Discrimination (D) testing evaluated knowledge questions, paired t-tests examined differences in pre- and post-intervention knowledge, and attitude responses were tested with the Wilcoxon signed rank test. Linear regression analysis and logistic regression were used to assess the contribution of different categorical responses to specific sub-questions. RESULTS: Of 175 workers completing the baseline survey, 127 were born in the U.S. and 41 were born in Mexico; 40% of those who reported ethnicity were Hispanic. Follow-up surveys were completed by 92 (53%) respondents and documented significant increases in both fall safety and electrical safety knowledge. The most recent safety climate was associated with improvement in fall safety attitudes (slope = 0.49, $p < 0.005$) when adjusted by country of birth (slope = 0.51, $p < 0.001$). Workers born in Mexico had less formal education than U.S.-born workers and lower baseline knowledge scores, but more positive attitude scores at baseline and greater improvements in attitude at follow-up. CONCLUSION: Knowledge and attitude improvement following a one-hour safety class was measurable at three months in both U.S.-born and Mexican-born construction workers.

Soltaninejad, M., et al. (2022). "Safety climate and productivity improvement of construction workplaces through the 6S system: mixed-method analysis of 5S and safety integration." Int J Occup Saf Ergon 28(3): 1811-1821.

The purpose of this study is to develop a framework for integrating essential safety practices (visualization, job safety analysis and plan-do-check-act) into 5S steps and validate it. First, 18 interviews with a snowball sample of construction workers, safety representatives, supervisors and site and project managers were conducted. A grounded theory method was utilized to code the interview data. The results revealed that the studied construction companies implement a systematic safety-based methodology to minimize construction work injuries. Second, to validate the proposed framework, a pre-test and post-test study was applied. The case and control groups (26 participants) answered a 6S questionnaire before the 6S system and 1 month after implementation. The results revealed that safety climate and productivity significantly increased for the case group but reduced for the control group during time.

Sparer, E. and J. Dennerlein (2017). "Safety Communication & Recognition: From Research to Practice in Construction." Professional Safety 62(3): 30.

Sparer, E. H., et al. (2016). "Improving safety climate through a communication and recognition program for construction: a mixed methods study." Scand J Work Environ Health 42(4): 329-337.

OBJECTIVES: This study aimed to evaluate the efficacy of a safety communication and recognition program (B-SAFE), designed to encourage improvement of physical working conditions and hazard reduction in construction. METHODS: A matched pair cluster randomized controlled trial was conducted on eight worksites (four received the B-SAFE intervention, four served as control sites) for approximately five months per site. Pre- and post-exposure worker surveys were collected at all sites (N=615, pre-exposure response rate of 74%, post-exposure response rate of 88%). Multi-level mixed effect regression models evaluated the effect of B-SAFE on safety climate as assessed from surveys. Focus groups (N=6-8 workers/site) were conducted following data collection. Transcripts were coded and analyzed for thematic content using Atlas.ti (version 6). RESULTS: The mean safety climate score at intervention sites, as measured on a 0-50 point scale, increased 0.5 points (1%) between pre- and post-B-SAFE exposure, compared to control sites that

decreased 0.8 points (1.6%). The intervention effect size was 1.64 (3.28%) (P-value=0.01) when adjusted for month the worker started on-site, total length of time on-site, as well as individual characteristics (trade, title, age, and race/ethnicity). At intervention sites, workers noted increased levels of safety awareness, communication, and teamwork compared to control sites. CONCLUSIONS: B-SAFE led to many positive changes, including an improvement in safety climate, awareness, teambuilding, and communication. B-SAFE was a simple intervention that engaged workers through effective communication infrastructures and had a significant, positive effect on worksite safety.

Sparer, E. H., et al. (2015). "Development of a safety communication and recognition program for construction." New Solut 25(1): 42-58.

Leading-indicator-based (e.g., hazard recognition) incentive programs provide an alternative to controversial lagging-indicator-based (e.g., injury rates) programs. We designed a leading-indicator-based safety communication and recognition program that incentivized safe working conditions. The program was piloted for two months on a commercial construction worksite and then redesigned using qualitative interview and focus group data from management and workers. We then ran the redesigned program for six months on the same worksite. Foremen received detailed weekly feedback from safety inspections, and posters displayed worksite and subcontractor safety scores. In the final program design, the whole site, not individual subcontractors, was the unit of analysis and recognition. This received high levels of acceptance from workers, who noted increased levels of site unity and team-building. This pilot program showed that construction workers value solidarity with others on site, demonstrating the importance of health and safety programs that engage all workers through a reliable and consistent communication infrastructure. © The Author(s) 2015 Reprints and permissions: sagepub.co.uk/journalsPermissions.nav.

