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Path forward: Emerging issues and challenges

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ABSTRACT

The NIOSH Construction Program worked with industry stakeholders to develop a National Occupational Safety and Health Construction Agenda to target future research and activities. The Program and its partners are also cognizant that new developments can emerge over time and that research can play an important role in helping to understand and address these emerging issues. Examples of emerging issues relevant to construction safety and health are described. These include: (a) climate change and energy considerations; (b) green construction developments and opportunities; (c) new materials; (d) changes in industry structure and practice; (e) workforce developments and disparities; (f) injury underreporting and cost and risk shifting; and (g) increased interest in addressing root causes. Responding to emerging issues while maintaining a focus on fundamental longstanding issues represents an ongoing challenge for researchers and industry organizations. Additional research to understand the diffusion and adoption of research by the industry is also needed. Research accomplished to date provides a strong foundation for addressing future industry needs and trends.

1. Introduction

The National Institute for Occupational Safety and Health (NIOSH) Construction Program is well-poised to increase its impact in the decades ahead. The National Occupational Safety and Health (NORA) National Construction Agenda, developed with stakeholder input to address priority occupational safety and health (OSH) problems in the construction industry, provides a roadmap to guide the research and activities needed to improve industry performance and position the industry to address recognized challenges.[1] The Program continues to build partnerships and improve capacity to move research to practice. A recently completed comprehensive evaluation by the National Academies (2008) confirmed that the Program is robust, scoring highly on relevance and impact. The evaluation also supported the need for continuing the efforts of the Program on National Construction Agenda priority areas. Maintaining a focus on these priorities over the next decade will help all stakeholders to successfully work together to accomplish mutual goals.

However, the construction industry is not static; while it can be relatively slow to change, innovations and transitions do occur, especially when driven by influential clients, large construction firms, and regulations. The industry is also directly shaped by political, economic, and societal developments. Identifying what changes might be on the horizon for the construction industry and worker safety and health over the next 20 years is a significant challenge.

It seems unlikely that fundamental characteristics of the industry, such as a preponderance of small employers, short term contracting and temporary employment, multi-employer worksites, multi-cultural workforce, and episodic exposure to risks, will change significantly. Many of the long-standing needs and hazards identified in the National Construction Agenda will likely continue as important priorities. While it is important to focus on strategic goals, it is also important to reserve resources to target "emerging issues." And while no one can predict the future, here are several examples of potential emerging issues and developments that bear watching.

2. Climate change and energy considerations

Taken together, U.S. commercial and residential buildings account for 40% of primary energy consumption nationwide (this includes 72% of electricity and 55% of U.S. natural gas; Rogers, 2008). This level of consumption exceeds that for either transportation or industrial sectors, and

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[1] The National Construction Agenda is available at http://www.cdc.gov/niosh/NORA/comment/agendas/construction/pdfs/ConstOct2008.pdf.

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usage is also increasing at a faster rate (Rogers). An emphasis on energy efficiency and reduction of carbon emissions from industrial, utility, commercial, and residential buildings is already underway, and this pace is likely to pick up sharply in the future as new innovations are commercialized. For example, the U.S. Department of Energy's Commercial Building Initiative has set a goal to achieve marketable, net-zero energy commercial buildings in all U.S. climate zones by 2025 (Department of Energy [DOE], 2008). New types of work will need to encompass both retrofit and new construction. It will also involve construction of additional energy generation infrastructure and alternative energy sources. Recent increases in development of wind power and more efficient and flexible energy grids are examples of this trend.

The energy efficiency (or inefficiency) of the construction process itself is also likely to come under additional scrutiny in the years ahead, leading to possible changes in how construction projects are designed, what materials and types of equipment are used, and how construction tasks are performed. Cement is an example of a construction material undergoing scrutiny given that current production methods are associated with very high energy consumption and waste generation (e.g., about a ton of carbon dioxide is produced for every ton of cement produced; Fountain, 2009).

