Theorizing the State of Health Practices and Climate in Construction

via Fourfold Structuration

by

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ABSTRACT

Regulatory agencies, such as the Occupational Safety and Health Administration (OSHA), and the National Institute of Occupational Safety and Health (NIOSH), recognize that decisions regarding occupational health are often economically driven, with worker health only a secondary concern (Ruttenberg, 2014).

To investigate the four National Occupational Research Agenda (NORA) long-standing health concerns—welding fumes, crystalline silica, noise, and musculoskeletal disorders—a mixed methods research is conducted. Fourfold structuration, a holistic communication process with roots in indigenous/ancient knowledge, is used to organize data and facilitate making tangible relationships of health to productivity and profits that are abstract and often stated by industries, such as construction, as difficult to quantify. From both construction trade worker and occupational health and safety expert interviews data/codes are developed. For the qualitative method, the codes are organized into a constructivist grounded theory depicting the construction industry with regard to its foundation – profits. A theoretical exercise translating the qualitative codes into potential productivity losses is presented as a way for quantifying the abstract relationships of health to productivity. For the quantitative study, the data/codes are used to develop a comprehensive list of practices, barriers to, and catalysts for addressing health in construction. A significant quantitative finding is that occupational health and safety (OSH) experts are not traditionally involved at the highest levels of the OSHA Hierarchy of Controls, where the greatest opportunity to prevent exposure to health hazards is possible. Organized via a holistic framework, this research emphasizes our primary responsibility to each other as highlighted in recent NIOSH worker health agendas.

To my Ancestors, especially El Cacique and Spider Woman…*I am the one.*

To my Parents…*Thank you. I love you very much.*

To all my Friends…*I am grateful for your patience and support.*

God is good.

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CHAPTER 1: MOTIVATION

Regulatory agencies, such as the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), and National Institute of Occupational Safety and Health (NIOSH), recognize that *intentional* management decisions regarding occupational health are often economically driven, with only secondary concern for the health of a workforce (Ruttenberg, 2014). Though the construction industry's concern for its workforce may have been secondary, the increase in profits resulting from safety practices has fed the economic motivation of the industry to continue its focus on safety and safety research. Profitability, therefore, is the driving factor for the attention to safety. Worker health is an untapped opportunity for increasing profitability. Though models exist for determining the value of the statistical life of a worker, challenges the models have in common are finding the balance between the risk level a worker is willing to accept in exchange for financial compensation and determining the accuracy of the variables and the validity of the values of the variables within the models. Because financial compensation for labor is the largest expense and impact to profits, these challenges can affect the employer integrity and ethics in the development of the models. It is important to ensure the reported risks and expenses are not skewed to favor employer profitability via short-changing the compensation and minimization of the worker risk exposures (Ruttenberg, 2014).

This economic motivation of the construction industry is an opportunity for establishing on-site health practices that will mitigate or eliminate exposure of its limited skilled workforce to both short-term and long-term health hazards and increase profitability (Craft Workforce Development, 2013). Mitigating and/or eliminating exposure of cumulative health hazards to a limited skilled workforce can increase profitability by reducing costs related to issues such as the replacing of sick workers, the hiring and training of new workers, and the learning curve of newly trained workers until they perform at an expected proficiency (Craft Workforce Development, 2013).

If profits are the driving factor for the construction industry, then opportunities for untapped profitability are of potential interest. Worker health is that untapped profit potential. The increased profitability through a focus on safety can serve as a model for the potential gains in profitability via a focus on worker health. This is particularly true because there is minimal research and application regarding health within the construction industry and the fact that health in construction is relegated to the arenas of industrial hygiene and epidemiology. Construction lacks a focus on health. This research focuses on identifying feasible and implementable health practices as well as the barriers to and catalysts for the implementation of health practices within construction.

The theoretical model developed within this research illustrates how workers' long-term health and company profitability are inextricably tied to each other and impacted by the barriers to and catalysts for the implementation of practices that address the long-standing health concerns of construction trade workers. By modeling the construction industry, how the components work together and impact each other facilitates an understanding of present knowledge regarding health in construction and illuminates the present gaps. Moreover, the use of fourfold structuration further illuminates the relationships among the present known data, the unknown data gaps, and the challenges of existing attempts to quantify risks and associated costs.

The overall motivation for this research is to enhance the health climate within the construction industry via the implementation of preventative and compensatory health practices at construction jobsites. This research is a foundation for facilitating an informed "sale" of the importance of worker health, and strives to develop a case for health as an untapped opportunity for profitability within the construction industry. Hence, this research can facilitate for occupational health and safety experts the "sale" to those with the authority to make changes the importance of focusing on the long-standing health concerns of construction trade workers as an opportunity for increasing profitability and not as a loss of capital investments.

1.1 Introduction

There is a shortage of skilled craft workers (NORA, 2008). This is a concern for the construction industry because craft workers generate the billable hours or profits for a company. If there is an existing shortage, then industry profits are impacted when production demand cannot be met because the necessary workers are not available. Of the available workers, if the workers are ill, the worker will not perform optimally (Viscusi & Evans, 1990). A less than optimal effort translates into increased costs caused by increased labor hours, rework, missed workdays, project delays, and/or over budget expenditures (Zhao & Chua, 2004).

Cumulative health hazards, such as welding fumes, crystalline silica, noise, and musculoskeletal disorders, are long-standing health concerns that impact worker health status and, thus, the ability of the worker to perform optimally and maximize profitability for the employer (Viscusi & Evans, 1990). Regulations regarding worker health will not motivate industries to concern themselves with worker health in the same way that the potential for profits does (Ruttenberg, 2014). The strategic goals of the National Occupational Research Agenda (NORA) (2008) focus on understanding cumulative health hazards within the construction industry and illuminating the challenges of health issues. The fact that the exposure mechanisms and adverse health impacts of cumulative exposures are not as immediate and apparent as, for example, a broken bone from a fall, is a main reason health issues have not received the same level of attention as safety issues (NORA, 2008). The exposure mechanisms by which worker health is cumulatively impacted challenge the ability to determine how illnesses in workers progress from exposure to the onset of symptoms and illness. The Occupational Safety and Health Administration or OSHA estimates that every year the lack of attention to the seriousness of cumulative health hazards manifests in the deaths of more than 150 out of every 1,000 silica exposed workers (Ruttenberg, 2014). Overall, across all sectors, deaths result from diseases that include silicosis, cancer, and auto-immune illnesses, each of which is greatest in the painting and masonry trades (Painting Pro Times, 2014).

The construction industry is a major economic contributor (Bourdon & Levitt, 1980). Labor is the largest expense and, therefore, reducer of profits. The desire for profitability and labor costs are therefore at odds, which is a circumstance set up by the present industry mindset. This circumstance drives some construction business owners to utilize questionable practices that shift the responsibility of health costs/risk acceptance onto the worker in order to lessen the economic burden upon the owner (Ruttenberg, 2014). The recognition of the impact of questionable employer practices on worker health is a motivation for achieving NORA's strategic goals (NORA, 2008). The questionable practices that place the burden of health costs on the worker often are the classification practices of workers within the construction industry where these practices privatize profits and social costs through the transfer of health costs on the worker and impact to a laborer's eligibility for workers' compensation filing. Models, such as The Value of a Statistical Life (VSL) of a worker, explored the determination of fair worker compensation for higher risk labor. Some workers are willing to accept a higher risk job for higher pay (Black, Galdo, & Liqun, 2003). However, there are challenges to determining fair worker compensation for higher risk labor that are often based on beliefs regarding the cost of implementing health and safety practices.

Another challenge to establishing a direct relationship between worker health and profitability is the organization of the construction industry and the diversity of company structures (Bourdon & Levitt, 1980). Open shop and union labor models have recognized the relationship between safety and profitability. However, the relationship between worker health and profitability has yet to be fully acknowledged. Workers are financial investments that the construction industry needs to protect. Based on discussions with master craftsmen interviewed for this research, it takes approximately three years to master the fundamentals of craftwork and practice and a minimum of seven more years before being considered a master craftsman. Thus, given the amount of time, resources, and invaluable experience from years on the job that go into developing a skilled worker, not protecting worker health seems counterproductive to the driver of industry—profits. If workers—via their labor—generate an industry's profits, then the long-term health concerns of construction craft workers are a potential opportunity for increasing profitability. The longer the industry can keep a worker healthy, the more work/profits the worker can produce via the minimization of project costs, such as the hiring and training of new workers, rework from inexperienced workers, and the slower pace of new laborers (Viscusi & Evans, 1990).

Workers are assets whose health status can be linked to productivity and profitability, which is why worker health should tie directly into the economic motivation of the construction industry. There is a gap within the construction industry in the understanding of the relationship between worker health status and profits. The gap is highlighted in the results of this research, which points to the fact that occupational safety and health (OSH) experts are not present where they could have the greatest impact—in the design and planning stages of a project.

This leaves OSH experts to perform a triage-type approach to health rather than work within opportunities that prevent, mitigate, and/or eliminate health impacts from the start. Understanding how worker exposures to cumulative health hazards, regulations, company/industry mindsets, policies and practices, illness/health status, and profitability all relate can bring awareness to the construction industry of the opportunity for increasing profitability. Focusing on health in a similar fashion to the focus on safety over the past 20 years can potentially increase profitability. A challenge is to illustrate for the construction industry how if *profits* are their main interest, then *profits* are analogous to a millwheel driven by the behaviors and ethics within all levels of the industry. In order for those with authority to make or impact changes to understand that an intentional focus on worker health can potentially increase profitability, it is key to communicate that it is the actions of all levels/components of the industry what have manifested/caused the present state of the health climate.

Fourfold structuration is a communication process/framework that can illuminate/ organize/harmonize the present state of the health practices and climate in construction. An organization of data that reflects the interactions of the multiple levels/energies within the construction industry and makes visible the gaps in understanding, research, practice, and application with regard to health (Men, 2010). Western dualistic thought models consider data/thoughts or system contents as either true or false, good or bad. Western triadic thought models, such as the "thesis-antithesis-synthesis" approach, unite sharp divisions by a third term, giving the sense that things or ideas are contradicted or opposed by things that come from outside the system. The issue with dualistic or triadic thought models is that they create circumstances that potentially allow gaps between the relationship of health and profits to be missed or overlooked (Kelly, 1976). Fourfold structuration models, such as engineering control process states or the Native American Medicine Wheel, offer a thought-tool beyond Western or American dualistic and triadic models by transcending thinking in twos and threes engrained within the Western culture and instead provide an integrated-thought instrument in terms of four (Wiki: Georg Wilhelm Friedrich Hegel, n.d.). An integrated-thought instrument can capture the complexities of the existing state of health practices and climate within the construction industry. This instrument can also make obvious and apparent the adverse impacts on industry profitability that occur by continuing to overlook and/or minimize the long-standing health concerns of construction trade workers.

1.1.1 What is Fourfold Structuration

Fourfold structuration is a form of four-division communication, whose original Greek roots are related to the term dialectics, meaning a form of practical logic used in a communication (Kuilman, 2013, para. 2). Where dialectics is a two-division communication system, quadraletics is a four-division communication system.