Sparer, E. H., et al. (2013). "Correlation between safety climate and contractor safety assessment programs in construction." Am J Ind Med 56(12): 1463-1472.

Background: Contractor safety assessment programs (CSAPs) measure safety performance by integrating multiple data sources together; however, the relationship between these measures of safety performance and safety climate within the construction industry is unknown. Methods: Four hundred and one construction workers employed by 68 companies on 26 sites and 11 safety managers employed by 11 companies completed brief surveys containing a nine-item safety climate scale developed for the construction industry. CSAP scores from ConstructSecure, Inc., an online CSAP database, classified these 68 companies as high or low scorers, with the median score of the sample population as the threshold. Spearman rank correlations evaluated the association between the CSAP score and the safety climate score at the individual level, as well as with various grouping methodologies. In addition, Spearman correlations evaluated the comparison between manager-assessed safety climate and worker-assessed safety climate. Results: There were no statistically significant differences between safety climate scores reported by workers in the high and low CSAP groups. There were, at best, weak correlations between workers' safety climate scores and the company CSAP scores, with marginal statistical significance with two groupings of the data. There were also no significant differences between the manager-assessed safety climate and the worker-assessed safety climate scores. Conclusions: A CSAP safety performance score does not appear to capture safety climate, as measured in this study. The nature of safety climate in construction is complex, which may be reflective of the challenges in measuring safety climate within this industry. © 2013 Wiley Periodicals, Inc.

Spector, J. T., et al. (2011). "Burden of work-related knee disorders in Washington State, 1999 to 2007." J Occup Environ Med 53(5): 537-547.

OBJECTIVE: To describe the burden of knee work-related musculoskeletal disorders (WMSDs). METHODS: Knee WMSDs were identified using Washington State Fund workers' compensation data from 1999 to 2007 and analyzed by cost, industry, occupation, and claims incidence rates. RESULTS: Knee WMSDs accounted for 7% of WMSD claims and 10% of WMSD costs. The rate of decline in claims incidence rates for knee WMSDs was similar to the rate of decline for all other WMSDs. Industries at highest risk for knee WMSDs included construction and building contractors. Occupations of concern included carpenters and truck drivers in men and nursing aides and housekeepers in women. CONCLUSIONS: Between 1999 and 2007, Washington State Fund knee WMSDs were widespread and associated with a large cost. Identification of specific occupational knee WMSD risk factors in high-risk industries is needed to guide prevention efforts.

Stiehl, E. and L. Forst (2018). "Safety Climate Among Nontraditional Workers in Construction: Arguing for a Focus on Construed External Safety Image." New Solut 28(1): 33-54.

Safety climate, employees' perceptions of work-related safety, (1) has been promoted as a leading indicator of workplace safety in construction. (2 , 3) While research has primarily examined internal organizational sources (e.g., manager attitudes, formal organizational policies) on these perceptions, external sources of information might be more relevant to construction workers in nontraditional jobs who work for a limited time and/or have limited interaction with other employees. This paper argues for the future development of a construed external safety image scale to measure employees' perceptions about how external groups view their organization's safety. (4) The construed external safety image would capture the external sources that nontraditional workers use to assess safety climate and will allow public health researchers to identify and change dangerous workplaces while more effectively communicating information about safe workplaces to workers. The public health relevance of safety climate and construed external safety image for monitoring and communicating safety to nontraditional workers require examination.

Taylor Moore, J., et al. (2013). "Construction workers' reasons for not reporting work-related injuries: An exploratory study." International Journal of Occupational Safety and Ergonomics 19(1): 97-105.

Although under-reporting of work-related injuries by workers is recognized as a significant problem in construction and other industries, little is known about the specific reasons for such occurrences. Qualitative and quantitative methods were used in this study to (a) identify reasons why construction workers may choose not to report work-related injuries, and (b) to investigate the frequency of the identified reasons. Twenty-seven percent of a sample of construction workers (N = 135) indicated that they had failed to report a work-related injury. The most frequent reasons given were related to perceptions of injuries as "small" and "part of the job" as well as fear of negative consequences, which may follow injury reporting. These findings are discussed in terms of practical implications. Strategies to overcome these reasons are suggested to decrease the under-reporting of injuries in the construction industry. © 2013, Taylor & Francis Group, LLC. All rights reserved.