Climate change will likely result in increased concern about heat stress and other heat-related illnesses. Outdoor workers such as agricultural and construction workers are among the groups who are most likely to be affected. Schulte and Chun (2009) point out that most health-related climate change research has focused on the health of the general population rather than on occupational health and safety and they present a conceptual framework for determining how climate change could affect the workplace. Examples include: increased heat stress/stroke, increased air pollution, changes in vector borne diseases, and increased exposure to extreme weather events. Kjellstrom, Ingvar, and Lemke (2009) suggest that because urban heat island effects can influence local temperature and humidity levels, some geographic locations may experience faster and higher temperature gains in coming years.

Individual susceptibility factors also influence the extent to which workers are affected by thermal stress. For example, age, weight, degree of physical fitness, and a variety of medical conditions such as hypertension can affect individual response to heat (Schulte & Chun, 2009; Occupational Safety and Health Administration [OSHA], 1999). Increased fatigue and reduced perception and motor performance during hot weather conditions could potentially contribute to more injuries. In sum, it is likely that more emphasis on research and work practice modifications will be needed to understand and address emerging heat hazard issues in the years ahead.

3. “Green” construction developments and opportunities

Buildings consume more than just energy. Buildings use large amounts of potable water and construction consumes large amounts of raw materials and generates large quantities of waste. Buildings have a considerable impact on human health and the environment. Green construction is defined by the U.S. Environmental Protection Agency (EPA) as “the practice of maximizing the efficiency with which buildings and their sites use resources — energy, water, and materials — while minimizing building impacts on human health and the environment, throughout the complete building life-cycle — from siting, design, and construction to operation, renovation, and reuse” (Environmental Protection Agency [EPA], 2008).

In the UK, the Building Research Establishment Environmental Assessment Method (BREEAM) was introduced in 1990 to support the assessment of environmental performance in new and existing buildings (BD&C, 2003). The U.S. Green Building Council (USGBC) was established in 1993 and the first version of its Leadership in Energy and Environmental Design (LEED) rating system was introduced in 1998. LEED currently scores buildings on eight categories: (a) Location and Planning, (b) Sustainable Sites, (c) Water Efficiency, (d) Energy and Atmosphere, (e) Materials and Resources, (f) Indoor Environmental Quality, (g) Innovation and Design Process, (h) and Regional Priority. Green building practices and the use of environmental scoring systems have grown rapidly over the last decade. For example, there are LEED projects in all 50 states and in 91 countries (United States Green Building Council [USGBC], 2009). Green construction poses a number of important questions for construction safety and health researchers and practitioners. Is construction safety and health currently included in green and sustainability concepts? What is the case for including it? How does green construction affect safety and health? Does the surge in interest in green construction provide opportunities or strategies for improving construction worker safety and health? Evaluation of green rating systems find only limited mention of construction worker safety. Rajendran, Gambatese, and Behm (2009) compared recordable injury rates among LEED and non-LEED construction projects and found no statistically significant difference in rates for the projects included in the study. Gambatese (2009) points out that some green design features could increase jobsite hazards. For example, the greater use of skylights and atria in buildings increases fall hazards on a project. There can also be greater risks of musculoskeletal injuries from increased jobsite manual handling and separation of materials to meet project recycling goals. He described a blind spot in sustainable design practice when it comes to worker safety and health.

This blind spot was highlighted for many in the construction safety and health community upon learning that the Las Vegas CityCenter complex[2] was awarded six Gold LEED certifications in November of 2009 (CityCenter, 2009). Unfortunately, the construction of this large multiple building project involved this same number (six) of construction worker fatalities and weaknesses in the safety program were reported (CPWR, 2008; Berzon, 2008). While there is no indication that these environmental certifications had anything to do with the safety record on the project, this example does spotlight the apparent disconnect between good environmental practice and good construction and safety and health practice.

There are opportunities ahead to promote worker safety and health as a fundamental dimension of true sustainability. Rating systems and designs that consider worker safety throughout the life cycle of a building will be needed, and green and safe approaches will be needed for other types of construction such as roads and bridges as well. Researchers and construction industry partners need to engage environmental practitioners in the years ahead to further explore these issues to ensure that green and sustainable buildings not only protect the environment but also construction and other workers.