Tetradic or fourfold ways of thinking are not new. The concept of divisions of four goes back to antiquity. In Sacred Tree or World Tree mythology (Figure 1), the fourfold is found as the four directions—east, south, north, and east—that are generated when moving out from the center of the tree and serve as a system for human beings to orient themselves in the cosmos (Christenson, 1997).

Figure 1. The "tree of life" stela, Stela 5, Izapa, Mexico, 200 B.C.–A.D. 100.

Fourfold thinking gives human beings balance—particularly regarding the horizontal perception of the ground when standing vertically. By extending our arms outward from a vertical position in relation to our physical centers, four quadrants are created (Christenson, 1997, pg. 11).

The concept of the fourfold is not relegated to ancient mythologies. Concepts of the fourfold live in the present day within the symbol of the Medicine Wheel (Figure 2), which is used by almost all the Native people of North and South America (Lane et al., 2014). The fourfold is expressed via this symbol in many different ways, such as the four grandfathers, the four winds, the four cardinal directions, and any other relationships that can be expressed in sets of four (Lane et al., 2014).

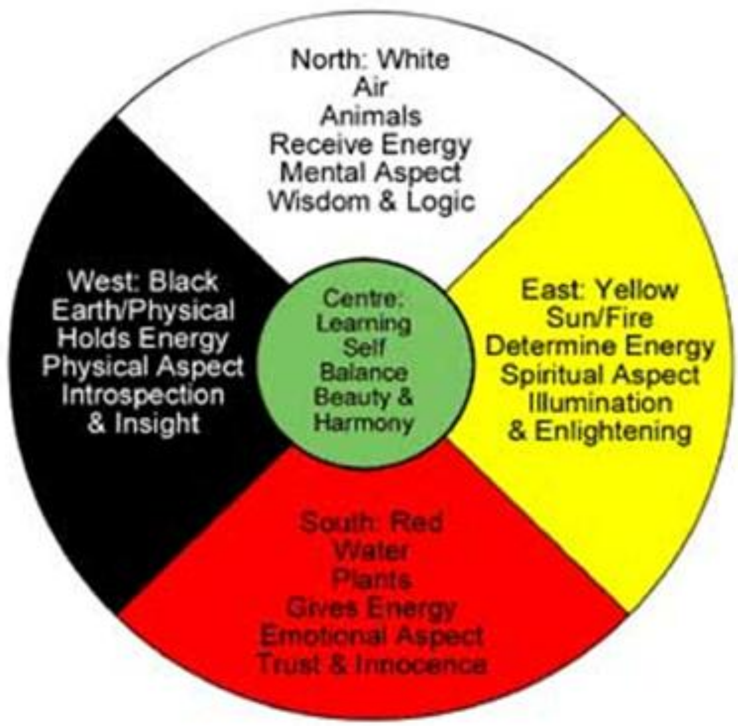

Figure 2. Medicine Wheel and aspects associated with each direction.

1.1.2 Why Fourfold Structuration in Engineering

The predominant literature regarding health hazards and worker health looks at hazards and health individually and not holistically. Fourfold structuration provides a holistic system for organizing information beyond viewing issues independently.

Fourfold structuration is not a new concept. Ancient peoples incorporated humanity into the larger cosmological system via orientation of religious structures to the four directions, equinoxes, or solstices (Scranton, 1953). Today, the fact that modern architects and engineers do not know how many ancient structures were built infers there is new wisdom to be gained by examining the old (Haughton, 2007).

In his lecture *Building Dwelling Thinking*, Heidegger (1993) discusses fourfold thinking in terms of human endeavors/construction that exemplifies the essence of being human. Heidegger (1993) states that technological components and scientific objects are not where truth is to be found. Rather, truth is found in works of art, such as that of William Blake's illustration of Milton's *Paradise Lost* (Figure 3), which attempts to express humanity's "struggle between" his divine station and human compulsions (Emslie, n.d.). This struggle is still present today between doing what is right at all levels of the construction industry regarding human safety and health versus giving into human behaviors/habits/desires for profits at the expense of the lives of others. Blake's illustration is an example of Heidegger's reference to schematic renderings as pictorial schemas for organizing and generating knowledge (O'Gorman, 2005).

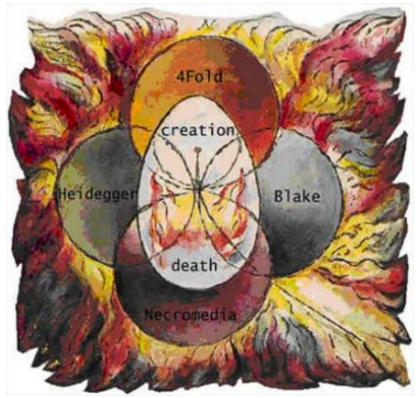

Figure 3. “Milton, A Poem,” Plate 33 (Erdman), Copy C (1811), with new text added, courtesy of New York Public Library.

Heidegger (1993) relates dwelling and building to four aspects of a primal oneness —earth, sky, divinities, and mortals. Here, mortals are distinguished within the “primal oneness” via the passage of time. Unlike the earth, sky, and divinities, when mortals pass through their four seasons, there is a finite point. A finality that can also be said of the buildings and dwellings mortals construct. Time also creates difficulty in recognizing the impact cumulative health hazards have on trade workers and the mortality or the finite amount of a worker’s life that is shortened by health hazard exposures. Thus, time is of particular importance, because mortals, like their constructions, eventually merge back into one or all of the other three aspects.

In engineering, fourfold structuration can be a framework consciously applied to the consideration of issues adversely impacting the health of the trade’s people. So, similarly to how ancient people, according to Men (2010), integrated the ideas of the importance of the individual, society, nature, and cosmos into their constructions, fourfold structuration can be a framework for understanding the importance of the health of the workers who construct the structures serving individuals and society today. Fourfold structuration organizes the knowledge regarding the four health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders. It organizes the knowledge with regard to long-standing health concerns of construction trade workers and expresses the importance of the workers/humans in relation to society, nature, and cosmos as part of a larger “construction cosmos” or system.

1.1.3 Fourfold Structuration as Framework for this Research

The act of dividing is the root of all communications, and the division choice determines the whole course of information exchange. A main clue to fourfold structuration is the “a priori” assumption that every communication is guided by a fourfold division of the conceptual world (Kuilman, 2013, para. 5). The communication between one division and another is the “distance or communication factor between the communication partners at a certain point in time and place” (Kuilman, 2013, para. 14). Ultimately, the aim of any human information exchange is “to come to a better understanding of each other,” and, because many understandings are caused by failing to notice the observational position of the other, fourfold structuration provides a framework needed to understand the “visio,” i.e., idea, concept, or notion, of each other “in terms of a (division) frame of mind” in order to gain a great deal of clarity (Kuilman, 2013, para. 17).

1.1.3.1 The four quadrants (directions). The aim of fourfold structuration for this research is to facilitate an understanding and organization of the present knowledge of the four main health hazards of concern and to facilitate a greater visibility of the existing knowledge gap and a measuring of the distance required to be bridged in order to achieve a greater comprehension of the impacts of the long-standing concerns of construction trade workers on both worker health and industry productivity.

1.1.3.1.1 Quadrant I—Invisible invisibility, south. The first quadrant is the "empty space" in a communication cycle that can only be measured from another quadrant. From a dualistic perspective, it is characterized by an "invisible invisibility." This quadrant, the "place of human endeavors for building bridges into the unknown" can be likened to the idea of an invisible invisibility, like the long-term "invisible" exposures to health hazards that result from the "invisibility" of the internal biological processes that result in the adverse health outcomes (Kuilman, 2013, para. 1). Expanding the imagination(s) of the construction industry to understand the fact that the health issues are a result of the summation of each individual exposure on each and every project is a first step in addressing the present state of the health practices and climate in construction. Sections 3.2 and 3.3, respectively, present overviews of the invisible invisibilities of health hazards and the construction industry, the exposure mechanisms of cumulative health hazards, and the progression of occupational illnesses.

1.1.3.1.2 Quadrant II—Invisible visibility, west. The emergence of a second quadrant is where at any given moment an idea or an interpretation becomes visible with the potential for further advancing communication. The shortage of skilled workers is an example of the "invisible visibility" contained within the second quadrant. The "visibility" of the skilled worker shortage as a symptom of the "invisible" circumstances within the construction establishes an opportunity to communicate about potential causes of the circumstance resulting in the worker shortages.

The second quadrant represents a "sky is the limit" opportunity for addressing issues such as long-standing health concerns of construction trade workers because there are no formal measuring standards. The second quadrant sets up a reference point for the communications of the third and fourth quadrants, but a third quadrant is needed to triangulate and establish standards for what has become visible within the second quadrant (Kuilman, 2013, para. 5). Sections 3.4 through 3.6 discuss topics ranging from the construction industry as a major economic contributor to how the structure of the construction industry has set itself up as an "or" outcome with regard to health and profits and has transferred the liability of health costs on to the worker at the detriment of the industry and worker's health.

1.1.3.1.3 Quadrant III—Visible visibility, north. According to Kuilman (2013, para. 8), the presence of a third quadrant allows the observations established in the second quadrant to become a "visible visibility" and tied to an empirical reality. This empirical reality is observed via two types of systems: 1) "a closed system with (temporary) fixed boundaries" and 2) "an open system." These two types of systems create distance between the observed and the observer. The distance is what facilitates the use of a measuring system to understand the statistical tendencies and behaviors of the observed. Whereas a closed system serves as an anchor from which the observer can gauge other observations, an open system provides opportunities to observe systems with dynamic boundaries where "nothing is fixed" and "randomness becomes a central theme" (Kuilman, 2013, para. 12). Sections 3.7 through 3.8, the "Value of a Statistical Life (VSL) of a Worker" through the "The Costs of Health and Safety Efforts" present ideas regarding the measurement of risk and the challenges to accurately and consistently define system factors that vary by firm size, region, and worker characteristics.

1.1.3.1.4 Quadrant IV—Visible invisibility, east. The action or measuring of an empirical reality takes place in the fourth quadrant. The fourth quadrant is a mirror of the second quadrant but with a more advanced empirical point of view "offers the chance to utilize the diversity of the quadrants simultaneously" (Kuilman, 2013, para. 13). Linear, straightforward approaches and cyclic settings break down merging into the full understanding that there is no formal difference. "Any linear progress, if carried out long enough, becomes cyclic," and "any large cyclical move can be regarded as linear if the scale is small enough" (Kuilman, 2013, para. 13). Thus, key to understanding this "*coincidentia oppositorum*" is "an awareness of the multitude, both in time and place" (citation). The visible invisibility of the fourth quadrant is, therefore, a tool for "extension of thought" that opens up a wide perspective (Kuilman, 2013, para. 14).

As defined by Kuilman (2013, para. 15), the visible invisibility of the fourth quadrant is where the visible guidelines and goals established spiral the communication process back to a place of invisibility, or to issues that still need further thought. This starts the process over but at a time and place where there is a greater awareness than previously held. Sections 3.9 and 3.10, "Current State of Practices and Perceptions Regarding Health and Safety" and "Challenges and New Directions for Regulatory Enforcement," present existing challenges faced by the construction industry with regard to transferring knowledge from theory into practice. Or, in other words, as more awareness is gained with respect to cumulative health hazard exposures, the more apparent it becomes that more attention is needed to address the long-standing health concerns of construction trade workers.