Wei, N. (2012). "Five Bad Environmental and Safety Decisions Leading to Catastrophic Results." Environmental Claims Journal 24(3): 245-259.

A power plant hired a painting contractor with a poor safety record history. Five painters perished in a fire when the contractor failed to adhere to OSHA's safety standards. The power plant faced criminal charges. Although later acquitted, the company had to pay millions in restitution and endure a public trial. A refinery with a major air permit operated without an environmental staff and endangered its neighbors and workers. Executives pleaded guilty to criminal charges. Another oil refinery failed to implement its own internal EHS audit findings months before a catastrophic explosion that killed fifteen employees and injured hundreds. © 2012 Copyright Taylor and Francis Group, LLC.

Welton, M., et al. (2018). "Ethnic Disparities of Perceived Safety Climate Among Construction Workers in Georgia, 2015." J Racial Ethn Health Disparities 5(3): 522-529.

BACKGROUND: Safety climate involves worker perception about the relative importance where they work and safety climate and has been shown to be a reliable predictor of safety-related outcomes. METHODS: The primary objective of this study is to investigate ethnic differences in perceived safety climate among construction workers. Surveys (n = 179) that included a 10-item safety climate scale were administered in Athens, Georgia (GA), at local construction sites and home improvement stores during June-August, 2015. RESULTS: The majority of respondents were carpenters or roofers (39%), followed by laborers (22%), painters and dry wall workers (14%), other skilled trades (14%), and supervisors (11%); 32% were Hispanic. Hispanic ethnicity ($p < 0.0001$), drinking two or more alcoholic beverages per day ($p < 0.0001$), working for a company that does not provide health insurance ($p = 0.0022$), and working for a company with fewer than ten employees ($p < 0.0001$) were significantly associated with lower perceived safety climate scores. CONCLUSION: The lower perceived safety climate scores among Hispanic workers indicate that the perception of the importance of safety on the job site is lower among Hispanics construction workers than non-Hispanics construction workers.

Winn, G. L., et al. (2004). "Fall protection incentives in the construction industry: literature review and field study." Int J Occup Saf Ergon 10(1): 5-11.

Safety literature confirms that incentives such as money or sunglasses seem to improve safety conditions over the short run. However, no studies could be found which tested the effect of incentives on fall protection for a period longer than a few days. In our research we found that after 6 months, the use of non-material incentives significantly improved on-time delivery and completion rates of a special inspection form (both $p <.005$). In addition, a questionnaire with embedded critical questions showed that even though workers said that they preferred material incentives, we conclude that their behavior was changed by the treatment (incentives). We further conclude that the use of natural reinforcers seems to influence worker behaviors and perception of management's commitment to safety over the long run, even though workers still say that they prefer tangible rewards. Future work should replicate these findings and explore why workers respond to natural incentives but express a preference for material incentives.

Zhao, D., et al. (2016). "Integrating safety culture into OSH risk mitigation: a pilot study on the electrical safety." Journal of Civil Engineering and Management 22(6): 800-807.

Efforts have been taken for years to minimize the occupational safety and health (OSH) risk, but the injury records remain a constant reason for worldwide concerns. Many firms often implement technology as an administrative hierarchy of control (HOC). However, technologies may also actively influence safe practices at the managerial level for administrative HOC. This research

examines electrical safety hazards in the U.S. construction industry as a basis for, studying the feasibility of using technology to integrate safety culture into the administrative level of OSH risk mitigation. The researchers introduce the concept of "habitus", which suggests one possibility for establishing a safety culture that increases workers' safety performance and integrates into workers' safety practices through cutting-edge information technology. A prototype application for OSH training based on mobile virtual reality (MVR) technology is demonstrated to help establish habitus in workers' daily practices, and ultimately to mitigate OSH risks at the administrative level of construction projects. Results from a preliminary validation test strongly support human behavior influence and safe work knowledge comprehension by the prototyped application. Although this prototype is demonstrated as a pilot study of electrical safety, the application is not limited to this area and is scalable to other OSH risks. © 2016 Vilnius Gediminas Technical University (VGTU) Press.

CPWR THE CENTER FOR CONSTRUCTION RESEARCH AND TRAINING

www.cpwr.com • www.elcosh.org