4. New materials

Development and use of new materials incorporating nanotechnology or light weight composites are likely to increase in use in the years ahead. Titanium dioxide (TiO2) nanoparticles are now being added to cement to break down organic pollutants via catalytic reactions. The

[2] The CityCenter project had a high profile because it was the largest commercial construction project in the U.S. at the time and was a main subject of a Pulitzer Prize winning series of articles in the Las Vegas Sun about Construction Safety and multiple workplace fatalities.

resulting "self-cleaning" concrete reportedly retains its whiteness and resists staining. Studies also show that adding nano-scale silica to cement improves particle packing, which in turn leads to increasing the density of the cement structure resulting in improved mechanical properties such as compressive strength (Surinder Mann Institute of Nanotechnology, 2006). Nanotechnology development is outpacing health effects research and more information is needed about the short and long-term effects of nanomaterials (National Institute for Occupational Safety and Health [NIOSH], 2009) and the nature of exposures to construction workers when these materials are used.

Other construction materials are undergoing change because they have been identified as promising candidates for "beneficial re-use" of waste materials such as fly ash from coal-powered energy generation. An estimated 23% of the total coal combustion waste produced in the United States each year is already used in construction products such as concrete, wallboard, roofing granules, wood substitutes, and aggregate for asphalt and paving materials. For example, one wood replacement product used for decking and fencing constitutes 50-85% fly ash encapsulated in polyurethane (Tenenbaum, 2009).

This trend is likely to increase. Potential environmental concerns with beneficial re-use construction products tend to focus on considerations such as whether toxic heavy metals in coal combustion products will leach out of the product to pollute water. However, evaluation for occupational safety and health exposures and concerns are needed as well because construction involves airborne dust-generating tasks such as drilling, grinding, cutting, or milling. These tasks could result in exposures to heavy metals such as arsenic, mercury, cadmium, and chromium. It is important to insure that construction worker exposure scenarios are addressed during the product development stage and that appropriate safety and health precautions and interventions are developed.

5. Changes in industry structure and practice

Strategic Goal 10 of the National Construction Agenda identified the need to better understand how the organization and structure of the construction industry can itself contribute to injury and illness outcomes. The industry is highly complex with multiple layers of organizations and disciplines simultaneously performing specialized tasks. The communication challenges and sheer number and self-interest of these entities can adversely affect safety planning and execution of programs and processes.

There is increasing awareness within the industry itself that organization and structure are important factors for business success. For example, a Construction Engineering and Management (CEM) award lecture on research needs for the next 50 years described the extreme vertical and horizontal fragmentation of the construction industry as a "ball and chain" thwarting attempts at systemic innovation. The need for more integrated delivery of construction and expanded early engagement of all project stakeholders was emphasized (Levitt, 2007). The architecture community is also developing new "integrated practice" approaches to address acknowledged limitations and inefficiencies in how construction projects are currently organized and implemented (American Institute of Architects [AIA], 2007).

A 2009 National Academies Report titled: "Advancing the Competitiveness and Efficiency of the U.S. Construction Industry" directly addressed these issues and provided several recommendations (National Academies, 2009). The report acknowledged that construction industry productivity experts disagree on whether industry productivity (i.e., how well, how quickly, and at what cost construction is performed) is improving or declining. However, it noted that these experts agree that there is significant room for improvement. Studies examining industry efficiency have documented 25-50% waste in coordinating labor and in managing, moving, and installing materials (Tulacz & Armistead, 2007). Other studies have found losses of $15.6 billion per year due to the lack of interoperability[3] (National Institute of Standards and Technology [NIST], 2004), along with transactional costs of $4 to $12 billion a year to resolve disputes and claims associated with construction projects (FFC, 2007). The report noted that the construction process involves a diverse and fragmented set of stakeholders following a complex sequential process and that shifting roles and risks can lead to problems. These were similar to the themes noted in the discussion for the National Construction Agenda Strategic Goal 10 on construction industry organization issues.