1.1.3.2 What manifests. The goal of fourfold structuration is to communicate with greater clarity the unseen factors within unseen realities that influence communication outcomes (Kuilman, 2013, para. 15). Hence, what manifests is the outcome/communication created from what has been illuminated in the previous three quadrants. So, with a focus on the state of health practices and climate within construction, each journey around the quadrants makes visible new knowledge and informs of areas that need attention. This research is thus a journey around the quadrants or medicine wheel that explores, through a mixed-methods approach, opportunities for expanding knowledge regarding cumulative health hazard exposures and their relationship to profitability.

1.2 Who Will Benefit

Construction craft workers will directly benefit from this research because this study will give a voice to their experiences regarding barriers to mitigating or eliminating their exposure to cumulative health hazards. Thus, safer and healthier workers will be able to spend more time with their families while prolonging their income-earning years.

By extension, construction firms of all sizes will benefit from elucidating conditional relationships between workers' health and the profitability of the firm. In doing so, owners, general contractors, and occupational health and safety experts will gain a greater understanding of the power they hold regarding the protection of human capital and its relationship to productivity and profitability. Vendors and manufacturers of safety and health products can acquire a clearer perspective on the role they play regarding worker health and safety and how it is linked to the effectiveness and marketability of their designs. Moreover, the federal government and other stakeholder agencies will understand more clearly the importance of existing regulations and the passing of future regulations regarding cumulative health hazards.

CHAPTER 2: RESEARCH QUESTIONS, OBJECTIVES, AND SCOPE

While safety is an integral part of the agenda at major professional construction conferences in the United States, health is simply not part of the discussion. Present research efforts mainly focus on safety, whereas health concerns are mostly constrained to occupational studies (NORA, 2008).

2.1 Research Questions

The overarching research question is “What role does worker health play within the construction industry?” The qualitative question is “What is the general perception of construction trade workers regarding health practices and profitability within the construction industry?” The quantitative question is “What are identifiable and quantifiable practices, barriers to, and catalysts for the improvement of worker health and health climate within construction for the long-standing health concerns of welding fumes, crystalline silica, noise, and musculoskeletal disorders?”

2.2 Research Objectives

The objectives of this qualitative and quantitative mixed methods research are to:

1) Develop a qualitative theory illustrating the state of health practices and climate within construction and to
2) Identify and quantify/characterize preventative practices, barriers to, and catalysts for the long-standing health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders.

2.3 Scope

The scope includes information pertaining to the four long-standing health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders as defined by the National Institute of Occupational Safety and Health (NIOSH) and the National Occupational Research Agenda (NORA). The unit of analysis is the interviewee, via his/her responses to semi-structured interview questions about the proactive assessment and the prevention of the four long-standing construction site health hazards identified by NORA (2008). The long-term goal of this research is to lay a foundation regarding worker health that demonstrates that prioritizing worker health does not sacrifice profitability but rather can provide opportunities for companies to increase profits.

This study focuses on the United States' construction industry. Though other industries and countries have similar health and safety issues, this study is not designed as a comparative study between the same or different industry sectors throughout the United States or in other countries. This study also focuses on the four major cumulative health hazards of interest to the National Occupational Research Agenda (NORA). In this vein, surveying only construction craft workers and occupational health and safety experts ignores the perspectives of other influential stakeholders within the construction industry.

CHAPTER 3: LITERATURE REVIEW

Many skilled workers have chosen not to enter the construction workforce or have chosen to leave the construction trades (Krugman, 2006; Rall, 2014). The result is a critical shortage in productive skilled craft labor (Amladi, 2013). This skilled worker shortage is a symptom of the current state of the lack of health practices and adverse health climate within the construction industry. The present minimal health practices impact worker health via long-term cumulative exposures to crystalline silica and welding fumes that can result in, and are not limited to, dermatological issues, respiratory conditions, auto-immune diseases, and even death. Long-term cumulative exposure to noise and repetitive motions can respectively result in permanent hearing loss and chronic musculoskeletal pain (Painting ProTimes, 2014).

3.1 Problem Statement

Health practices in the construction industry are presently minimal to non-existent. Compounding poor preventative and compensatory health practices with large deficiencies in employers' understanding of cumulative health hazards are contributing to a very unsafe and antagonistic working culture. The problem statement for this research is as follows:

1) The desire for profitability at the expense of worker health and safety creates barriers to the implementation of practices and protocols that mitigate or eliminate workers' exposure to cumulative health hazards.

To assess the potential barriers to improving the health climate and practices within construction, qualitative interviews with both craft workers and occupational health and safety experts have been conducted. The interviews developed data regarding silica, welding fumes, noise, and work-related musculoskeletal disorders. The data was used to identify existing barriers, which, if mitigated or eliminated, will potentially improve the positive health practices and climate within the construction industry.

3.2 Health Hazards and the Construction Industry

The construction industry is concerned with health hazards and resulting occupational illnesses (NORA, 2008). However, meaningful national statistics of occupational illnesses in construction workers are not available because longer-term illnesses tend not to be recognized or reported (NORA, 2008). According to Steenland et al. (2003), and based on the 1997 Census of Fatal Occupational Injuries, national estimates suggest the total burden from deaths for all occupations due to selected respiratory diseases, cancers, cardiovascular disease, chronic renal failure, and hepatitis is approximately 49,000 per year with a range from 26,000 to 72,000. Comparatively, deaths from occupational injury are approximately 6,238 yearly. The United States has no national occupational disease mortality surveillance system. Though many life-threatening diseases are associated with hazardous exposures at work Rutstein et al., 1983; and Mullan & Murthy, 1991), only a few diseases, such as pneumoconioses, are caused solely by work-related exposures. Therefore, all estimates of the magnitude of occupational disease are generated from multiple data sources and available epidemiologic studies (Steenland et al., 2003).

Among construction employers and employees, there is less awareness about health hazards than injury hazard awareness. There is less awareness regarding health hazards because some substances have few warning properties upon exposure, whereas safety issues, like falls, are immediate with the costs evident (NORA, 2008). Moreover, “in place” hazards, such as lead paint or silica in structures and surfaces undergoing construction, are not immediately recognizable to workers or contractors without testing or awareness training. Also, the delayed onset of most chronic occupational illnesses resulting from exposures spread illnesses over time and over various worksites, which makes it more difficult for employees and employers to link exposure and illness (NORA, 2008).

Currently, there are four primary culprits responsible for many cumulative health issues: silica, welding fumes, noise, and persistent musculoskeletal strain (NORA, 2008). This literature review will focus on studies that 1) outline opportunities for improving the health practices and climate within construction regarding the four primary health hazards and 2) reintroduce fourfold structuration concepts known since antiquity that demonstrate the importance of maintaining system homeostasis. Homeostasis has been disrupted via the actions of one worker, one manager, one owner, one stakeholder, and one member of the general public, because, whether visibly apparent or not, actions large and/or small of any component of the construction industry impact overall system equilibrium.

3.3. Exposure Mechanisms of Cumulative Health Hazards and the Progression of Occupational Illnesses

On a daily basis, over 1.7 million U.S. workers are exposed to respirable crystalline silica (NIOSH, 2008). Respirable crystalline silica exposure occurs in a wide variety of industries and occupations, with the most significant exposure risks to construction craft workers in the painting (blasting), labor, and masonry trades (Calvert et al., 2003; Carlo et al., 2010). Diseases such as silicosis, cancer, and auto-immune diseases result from cumulative exposures and the breathing into the lungs of microscopic particles of crystalline silica dust (Teicholz, 2013; Painting Pro Times, 2014). In construction and shipyards, 38 percent of on-site deaths each year are caused by crystalline silica at or below current Permissible Exposure Levels (PELs). And, based on OSHA's assessments for all business sectors, more than 150 out of 1,000 silica-exposed workers die from their exposure (Ruttenberg, 2014).

3.3.1 Crystalline Silica

According to NORA (2008), the most common exposures to crystalline silica dust in the construction industry are from the following activities:

- Chipping, hammering, and drilling of rock
- Crushing, loading, hauling, and dumping of rock
- Abrasive blasting using silica sand as abrasive
- Abrasive blasting of concrete, regardless of the abrasive used
- Sawing, hammering, drilling, grinding, and chipping of concrete or masonry
- Demolition of concrete and masonry structures
- Blowing concrete, rock, or sand dust with dry sweeping or pressurized air.

3.3.1.1 Silica regulations, standards, and guidelines. The Office of Research and Development (1996) has reported that several regulatory and research agencies have established regulations, standards, and guidelines for silica exposure levels. The American Conference of Governmental Industrial Hygienists (ACGIH) has set a threshold limit value (TLV) of 0.025 mg/m^3 for silica exposure. The National Institute of Occupational Safety and Health (NIOSH) sets the exposure limit for breathable crystalline silica during a 10-hour total weighted average (TWA) at 0.05 mg/m^3. Whereas, OSHA regulates the permissible exposure limit (PEL) for an 8-hour TWA for the construction industry. Appendix A presents the summary, key provisions, and OSHA Fact Sheet Final Rule Overview for occupational exposure to breathable crystalline silica, as has been reported by the National Archives (2016).

3.3.1.2 Silicosis—A recognized deadly occupational disease. Silicosis, one of the first recognized occupational diseases, remains a deadly illness in U.S. workplaces. The most prevalent symptom is dust-induced lung damage. Silicosis is often misdiagnosed or not recognized, because many clinicians are under the impression that it is no longer a serious problem, even though Nash (2014) notes that silica is a known carcinogen. Initially, workers may have no symptoms. However, as the disease progresses, breathing becomes difficult because the alveolar and bronchial pathways become impeded. Ultimately, a worker may experience shortness of breath, severe cough, and uncharacteristic weakness. This perpetual inflammation may result in cancer, bronchitis, tuberculosis, immunological disorders, kidney ailments, or death. The damage is often permanent, even though symptoms of the disease may not appear for many years (NORA, 2008). Table 1 lists the three types of silicosis a worker may develop, depending on the concentration of silica dust and the duration of exposure.

Table 1

Types of Silicosis

Chronic Silicosis	▪ Most common of all types ▪ Symptoms usually occur after 10 years of mild exposure ▪ Common for symptoms to arise up to 45 years after exposure ▪ Chest X-ray can reveal symptoms in the lungs
Accelerated Silicosis	▪ Also known as progressive massive fibrosis ▪ Most likely the rarest form of silicosis ▪ Symptoms develop quicker than Chronic Silicosis—5 to 10 years—and typically result from moderate overexposure ▪ Results in death after only a few years of its development
Acute Silicosis	▪ Most rapidly developing of the three ▪ Causes massive lung damage in a very short period of time ▪ Symptoms typically develop within weeks up to 5 years of inhaling very large amounts of silica ▪ Does not progress to the chronic stages ▪ Limited hope for patients, i.e., need a lung transplant.

Note. Adapted from NORA, 2008; The Workers' Compensation Board of British Columbia, 2016.

3.3.2 Welding Fumes

A number of construction trades such as pipefitters, sheet metal workers, ironworkers, boilermakers, and specialty masons are affected by welding fumes. Estimates on the number of construction workers who perform welding or the most common welding methods used in construction welding are currently not available (NORA, 2008).

Noise, heat, ultraviolet radiation, gases, electromagnetic radiation, and fumes are emitted in the complex welding process. According to NORA (2008), the type and amount of contaminants emitted vary depending upon factors such as the type of welding performed, the base metal worked on, the presence of coatings, and the work conditions. The characteristics of metal fumes, such as particle size distribution, distribution of metals, and fume surface area, vary depending on numerous factors. The fumes produced during welding and hot cutting (hot work) operations are collectively known as welding fumes (Health and Safety Executive, 2010). The type of welding process performed determines the type of fume generated. The generated fume is a complex and highly variable mixture of gases and particulates that, depending upon their size, have the potential to be deposited deeply in the lung (alveoli) (Health and Safety Executive, 2010).

3.3.2.1 Welding fumes regulations, standards, and guidelines. Welding fumes emit many toxic substances. Two of these substances, chromium (CrVI) and manganese, have been associated with lung cancer and occupational asthma. According to NORA (2008), manganese—found in steels, filler metals, and electrodes—has been associated in some studies with neurological conditions similar to Parkinson’s disease. Although OSHA has recently lowered the PEL for CrVI to 5 ug/m^3 of respirable air (NORA, 2008), the precise level of risk from the fume depends on three factors: 1) fume toxicity, 2) fume concentration, and 3) duration of exposure. Exactly how an individual will be affected cannot be predicted (Health and Safety Executive, 2010).

3.2.2.2 Welding fumes—Deadly occupational hazard. The visible cloud fume of welding and hot cutting processes is a mixture of airborne gases and very fine particles of metal, metal oxide, and flux, which, if inhaled, can cause ill health. Pneumonia, occupational asthma, cancer, metal fume fever, irritation of throat and lungs, and temporary reduced lung function are illnesses caused by welding fumes and gases. Short-term illnesses that can result from welding fume exposure can be dryness of the throat, tickling, coughing, or a tight chest, in addition to flu-like symptoms, fever, pulmonary edema, and fluid on the lungs (Health and Safety Executive, 2010).

On average, pneumonia resulting from metal fume inhalation causes 40–50 welder hospitalizations annually, and two welder deaths per year (Health and Safety Executive, 2010). Moreover, approximately nine welders get such intense cases of asthma each year that they are able to claim industrial injuries and collect disability benefits (Health and Safety Executive, 2010).

3.3.3 Noise

Another overlooked example of damage that accumulates over time is on-site noise. Exposure to harmful noise is common in construction work given the frequent use of heavy equipment and power tools (NORA, 2008). As a result, all construction workers have the potential to develop hearing loss and other conditions like tinnitus, a persistent ringing in the ears, after a lifetime of construction work. The average hearing loss for all construction trades is up to 60% in one or both ears and up to 80% in specific trades, such as steam fitting (Dement et al., 2005). If hearing loss is in higher decibel ranges, even the best hearing aids cannot restore normal auditory function (Dement et al., 2005).

3.3.3.1 Noise regulations, standards, and guidelines. Currently, there are no regulatory requirements for construction employers to provide hearing conservation programs (NORA, 2008). In 2007, a voluntary standard ANSI A10.46- 2007: "Hearing Loss Prevention in Construction and Demolition Workers" aimed at helping employers develop hearing conservation programs to prevent hearing loss among construction workers was issued. The standard identified seven components for a hearing conservation program: 1) identification of hazardous exposure, 2) controlling the hazard, 3) hearing protection devices, 4) audiometry, 5) training, 6) recordkeeping, and 7) evaluation (NORA, 2008).

3.3.3.2 Noise—Deafening occupational hazard. Without hearing protection, one study reported that exposure for just 45 minutes to noise levels from screw guns, hammer drills, routers, and jigsaws was high enough to expose carpenters to noise that exceeded the recommended noise dose for an entire 8-hour day (NORA, 2008). The perceptions of noise reported by the carpenters and trade representatives in this study were that they did not identify these tools as noisy or just borderline noisy (NORA, 2008). Perceptions of noise impede "motivating workers and employers to take action to reduce noise or to use hearing protection" (NORA, 2008, p. 37). As tools and equipment reach the end of their useful life, an opportunity for noise reduction is the rental or replacement of construction tools and equipment via quieter models. Therefore, an important prerequisite for making progress in the reduction of hearing loss in construction workers is increasing awareness regarding noise (NORA, 2008).

3.3.4 Musculoskeletal Disorders

Working with high vibrational tools, such as jack hammers and materials that require repetitive and overhead handling, can also result in injuries or illnesses of the muscles, tendons, joints, and nerves, which are collectively known as musculoskeletal disorders (MSDs) (NORA, 2008). Inflamed tendons or joints, tissue inflammation, herniated discs, rotator cuff syndrome, carpal tunnel syndrome (CTS), and back or neck strain are examples of MSDs (NORA, 2008). In 2005, the U.S. Bureau of Labor Statistics (BLS) estimated that 35,900 construction workers had developed a musculoskeletal disorder. Of those, 42% were laborers and carpenters (NORA, 2008).

As the construction workforce ages, problems such as hearing loss, worker musculoskeletal disorders (WMSD), and ergonomic issues are expected to increase (NORA, 2008). Although WMSDs are recognized as a major health issue, musculoskeletal disorders are underreported by construction companies. The multiple risk factors that cause musculoskeletal disorders include the following (NORA, 2008):

1) High physical exertion, such as manual material handling
2) Prolonged static or stationary postures, like working with arms or shoulders raised or working in a kneeling position
3) Repetitive physical exertion, like the use of manual and power tools
4) Awkward working postures, like squatting to work at floor level
5) Confined areas such as crawl spaces where awkward postures may be required
6) Working in cold conditions

7) Whole-body or segmental vibration caused by tool vibration and mounted equipment vibration

3.3.4.1 Musculoskeletal disorders—Regulations, standards, and guidelines. In 2001, Congress invoked the Congressional Review Act (CRA) of 1996 where by President Bush signed into law a repeal of the Clinton administration regulations that set new workplace ergonomic rules to combat repetitive stress injuries (CNN, 2001, para. 1). The claim by President Bush for the repeal of the ergonomics rules was that:

> There needs to be a balance between and an understanding of the costs and benefits associated with federal regulations. In this instance, though, in exchange for uncertain benefits, the ergonomics rule would have cost both large and small employers billions of dollars and presented employers with overwhelming compliance challenges. Also, the rule would have applied a bureaucratic one-size-fits-all solution to a broad range of employers and workers -- not good government at work" (CNN, 2001, para. 9).

Bush further stated that "the safety and health of our nation's workforce is a priority for my administration" (CNN, 2001, para. 10). Bush promised "to look for other ways to address worker and union concerns about ergonomics and related workplace issues" (CNN, 2001, para. 10).

Estimates by The Occupation Safety and Health Administration were that the new rules would have generated benefits of $9.1 billion a year for each of its first 10 years, and would have prevented 460,000 musculoskelatal disorders a year. It said employers pay $15 billion to $18 billion a year in workers' compensation costs as a result of such disorders (CNN, 2001, para. 11).

The Bush White House spokesman Ari Fleischer said Bush had directed Labor Secretary Elaine Chao to find ways to protect workers' health and safety without hurting businesses. Chao has said she would consider issuing a different ergonomics rule (CNN, 2001, para. 12). The Bush White House Spokesperson, Ari Fleischer, said "he [Bush] believes that we can protect the health and safety of workers without passing a regulation that is terribly burdensome to the economy and to the small businesses on which their growth depends" (CNN, 2001, para. 14). Fleischer further stated that "Particularly, in this time of fragile economic circumstances, he [Bush] does not want to take any action that would hurt economic growth and cost small businesses and other businesses billions of dollars" (CNN, 2001, para. 15). As of 2016 while Congress has considered several CRA joint resolutions of disapproval since 1996, only one agency final rule has been overturned, the 2000 Occupational Safety and Health Administration (OSHA) rule related to workplace ergonomics standards (CRS, 2016).

3.3.4.2 Musculoskeletal disorders—Debilitating occupational hazard. In national U.S. injury and illness statistics it is commonly understood that the incidence and prevalence rates of MSDs are underreported (NORA, 2008). Even though MSDs are underreported, many industry stakeholders recognize MSDs as a major problem because of the significant hardship for workers and increased costs for contractors and building owners (NORA, 2008).

Research in the U.S. and elsewhere has demonstrated that high incidence or prevalence rates of musculoskeletal symptoms and disorders occur in construction workers in certain trades. The Bureau of Labor Statistics (2006) reports that 42% of the construction workers with MSDs are laborers and carpenters and that the median number of days away from work as a result of an MSD is 10 days. According to the Bureau of Labor Statistics' 2013 data, MSDs account for 380,600, or one-third, of days-away-from-work cases (MSDSOnline, 2015). The highest incidence rates are in transportation and warehousing, healthcare, entertainment/recreation, agriculture, construction, and manufacturing (MSDSOnline, 2015). This is a significant proportion of lost-time injuries and a disproportionate amount of workers' compensation costs associated with work-related MSDs (NORA, 2008).

As the construction workforce ages, MSDs incidence and prevalence is expected to increase. As many of the physical demands associated with construction, such as manual material handling and sustained overhead work, are often incompatible with the physical capabilities of older workers (NORA, 2008).

While national injury and illness statistics may not reflect a complete count of the incidence and prevalence rates of MSDs, they provide a more reliable description of workers' experiences (NORA, 2008).

> The conflict between the national data and the results of epidemiological studies showing higher MSD incidence or prevalence, suggests the burden of MSDs is largely borne by the individual worker, their family, private medical insurance, and government social service agencies. (NORA, 2008, p. 57)

According to MSDSOnline (2015), 2013 data from the BLS shows workers suffering from MSD-related injuries require more time off the job (a median of 11 days versus eight days) than those with other types of workplace injuries and illnesses. "Statistics from OSHA reveal that related workers' compensation expenses cost businesses $15 to $20 billion each year" (MSDSOnline, 2015, para. 3). Moreover, the "Institute of

Medicine estimates the total annual economic burden resulting from workplace MSDs from $45 to $54 billion" (MSDSOnline, 2015, para. 3).

3.4 Overview of the Construction Industry: A Major Economic Contributor

According to the U.S. Department of Labor (2016), it will be especially challenging to replace the predicted skilled labor shortfall of approximately 1.5 million workers. Many workers have left the construction industry since the recession in 2007 and subsequently retrained in other professions; thus, they are unlikely to return to construction within the next decade (Craft Workforce Development, 2013). As a result, workers who could potentially return to or enter the construction field have chosen not to enter the industry (Krugman, 2006; Rall, 2014). Figure 5 shows the hardest construction positions to fill.

Hardest Positions to Fill

Percentage of respondents who are having trouble filling jobs

CRAFT	
Carpenters	66%
Roofers	64%
Equipment operators	59%
Plumbers	54%
Electricians	52%
PROFESSIONAL	
Project managers/supervisors	48%
Estimators	32%

AGC MEMBER SURVEY

Figure 5. Hardest construction positions to fill (Gavin, 2015).