The increased focus on construction industry organization and process represents important opportunities for partnering by safety and health stakeholders. The timing seems ripe for new types of industry level initiatives and solutions. For example, the National Academies report recommended "Widespread deployment and use of interoperable technology applications, also called "Building Information Modeling (BIM)." It will be important to ensure that safety and health is integrated into BIM, in order to benefit from the anticipated planning and efficiency gains.[4] In addition, efforts to increase construction efficiency, such as accelerated scheduling, could have inadvertent negative impacts on safety and health unless consideration of worker safety is an integral component of the process.

6. Workforce developments and disparities

The construction workforce has undergone numerous changes over the previous two decades. There has been an influx of immigrant labor into construction in the United States and in many other countries of the world, from Australia to Ireland to Dubai. In the United States, the construction industry had the highest percentage (25%) of foreign-born workers of any industry sector in 2008 (CPWR, 2009). Numerous studies have found that immigrant construction workers are at higher risk of injury (Dong, 2009). Given the intensely competitive nature of construction, and the aging of the current construction workforce in many countries, this trend is likely to increase rather than subside.

The aging of the workforce is another trend likely to drive changes in construction. Older more experienced workers are viewed as more productive and are valued by employers for that reason. But when older workers are injured on the job, the consequences are more severe and the time lost is greater (Dong, 2009). Construction remains a physically demanding occupation. It is possible that employer interest in accommodating aging workers to keep them on the job will generate demand for interventions that reduce the physical demands of construction tasks. This interest could coincide with increasing interest among safety and health professionals to reduce overexertion injuries and musculoskeletal disorders. Thus, conditions may be more receptive for contractors to embrace ergonomic interventions in the years ahead.

The increasing proportion of independent contractors in construction is another important workforce development. Close to 25% of individuals now working in construction are employed as independent contractors (CPWR, 2007). This trend is likely to grow in the future and it

[3] The NA report defined Interoperability as the ability to manage and communicate electronic data among owners, clients, contractors, and suppliers, and across a project's design, engineering, operations, project management, construction, financial, and legal units.

[4] The National Construction Agenda includes Research Goal 13.3.1 to explore opportunities for integrating Construction Hazard Prevention through Design into newly emerging design tools and practices such as Building Information Modeling (BIM).

presents a number of important challenges to safety and health researchers and practitioners. One category of independent contractors represents legitimate self-employed small businesses, whereas another category represents misclassified employees. Misclassification strips workers of legal rights to overtime pay, workers' compensation coverage, unemployment and health insurance benefits, and shifts tax withholding to workers (Workers Defense Project, 2009). What safety and health challenges do these different categories of independent contractors face? How do they obtain safety and health information? What channels are most effective for reaching them?

7. Injury underreporting and cost and risk shifting

Occupational injury statistics provide national metrics and indicators for evaluating occupational safety and health, including identifying priority and emerging issues. Injury rates and related "Experience Modification Ratings" are widely used by construction owners, workers' compensation carriers, and large construction management firms to pre-qualify subcontractors and to set prices for insurance coverage. However, there is increasing evidence that occupational injuries are underreported by some employers, including construction employers, thus obscuring the true national picture (Glazner, Borgerding, Lowery, Bondy, & Kreiss, 1998; Welch, Dong, Carre, & Ringen, 2007; Azaroff, Levenstein, & Wegman, 2002). Pressure not to report extends beyond workers. A U.S. Government Accountability Office (GAO) study across multiple industries found that it affects occupational practitioners as well. From its survey of U.S. health practitioners, GAO found that over a third had been subjected to employer pressure to provide insufficient medical treatment that avoids the need to record the injury or illness (Government Accountability Office [GAO], 2009).

The burden and costs of unreported injuries are shifted from the employer to worker families, health insurance, future employers, and social services. There is likely to be increased interest in better understanding both how to improve the accuracy of reporting, and the extent and consequences of cost and risk shifting.

Lastly, despite limitations, national injury data are robust in comparison to the current picture for tracking occupational illnesses. This remains an important problem given the delayed onset of chronic occupational illnesses and difficulty in clinically distinguishing occupational illness from non-occupational maladies. Construction, with its multiple employers and projects, poses special challenges for recording and tracking occupational illnesses, and is an issue that will need to be addressed in the years ahead.