3.5 Industrial Organization and Diversity of the Construction Industry

According to the U.S. Department of Labor (2016), the construction sector is comprised of the following subsectors: building construction, heavy and civil engineering construction, and specialty trade contractors. Specialty trade contractors include foundation, structure, and building exterior contractors; building equipment contractors; and building finishing contractors. These subsectors engage in constructing buildings or engineering projects (e.g., highways and utility systems), preparing sites for new construction, and subdividing land for sale as building sites. Construction work may also include additions, alterations, or maintenance and repairs to buildings or engineering projects.

3.5.1 Types of Construction Work and Varying Environments

Construction work consists of various types of projects performed on location under various types of environmental conditions. Production responsibilities for the construction sector are usually specified in prime contracts or contracts with the owners of construction projects or subcontracts with other construction establishments.

The fact that construction sites are in separate locations from that of a central management site is important because contracts outlining on-site health and safety measures to protect workers can only truly be enforced in person, if these measures are contractually specified at all. If the on-site reports maintain a project schedule, budget, and scope, the off-site contract manager may have no reason to doubt reports provided by the on-site overseer. Thus, health and safety contract violations may never come to the attention of the off-site contract overseer (Federal Construction Contract Provisions, 2013).

3.5.2 Construction Industry Revenue of 500 + Employee Construction Companies

Based on 2013 U.S. Census Bureau data, construction companies that employ 500+ employees represent 0.197% of the entire construction industry; however, they generate 21.7% of the total industry revenue.

3.5.2.1 Targeted OSHA enforcement. OSHA has approximately 2,000 inspectors for 3,292,415 construction establishments. Therefore, targeting the 0.197% of construction companies that generate 21.7% of the industry revenue is logistically more realistic than attempting to target the 21.803% of the industry that falls under OSHA because it employs less than 500 employees and greater than 10 employees. Because interestingly enough, the largest portion of the construction industry (78%), because it employs less than 10 employees, is not required by OSHA to report injuries and illness. Moreover, based on 2013 U.S. Census Bureau data, this 78% of the construction industry employs approximately 2 million more workers than the 0.197% of companies that employ 500+ employees.

3.5.2.1.1 Administrative burden on OSHA. OSHA does not have the human resources to follow up on all the potential violations within 78% of the construction industry. Hence, because of the administrative burden it would create on OSHA, as well as companies with less than 10 employees — targeted enforcement on larger companies seems the most realistic approach. Though targeted enforcement is not necessarily the most conscientious; because larger firms have the capital to pay the fines or costs for cited violations, targeted enforcement is a more realistic approach for self-funding agencies like OSHA.

3.5.3 Construction Industry Revenue of Employee Construction Companies with Less Than 500 Employees

The U.S. Census Bureau (2012) has found that 83.3% of all construction employees are employed by enterprises with fewer than 500 employees, while 41.7% of all employees of specialty trade contractor establishments are employed by small enterprises. Figure 6 shows the U.S. Census Bureau's classifications of enterprise employment size. Figure 7 shows the number of construction enterprises with greater than 500 employees and the number of construction enterprises with fewer than 500 employees.

Enterprise Employment Size Term

Term[1]	Enterprise employment size
Very small enterprises	Fewer than 20 employees
Small enterprises	20 to 99 employees
Medium enterprises	100 to 499 employees
Large enterprises	500 or more employees

Figure 6. U.S. Census Bureau's enterprise classifications by number of employees (Caruso, 2015).

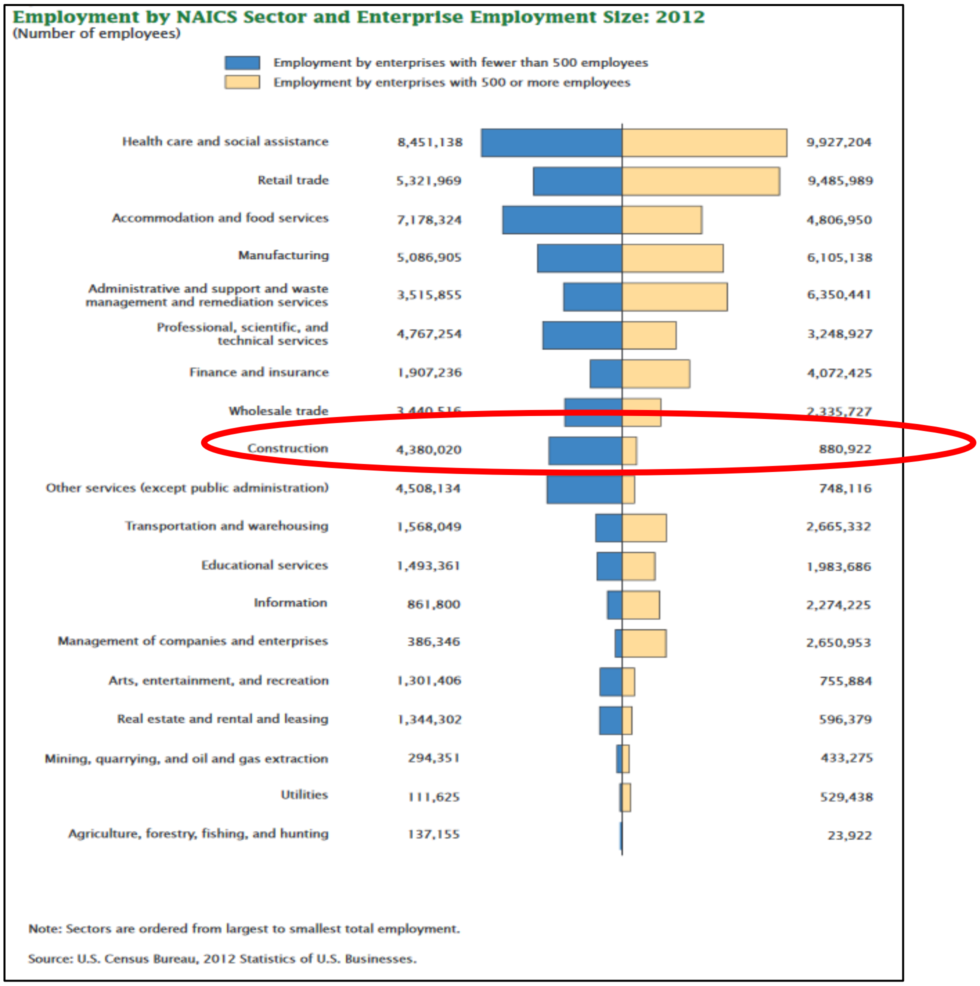

Figure 7. Number of construction enterprises with greater than 500 employees (Caruso, 2015).

3.5.3.1 Sources of general contractor labor. The large number of construction companies with fewer than 500 employees is significant because subcontracting is prevalent in the construction industry. This allows general contractors to undertake projects of considerable size without employing large amounts of direct labor (Bourdon & Levitt, 1980). Furthermore, subcontractors who bid on highly specialized contracts can start their enterprise with only one or two employees.

3.5.3.2 Injury and illness exemptions for employers with 10 or fewer employees. Critically, however, federal regulations (29 CFR 1904) giving a partial exemption for employers with 10 or fewer employees, states:

> All employers covered by the Occupational Safety and Health Act (OSH Act) are covered by Part 1904 regulations, and most employers do not have to keep OSHA injury and illness records unless OSHA or the Bureau of Labor Statistics (BLS) informs them in writing that they must keep records (29 CFR 1904.1 subpart B)

U.S. Census Bureau (2013) data reveals that the total number of firms with fewer than 10 employees in 2013 was 2,551,459 out of a total of 3,235,731 for all NAICS construction codes (see Appendices B–D for tables showing data for construction firm sizes in the U.S.). Hence, approximately 78% of all construction firms in 2013 did not need to keep OSHA injury and illness records (U.S. Census Bureau, 2013).

3.5.3.2.1 Reporting requirements for occupational fatalities. Moreover, as required by § 1904.39, employers protected by the OSH Act must communicate to OSHA any workplace fatality or the hospitalization of three or more employees (29 CFR 1904). Given that most subcontractors who bid on specialized contracts can start their enterprises with only one or two employees, a majority of subcontractors who provide labor to general contractors are not required to keep occupational health and safety records. To do so in a cost-effective manner, these subcontractors classify a majority of their personnel as independent contractors or 1099 employees in order to save money on insurance costs, payroll taxes, and other employee costs (J. Cahill, personal communication, March, 16, 2016). See sections in 3.6 Union and Open-shop Model for discussions regarding how employers use worker classification to affect project expenditures.

3.5.3.3 IRS regulations for employee classification. The practice of classifying workers as independent contractors—when based on Internal Revenue Service (IRS) regulations the workers fall under the classification of an employee—is alleged to be present in many construction subspecialties, including painters, framers and roofers, and is reported to be prevalent in large subdivisions currently under construction (J. Cahill, personal communication, May, 10, 2016). This illegal practice allows subcontractors to outcompete others who obey the law and classify workers appropriately. The savings to employers by classifying workers as 1099 employees when the worker should be classified as an employee permits subcontractors to underbid other licensed contractors by as much as 25% (J. Cahill, personal communication, May, 10, 2016).

3.6 Union and Open-Shop Labor Models

According to the U.S. Bureau of Labor Statistics (2016), 2015 union membership and representation for the construction sector was 13.2% and 14%, respectively. Therefore, the number of respondents surveyed who are non-union and non-union represented is 86.8% and 86%, respectively. Union representation has been instrumental in ensuring that health and safety provisions have been included in labor contracts. These provisions include joint labor-management health and safety committees, grievance procedures, ergonomic evaluations and studies, procedures involving the refusal to perform hazardous work, committee reviews of hazard communication programs, and collective bargaining agreements (Gray, Myers, & Myers, 1998). Nonetheless, a majority of trade workers both union and open shop within the construction sector remain vulnerable to the caprices of project owners and contractors because of a lack of immediate channels through which to bring forth and address concerns regarding exposures to cumulative health hazards (Bernhardt et al., 2008). Instead, workers rely mainly on state or federal health and safety regulatory agencies for addressing health and safety issues. These regulatory agencies' processes are not known for their immediate and timely resolution of worker concerns (Bernhardt et al., 2008).

Table 2

Union Membership and Representation for the 2015 Construction Sector

Union membership and representation	**2012**	**2013**	**2014**	**2015**
Members of unions (percent of wage & salary workers)	13.2%	14.1%	13.9%	13.2%
Represented by unions (percent of wage & salary workers)	13.7%	14.9%	14.7%	14.0%

Note. U.S. Department of Labor, Bureau of Labor Statistics, 2016.

3.6.1 Union Membership and Representation

BLS survey data shows that union membership and representation have declined from 17.7 million union workers in 1983 to 14.8 million union workers in 2016 (U.S. BLS, 2016). This decline is most likely a result of economic and political conflicts between open-shop (non-union) and union sectors that encourage competition as a means to fight inflation (Bourdon & Levitt, 1980). Furthermore, reduced numbers of union workers results in more disenfranchised workers.

3.6.1.1 Non-unionized workers and health hazard education. Disenfranchised, or non-unionized, workers have a more difficult time informing themselves of and/or organizing against labor violations and lack channels to educate themselves about and communicate concerns regarding cumulative exposures to health hazards. Consequently, immoral owners and contractors can more easily manipulate an uninformed work force (Bernhardt et al., 2008).

3.6.2 Union and Open-Shop Labor Policies

Although union and open-shop firms have common management tasks, their labor policies (e.g., overtime and sick pay and paid time off) vary by type and scale of construction work. Hence, when comparing union and non-union construction firms, Bourdon and Levitt (1980) posit that it is imperative to define the specific context within which comparisons are made. For example, a small residential firm may find a specific union rule or wage level too limiting or expensive for a given project; whereas, a large commercial contractor may not. Accordingly, larger firms can afford to hire more union workers—whose health insurance and safety regulations are most likely regulated by the union—whereas, smaller firms, comprising a majority of the construction industry, can hire mostly non-union workers who are sub-contracted to these larger contractors without the protection of a union.

3.6.2.1 Union utilization of union and open-shop models for member employment. Craft unions, like the International Bricklayers and Allied Craft Workers Union, can utilize many institutional models, such as union or open-shop models, to increase employment opportunities for their skilled workers, including those whose employment normally consists of multiple short-term jobs. Union models also implement formal apprenticeships to provide workers with necessary skills and training, for example with regard to occupational health. Doing so can allow contractors to save a significant amount of time searching for skilled workers.

3.6.2.1.1 Open-shop use of uniform union wages as competitive metrics. However, non-union firms can use a uniform union wage and worker productivity quotas as competitive metrics by which to select for skilled labor, if a union worker's skills cannot be reflected in his or her hourly wage. Furthermore, Bourdon and Levitt (1980) state that "non-union firms can compete only at the margins of the industry or in isolated sectors by paying lower wages and by resisting any attempts at union organization" (p. 3).

Therefore, it behooves businesses using an open-shop model to hire non-union labor because unlike the union model, non-union models do not usually set wage scales, working hours, training, health and safety, overtime, grievance mechanisms, and opportunities to participate in workplace or company affairs (Bourdon & Levitt, 1980).

3.6.2.1.2 Unions and collective bargaining agreements. Unions may negotiate with a single employer or group of businesses to reach an agreement that can serve as a legal precedent for future grievances. While union workers are guaranteed provisions from a full collective bargaining agreement, non-union workers have no guaranteed wage scales, working hours, training, health and safety, overtime, grievance mechanisms, or workers' compensation benefits, should they file an employer complaint.

3.6.2.1.3 Non-union workers financially responsible for job-related illnesses and injuries. Under these conditions, non-union workers are financially responsible for any job-related illnesses and injuries. Non-union workers are eligible for workers' compensation benefits from an employer, solely based upon their IRS classification under an employer. If a non-union worker is classified as an independent contractor, he or she will not be eligible for workers' compensation unless he or she pays into the workers' compensation fund as an individual. The problem is that most workers are not aware of their IRS classification (The Industrial Commission of Arizona, 2015).

3.6.2.1.4 Non-union workers and workers' compensation eligibility. As such, any workers' compensation a non-union worker would receive would be based on the workers' compensation payments the worker would pay for him/herself in his or her workers' compensation fund. Importantly, a subcontractor or employer who employs fewer than 10 full-time employees for an entire calendar year does not need to submit health and safety reports for injuries and illnesses to OSHA. In turn, a non-union worker injured on the job may find it difficult to legally claim workers' compensation benefits, especially if the worker has no knowledge of his or her classification as an independent contractor, in which case he or she would be responsible for paying his or her workers' compensation fees (The Industrial Commission of Arizona, 2015).

3.6.3 Workers' Compensation Structure

Presently, the structure of the workers' compensation system is such that a workers' compensation claim is not necessarily associated with an employer, whose negligence may have caused the illness or injury (The Industrial Commission of Arizona, 2015). Instead, a misclassified worker's previous employer is charged for an approved workers' compensation claim. Furthermore, a worker must have experienced an acute injury within a specific timeframe before a claim is filed in order to qualify for workers' compensation. Workers' compensation is not set up for chronic health issues that accumulate over time.

A worker who cannot attribute a chronic injury or illness to a specific incident on a specific date will be denied a claim because the injury or illness will not be traceable to an employer. Moreover, a previous employer's workers' compensation account will be charged for an approved workers' compensation claim if a worker is not covered under a current employer. Therefore, the structure of the workers' compensation system makes it difficult for workers to obtain financial compensation for health issues resulting from cumulative exposures to pathogens or hazards.

3.6.3.1 IRS employee classification and workers' compensation eligibility. A worker's IRS employment classification is what ultimately determines his or her eligibility to receive workers' compensation benefits in the event of an injury or illness incurred on the job. Even if a subcontractor is required to follow contractual health and safety requirements, it is ultimately the financial responsibility of the subcontractor and his or her independent contractors to come to the jobsite prepared to fulfill the principal employer's contract requirements (J. Cahill, personal communication, May, 10, 2016). In other words, the principal contractor is directly responsible for ensuring his or her subcontractors have properly established health and safety protections, as laid out by the contract; however, it is not the principal contractor's responsibility to ensure workers have preventative safety training and on-site precautions, like the most up-to-date protective gear (J. Cahill, personal communication, May, 10, 2016).

3.6.4 Classification of Workers

The United States Senate Subcommittee on Labor describes the contingent workforce as consisting of part time, temporary, leased employees, independent contractors, and can include anyone who is not a full time employee (S. Hrg. 103-620. 103rd Congress, 1988). As can be derived from this vague classification scheme, there is a dire need for clearer guidelines to specifically define contingent employees.

Conversely, U.S. businesses can look to the Department of the Treasury Internal Revenue Service’s *Employer's Supplemental Tax Guide* for guidelines on the proper classification of an industry’s work force. Appendix E presents an overview of each type of potential employer/employee business relationship.

Using IRS forms W-2 and 1099, employers pay different taxes (i.e., Social Security, Medicare, and unemployment taxes) on the wages of a worker classified as an employee.   However, these taxes are generally not paid on the wages of a worker classified as an independent contractor. Rather, workers classified as independent contractors are responsible for both their employer’s share of the taxes and their self-employment taxes at the end of the year (Department of Treasury, Internal Revenue Service, 2014). Thus, if an employer can classify a wage earner—regardless of status—as an independent contractor, the taxes owed become the responsibility of the wage earner (United States General Accounting Office, 1996).

3.6.4.1 Construction industry and percentage of misclassified workers. In 1984, the construction industry had the highest percentage of misclassified workers. These misclassified workers lost out on an estimated $1.6 billion in social security tax, unemployment tax, and income tax that should have been withheld from their wages (United States Government Accounting Office, 1996). The United States General Accounting Office (1996) estimated that the tax gap associated with worker misclassification was $2.3 billion in 1982 and $3.3 billion in 1987, for social security and unemployment taxes. Table 3 summarizes the total estimated tax loss, converted to 2016 dollars from worker misclassification in the construction industry for the respective years above.

3.6.4.2 Predicted infrastructure demands and why worker health matters.

According to the American Society of Civil Engineers' (ASCE) 2013 Report Card of America's Infrastructure, an investment of \$3.6 trillion would be required to meet the cumulative infrastructure needs projected for the year 2020. Table 4 summarizes the total investment that will be needed to create and support America's infrastructure in 2020, as well as the cumulative infrastructural needs, by system. (Dollars in \$2010 billions).

The Construction Labor Research Council (CLRC) notes that over the last 30 years, the construction industry has been able to retain workers during a recession and rehire them afterward. However, recent declines in both budget and demand have dramatically reduced the industry's ability to rehire workers after recession layoffs. This will create a large labor deficit and render the construction industry unable to obtain the 185,000 new workers needed annually for the next decade's worth of projects.

Table 3

Total Estimated Tax Losses from Worker Misclassification in the Construction Industry Converted to 2016 Dollars

Total Estimated Tax Loss via Worker Misclassification	**Tax Non-Compliance**	**Tax Non-Compliance, All Sectors (2016)**	**% of Misclassified Workers (1984)**	**Tax Non-Compliance Construction (2016)**
Social Security/Unemployment Tax/Income Tax	$1.6 Billion (1984)	$3.64 Billion	19.8%	$0.73 Billion
Social Security/Unemployment Tax	$2.3 Billion (1982)	$4.79 Billion	19.8%	$0.95 Billion
Social Security/Unemployment Tax	$3.3 Billion (1987)	$5.57 Billion	19.8%	$1.1 Billion

Note. Adapted from the United States General Accounting Office, 1996.

Table 4

Cumulative Infrastructure Needs by System, Projected to 2020 (Dollars in $2010 billions)

Infrastructure Systems	**Total Needs**	**Estimated Funding**	**Funding Gap**
Surface Transportation	$1,723	$877	$846
Water/Wastewater	$126	$42	$84
Infrastructure Electricity	$736	$629	$107
Airports	$134	$95	$39
Inland Waterways & Marine Ports	$30	$14	$16
Dams	$21	$6	$15
Hazardous & Solid Waste	$56	$10	$46
Levees	$80	$8	$72
Public Parks & Recreation	$238	$134	$104
Rail	$100	$89	$11
Schools	$391	$120	$271
Totals	$3,635	$2,024	$1,611
Yearly Investment Needs	$454	$253	$201

Note. Adapted from American Society of Civil Engineers, 2013.

3.6.4.3 Mitigating or eliminating health hazard exposures to limited craft workforce. According to the U.S. Department of Education, “60 percent of the new jobs that will emerge in the 21st century will require skills possessed by only 20 percent of the current workforce” (Amladi, 2013, para. 8). This bottleneck will present a critical challenge to the construction industry’s ability to compete for talent and keep it. Therefore, the industry cannot continue to neglect finding business practices that will mitigate or eliminate exposure of its limited craft workforce to long-term cumulative health hazards (Craft Workforce Development, 2013).

3.6.4.3.1 Asynchrony between exposure and onset of health issues obscures responsibility. Before 2014, health issues in construction work had been largely uninvestigated. A potential explanation for this ignorance is that long-term health issues caused by continued exposure to hazards typically accumulate slowly over time and are likely to manifest after workers quit or retire (Craft Workforce Development, 2013). This asynchrony between exposure and onset of health issues obscures the employer’s responsibility to both prevent and reimburse workers for the risks they take to perform daily tasks.

Paradoxically, the cognizant ignorance of cumulative damage incurred on the job actually detracts from both long-term and short-term profits. Because skilled labor is trained and efficient, to hire a replacement requires more financial input to train and manage new workers. This can substantially slow a project’s schedule. On a more basic level, worker output is greater when a worker is in good health (Viscusi & Evans, 1990).

3.6.4.4 Worker health status and productivity impacts throughout project delivery process. If a business culture can come to clearly understand how the construction industry's productivity and profitability are impacted by cumulative health damage incurred by workers throughout the project delivery process, preventative safety measures and compensation plans can be implemented both to save companies money in the short-term and to maximize profits in the long-term. Ironically, in neglecting to pay applicable taxes by intentionally misclassifying workers, employers actually decrease a city's funding to pay for public infrastructure projects and thereby deny themselves future earnings (American Society of Civil Engineers, 2013).