8. Increased interest in addressing root causes

The occupational injury research literature provides for considerable understanding of the extent and pattern of injuries in construction. Researchers have also developed numerous accident causation models to understand and organize the causal factors and processes involved in accidents in order to develop strategies for accident prevention (Toole, 2002; Abbdelhamid & Everet, 2000; Reason, 1990). Researchers at Loughborough University (2003) have examined causal factors specific to construction accidents, and identified a number of important shaping factors and circumstances relevant to preventing injuries. Bomel Limited (2004) developed an influence network model with categories of root causes starting with *Direct performance Influences* (e.g., fatigue/attention among workers), extending outward to *Organizational Influences* (e.g., provision of training by local management), then to *Policy Influences* (e.g., health and safety management at the firm and client level), and finally to *Environmental influences* (e.g., regulatory influence by local and national agencies). They have used this model to examine and map influences for construction falls from heights and construction transportation accidents. Scheduling pressure is an example of a causal factor that is very relevant for construction. The contribution of design to construction hazards is another example. Comprehensive consideration of root causes provides the potential for more effective injury and illness prevention efforts.

Integrating this research knowledge into everyday construction safety practice is a challenge for the decade ahead. There is increasing awareness among OSH practitioners of the importance of factors such as design, system safety, training, safety culture, employee involvement, and safety and health programs, but there is a need to develop products and tools to support effective implementation efforts. One possible obstacle and challenge is posed by our current workplace safety regulations. How well do they address the range of important causal factors? This is an important question given that regulations and inspection practices influence and shape many employer safety programs and practices.

Mitropoulos et al. (2005) describes limitations inherent in the current approach to accident prevention used in construction based on OSHA's "violations approach." They describe this approach as focusing on prescribing and enforcing physical and procedural defense barriers to reduce workers' exposure to hazards, with violations of these barriers considered "unsafe conditions" and "unsafe behaviors." The authors make the case that this approach is primarily reactive rather than proactive — so it ignores the work system factors and interactions that generate the hazardous situations and shape the work behaviors. They suggest that focusing only on violations of direct level conditions and behaviors affects prevention efforts and limits the ability to understand and learn about other important root causes likely to contribute to future accidents. The authors also make the case that the violations approach does not always suit the less structured, dynamic nature of the construction process and the large number of poorly defined situational hazards that can occur where existing defenses are bypassed. They point out an earlier evaluation by Benner (1985) of 17 accident investigation methodologies used by public agencies that found that OSHA's violations approach was among the lowest in its ability to identify root causes.

These are questions and topics likely to be discussed further. There is a need for additional research into causal factors in construction injuries, and there is a need to transfer existing research knowledge into construction safety practice in order to support significant reductions in injuries in the years ahead.

9. Conclusion

This short list provides a glimpse of some broad issues on the horizon for the construction industry and safety and health researchers and practitioners. Many more emerging issue topics could be added. Several of the issues relate to current National Construction Agenda topics. Prevention through Design (PtD) is an example of an important concept that has been recognized for its potential to transform safety and health efforts in construction. Making sure that PtD gains traction in the years ahead remains an important goal for the safety and health community. Responding to emerging issues while also maintaining a focus on fundamental longstanding issues represents an ongoing challenge for researchers and industry organizations.

Researchers have provided an important scientific basis for improving construction safety and health conditions over the past two decades. Future research will continue to build on this solid foundation. Researchers and research organizations such as NIOSH and CPWR have made important strides in embracing and understanding the concept of research to practice (r2p), which plays a key role in ensuring that research leads to tangible impact. Considerable research remains to be done to better understand the diffusion and adoption of research findings by the industry. The r2p foundation is still under construction.

The combined efforts of industry stakeholders, government agencies, labor, and academia have resulted in the identification of strategic goals and a significant plan for the future. The construction sector poses many challenges and opportunities for improvement. The framework is set, and the path forward is clear. Time will tell what issues emerge and how well the industry and researchers will work together to address them.

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