3.6.4.5 Misclassifying workers can lower employer operating costs. Using independent contractors and/or misclassifying workers as independent contractors can lower an employer's operating costs by as much as 25%, because he or she can avoid paying social security, federal and state unemployment insurance, and workers' compensation coverage. This cost advantage can be offset if an independent contractor negotiates higher payments to purchase their own health, retirement, or other benefits. Because construction craft workers typically do not have other marketable skills, they are often forced to accept employers' terms of employment.

3.6.4.5.1 Health and safety laws apply to employees. Further, many of the laws protecting workers' health and safety apply only to employees; workers classified as independent contractors are not protected. Therefore, regulations such as those put in place by OSHA to protect construction workers from health and safety hazards would not apply to these independent contractors. Even if some form of health coverage is contractually obligated, the quality of health and safety protection required of the contractor may be minimal. Moreover, per engineering controls, no dust should be created, and personal protective equipment should be a last resort for protecting the worker. However, providing a worker with a basic respiratory mask (Figure 8)—not accounting for the quantity of silica dust exposure (Figure 9)—would suffice as having fulfilled the terms of the contract. As constructed, the design of these masks does not take into account the quantity of crystalline silica exposure. (Cahill, 2016).

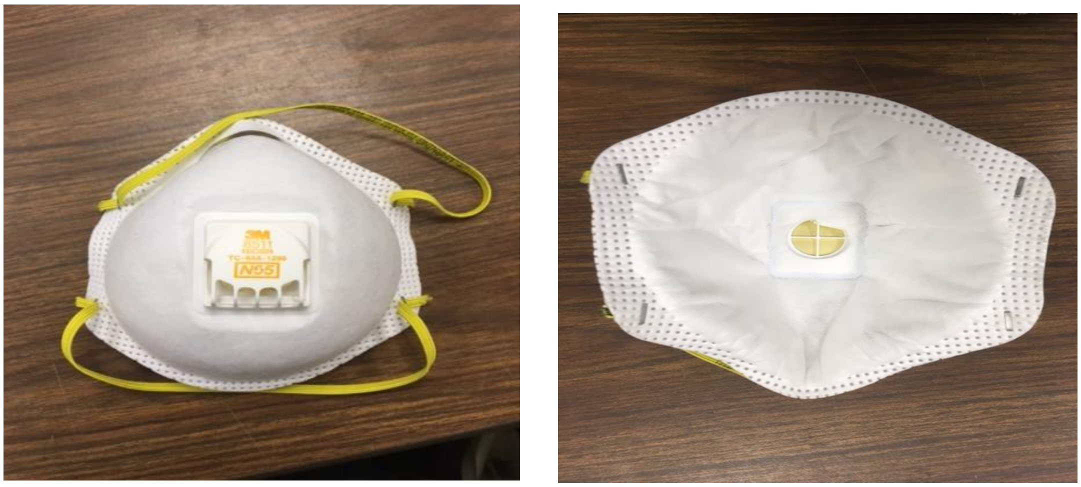

Figure 8. Basic respiratory protection in compliance with OSHA regulations.

Figure 9. Masons exposed to significant stone dust, including silica (Georgia Tech, n.d.)

3.7 The Value of the Statistical Life (VSL) of a Worker

Adam Smith (1776) puts forth in the *Wealth of Nations* that a premium wage garnered for work with a high risk of fatal or non-fatal injuries signifies a worker's acceptance of this risk (Black & Kniesner, 2003). However, defining high-risk of fatal or non-fatal injuries is influenced by many known and unknown factors. These factors differ by occupation and have occupational differences or measurement errors that influence the determined risk. Factors that can impact the determination of the value of risk include occupational errors, measurement errors of risk, measurement errors of risk correlated to worker characteristics, omitted variables related to worker characteristics, and unmeasured job characteristics (Black & Kniesner, 2003).

3.7.1 Economic Value of One Worker's Well-Being

Another challenge in determining the expense, or *value*, of a worker's life to a company has been the surplus of skilled workers in the construction industry that has lessened the economic value of any one worker's well-being. A subtraction of the economic value of any one worker's well-being has allowed companies to neglect preventative and compensatory measures for health and safety. Furthermore, in addition to a surplus of workers, individual worker characteristics (i.e., other co-variates) have also influenced how high risk for fatal or non-fatal injuries is determined. Co-variates, which regardless if known or unknown (i.e., omitted variables such as undefined worker characteristics and unmeasured job characteristics) have influenced the average willingness to pay (WTP) for a change in the risk measure of the tradeoff between the higher wage and the higher risk. This influence needs to be understood, because regardless of whether or not all variables are explicitly defined, by understanding the influence of the omitted variables on the overall WTP, then potentially the Value of a Statistical Life (VSL) or the wage a person is willing to accept to take on an additional unit of risk can be more easily determined. This section explores the economic complexities inherent in estimating the VSL (Office of Management and Budget, 2003).

3.7.2 Definition of the Value of a Statistical Life

The Office of Management and Budget (OMB) (2003) defines the VSL as the wage reduction a worker is willing to accept for a decrease in on-site health and safety risks. VSL estimates are commonly measured by economists using hedonic wage models, which are models that examine how workers weigh wages against workplace risks (Jones-Lee, 1974; Thaler & Rosen, 1976). The VSL is calculated by summing the average willingness-to-pay (WTP) for a small reduction in mortality risk over the population over which the average is computed. Given that riskier jobs are expected to offer wages high enough to attract people to these jobs, an estimate of the wages required to attract a worker to a risky job provides the basis for the VSL (Puckett, 2013). According to Puckett (2013), the estimated coefficients of fatal risks vary widely with the inclusion of occupation and/or industry fixed effects (i.e., characteristics of that occupation and/or industry that are normal and not randomly occurring). Examples of normal and not randomly occurring characteristics are that the industry is a science, technology, engineering, or mathematics field as opposed to a social science field. These characteristic changes in the job risk specification can result in very large changes in the estimated price of risk from both the perspective of the desired wage the worker is willing to accept for the risk and from the perspective of the wage an owner is willing to pay a worker for accepting a risk.

3.7.2.1 VSL used in regulatory analysis. The cost-benefit analyses of government programs preventing premature deaths frequently require placing a monetary value on mortality risk reductions (Puckett, 2013). VSL is commonly used in regulatory analysis to estimate the average willingness to pay for a change in risk (Puckett, 2013). The VSL estimate has been a primary input for cost-benefit analyses used to determine Environmental Protection Agency (EPA) health and safety recommendations and regulations, and, when applied to a large number of workers, a VSL estimate allows researchers to calculate a wage reduction associated with reducing the number of expected deaths by one worker (Black, Galdo, & Liqun, 2003).

3.7.2.2 Wage premiums instead of prevention. In the past, wage premiums—rather than prevention of or compensation for illnesses or injuries—have been the bargaining chips employers have used to acquire workers for jobs that render workers more likely to incur fatal or non-fatal injuries (Black, 2003). Wage premiums provided employers an incentive to reduce job risks and allowed employers to barter the cost of reducing workplace risks against the paybacks associated with the reductions. The reason was the perception that it was cheaper to dole out a slightly higher wage for risky labor than it would be to implement on-site safety precautions or pay for health insurance. Black (2003) has reported that job risk varies by firm size, region, and worker characteristics (e.g., trade experience, gender, age).

3.7.2.2.1 Change in willingness to pay for a change in risk reduction. The change in the willingness to pay for a change in the reduction of a workplace risk can be measured (Black & Kniesner, 2003). It is often measured by the change in the wage over the change in the reduction of the workplace risk. Cameron (as cited by Puckett, 2013) states that “VSL is calculated by summing the average willingness-to-pay (WTP) for a small reduction in mortality risk over the population upon which the average is computed and who are affected by the risk reduction" (p. 1). Puckett (2013) presented the following example for calculating VSL:

> Suppose it is estimated that each member of a population of a hundred thousand is willing to pay $50 on average for a 1/100,000 or a "micro-risk" decrease in the risk of dying during the next year. The corresponding VSL would then be $50 × 100,000 or $5 million. Thus, the VSL provides policy makers with an *ex ante* or pre-event estimate of the monetary benefit of a policy that reduces mortality risk. (p. 1).

A challenge to calculating VSL is that risk and wage data given by occupation often have errors, omissions, and unknown co-variates that affect the present hedonic wage models by either overestimating or underestimating the VSL (Black & Kniesner, 2003). So, knowing the change in the WTP over the change in risk or having job risk data and wage data facilitates VSL calculations.

3.7.3 Two Major Sources of Job Risk Data

Black (2003) cites the two major sources of job risk data: 1) the Survey of Working Conditions from the U.S. Bureau of Labor Statistics (BLS) and 2) the National Traumatic Occupational Fatality Survey from National Institute of Occupational Safety and Health (NIOSH). The NIOSH data provides single-digit codes to define occupation or industry mortality rates by state, while the BLS data presents fatality totals by three-digit occupation or industry codes, but with no regional variation. The BLS data does not provide the number of workers in an industry, just the number of deaths, and the NIOSH data does not require researchers to estimate workers in an industry. Instead, the NIOSH uses a five-year industry population average and allows job risk measures to vary by state. Variation may be smoothed using this five-year average, but doing so may omit important time-series variation (e.g., the day of the week and amount of mail delivered to a business, due to labeling a one-digit industry code versus a three-digit industry code).

3.7.3.1 Coding systems and job risk accuracy. Importantly, these coding systems tend to inaccurately classify relative risk across sectors. For example, NIOSH data treat police officers and dental assistants as having the same job risk, because their occupations or industries are classified as "service worker." NIOSH also ascribes the same job risk measure to a secretary in the coal mining industry as it does to the coal miner, because they are classified using the same industry code. Hence, examining risk by broad and superficial classifications neglects the important issue that individuals are unequally exposed to risk, even working the same job (Abadie, 2006). Therefore, relating VSL to the exposure of construction trade workers to cumulative health hazards can bring to light faulty decisions in labor policies, among other preventative measures to mitigate risk.

3.7.4 Risk Definitions

In construction, risk is the probability of exposure to an environmental hazard multiplied by the severity. The online Merriam-Webster dictionary defines risk as the

> possibility of loss or injury, someone or something that creates or suggests a hazard, the chance of loss or the perils to the subject matter of an insurance contract - the degree of probability of such loss, a person or thing that is a specified hazard to an insurer; and the chance that an investment (as a stock or commodity) will lose value.

Thus, to measure the risk of a fatality while on the job, Black (2003) matched multiple measures of job risk estimates from the Outgoing Rotation Groups of the Current Population Survey (ORG-CPS), the Bureau of Labor Statistics Survey of Working Conditions, and the National Institute of Occupational Safety and Health estimates from their National Traumatic Occupational Fatality survey. These multiple measures of job risk, as well as the aggregate measures of job risk by demographic groups were compared to infer the reliability of the job risk measures. The relationship among the variables was determined or correlated using regression analysis, a statistical process that helps to understand how the typical value of a dependent variable (or criterion variable) changes when any one of the independent variables change and the other independent variables are held fixed (Black, 2003).

3.7.4.1 Maximum correlation of risk. As reported by Black (2003), the average value of the coefficient of determination or R-squared (R^2) was a maximum correlation of 0.53 out of possible values ranging from 0 to 1. The closer the R-squared value is to 1, the better the relationship among the dependent and independent variables. Black (2003) also reported that the relationship of the risk of an on-the-job fatality reduced to as low as a range from 0.28 to 0.05, which means that the relationship between the dependent values and independent values of the risk of an on the job fatality became weaker as more job measures of job risk estimates were correlated. See Black's (2003) *On the Measurement of Job Risk in Hedonic Wage Models* for a complete review of the econometric background of and empirical results from studying the impact of measurement error correlations for hedonic wage models.

3.7.5 Methodological Flaws in VSL Estimation

Black (2003) has found several methodological flaws in studies estimating VSL to be between $4 and $9.5 million for a total annual risk reduction for each person in a population of 100,000. Estimates from the most methodologically sound studies have large variation that can be attributed to statistical challenges resulting from attempts to model amenability to job risks in relation to the characteristics of both workers and firms using methods that economists do not yet fully understand (Black, 2003). What the above means is that if the total annual risk reduction is divided by the population of 100,000 the resulting value will be the estimated wage reduction a worker is willing to accept for safer conditions. Conversely, the resulting value is also the wage increase a worker is willing to accept for a riskier job. Moreover, these estimated values for society's willingness-to-pay (WTP) for risk reductions reflect individual's risk preferences gathered through surveys or revealed through labor market decisions (i.e., the wages a worker accepted in return for doing the riskier job) (Kenkel, 1998). Hence, a VSL estimate is important because it helps the labor market make decisions regarding wage scales for its riskier jobs. Though estimated VSLs help labor markets set wage scales, the variability in job risks, and worker preferences, measurement variations for the estimates demonstrate that presently there is a void of statistically sound models to correlate the risk a worker is willing to accept with a desired wage or other variable. This, then, creates a level of unpredictability within market behaviors that makes it challenging for employers or workers to determine an equitable exchange between them for the work and for the wage.

3.7.5.1 Poorly measured workplace risk rates and omitted variables. Puckett (2013) further explains that aside from inconsistent methodologies and different sample populations, which cause variations in VSL estimates, two major issues significantly contribute to inaccurate estimates from hedonic wage literature: poorly measured workplace risk rates and omitted variables. This study cites limitations in the risk data available to researchers as a major cause of poorly measured workplace risk rates. All past hedonic wage studies have been examined in meta-analyses using a risk measure that was based on the number of fatal accidents for either a specific occupation or a specific industry across the U.S. This analysis has been used to correlate the risk measures and wage differentials in different jobs or industries that are not due to risk differences. Thus, correlating risk measures and wage differentials in different jobs other than those for which the original risk measures was created will then provide a risk measure for a job that may not have the same intrinsic risks. Because, either the resulting risk measure will be too high or the resulting risk measure will be too low. Consequently, with regard to exposures to health hazards, workers may be potentially exposed to greater health risks than previously perceived if specific risk differences are not included in the overall risk calculation for a job.

3.7.5.1.1 Causes of omitted variable bias. Omitted variable bias results from key worker characteristics, such as mixed risk preferences, being left out of commonly used labor data. Mixed risk preferences increase the difficulty in establishing a sound statistical model to correlate risk with desired wage, because then acceptable risks are based upon individual preferences. And, because individual preferences change moment to moment, day to day, then the instability of personal preference further compounds the challenge for employers to establish a baseline for market behaviors from which an equitable exchange between work and wage can be established.

3.7.5.1.2 Unseen job characteristics equal unknown risks. More troublesome, however, are unseen job characteristics, such as unknown risks, that may be correlated with both job risks and wages, which bias the risk coefficient estimates in hedonic wage measurements (DeLiere, 2010). Meaning, there may be an unobserved risk influencing the estimated wage measurements via the confounding of the unobserved risk within the observed variables. Hence, this confounding of an unobserved risk is not calculated into the wage compensation for the exposure. Therefore, again with regard to trade workers, if a risk is unknown it does not negate the worker's exposure to the risk. Consequently, if the worker is unaware of the dangers, then the worker's health may be compromised by adverse health outcomes that are greater than what the worker can afford with the calculated wage compensation or are a greater health detriment than the worker would have accepted at the given compensation.

3.7.5.1.3 Endogeneity—Illusion of correlation. Additionally, Puckett (2013) notes that biased estimation of risk premium could be caused by a correlation between a risk variable and the error term in a given model. For example, a positive correlation found between fatal risk and physical exertion required for a job or risk and environmental factors such as noise, heat, or odor may be a result of omitted variable bias. Whereas, rather than an actual correlation or relationship existing between the fatal risk and physical exertion, these variables both relate to a third omitted variable. And, because fatal risk and physical exertion are related to the third omitted or unknown variable, then it looks as though a positive correlation exists when in fact it does not.

The common illusion of a correlation is what economists refer to as endogeneity. Endogenic variables can skew the actual risk of a job by either overestimating or underestimating the risk. The main problem of endogeneity is that there are innumerable unobserved and observed unrelated variables to any of the other variables in the system that can result in a positive correlation when in fact it is the problem of unobserved heterogeneity in the sample. For example, higher insurance risk premiums could be estimated as a result of numerous unobserved and observed non-financial characteristics that create an illusion of a correlation between risk variables. Similar to creating illusions of variable relationships that can result in higher insurance risk premiums, endogenic variables can also create negative correlations or downwardly biased estimates between variables. For instance, estimates may be downwardly biased between fatal risk and job characteristics required for a job like office work or documenting skills if, for example, it is failed to be noted that this job location is at an active military installation during wartime. Thus, regarding health practices and climate within construction, unobserved and observed risk variables will impact the soundness of the statistical models that the market has to estimate a fair wage in exchange for the acceptance of a higher level of job risk, and in either direction, estimation results in an inequitable exchange for either the market or the worker for the accepted risk.

3.7.6 Economic Strategy is Business Planning for Uncertainties or Changes in Market Conditions

Ultimately, the relationship between poorly measured risk rates and omitted risk variables is an empirical question and is likely related to the jobs studied in any dataset. Few studies, however, have attempted to understand how researchers' econometric strategies might also influence VSL estimates, where economic strategy is business planning for uncertainties or changes in market conditions that allow a company to adjust quickly to new threats and opportunities (Puckett, 2013). Business planning can take place at 1) the corporate level, to help a company establish an overall frame of reference for how to use its inputs to make limited, expandable investments in assets that would facilitate adaptation to a particular scenario; 2) the business-unit level, where economic strategy can help test and refine business scenarios and how these scenarios impact existing economic strategies; and 3) on a daily basis, where economic strategy can be used by business units to make calculated decisions on near-term uncertainties that threaten the execution of their current strategy (Wood, 2012).

3.7.6.1 Economic strategies and construction industry market fluctuations. Thus, regarding improvements to health practices and climate within construction, econometric strategies can help the construction industry ride the market fluctuations in the availability of productive labor through appropriate short- and long-term business planning. Understanding the cyclical nature of the availability of the needed productive labor can facilitate an employer's ability to pay higher wages to skilled workers in lean times when these skilled workers are needed by the industry.

3.7.7 Instability of VSL: Random Versus Intentional Errors

In conclusion, though estimated coefficients of fatal risk can vary widely with the inclusion of occupation and/or industry fixed effects for strict statistical models, similar sensitivities to the choice of risk data and other model specifications, such as occupation and/or industry fixed effects, have been estimated using less stringent statistical models. This indicates that the instability of VSL estimates is not the result of omitted variables, but rather, non-classical measurement error or errors that are not randomly occurring but committed intentionally. Regarding wage compensation associated with jobs or occupations known for their inherent high risk, this means the present statistical models are not unstable because of omitted variables that skew the correlation between the risk of fatality and job characteristics. But, rather, the models are potentially unstable for the following reasons:

1) Misreporting: A will-full misrepresentation of the truth about the risk or job characteristics with reasons ranging from political, self-protection, and/or privacy protection;
2) Wrong recall: Such as survey respondents not remembering particular pieces of information like how many cookies they ate, and so they round the number to the nearest whole number or multiple of 5 or 10;
3) Careless answers: For example, when asked about the salary of individuals in certain professions people never considered an actual value, report rounded numbers, and make thoughtless guesses;
4) Inadequate questions: Questions that are not clearly written and allow for an interpretation other than that intended by the researcher;
5) Interviewer effects: Such as from an interviewer explaining instructions for a question differently to each interviewee, an interviewer showing judgment on his/her face, an interviewer coaxing a “right" answer from a respondent, or the interviewer asking questions based on his or her own biased opinions.

And, though non-classical measurement error can be prevented through very careful study design, the problems are that lies are not usually random, numerical answers are not randomly rounded, recall mistakes are not random, and/or hard questions are not randomly answered (Caetano, n.d.). Moreover, with regard to wage compensation models for riskier jobs, because humans tend to exhibit non-classical measurement error behaviors selectively, this implies a potentially intentional misrepresentation of fatality risks and job characteristics. Intentional misrepresentations skew the compensation required by workers to willingly accept a riskier job and/or the wages employers are willing to pay workers willing to accept the riskier job.

3.8 The Costs of Health and Safety Efforts

The following section highlights the research findings of Paez's (2013) dissertation titled "Financial Assessment of Health and Safety Programs in the Workplace," as well as findings from the thesis by Almond (2013) titled "An Analysis of a Missing Concept for Sustainable Buildings: Addressing the Safety and Health of Construction Workers."

Research into the assessment of the financial impact of occupational safety in the workplace was first introduced by Bird (1984) with the cost-of-the-accident iceberg. Researchers have shown the historical impact of occupational injuries and diseases on a firm; however, because traditional accounting systems do not translate the productivity impacts of the absence of the injured employee or the impact of operation disturbance into direct financial values, firms have been unaware of the magnitude of the financial losses occupational injuries and diseases have had on their desire for profitability.

3.8.1 Importance of a Good Accounting System

A main challenge to demonstrating how preventing health and safety issues is good for business is the accounting systems used by firms (Paez, 2013). Research by Rikardsson and Impgard (as cited by Paez, 2013) stated that "accounting systems are not suited for measuring resources involved in supporting health and safety activities" (p. 13). Without a comprehensive methodology for performing a cost analysis of occupational accidents providing "visibility of the contribution of health and safety programs to a company's profitability,…most corporations are reluctant to sponsor programs when there is no robust financial justification" (Paez, 2013, p. 14). Methods relating time, materials and components, external services, liabilities, type of accident, wage structure and policies, health and safety management, specific process vulnerabilities, absence of the injured employee, operation disturbance, and administration need to be developed so that the cost of operational injuries and diseases can be translated into impacts on profitability (i.e., a robust financial justification for firms to incorporate health and safety investments into their financial business strategy). Firms also need to make the reliability of their historical data a priority and find ways to translate how a broad range of business drivers contribute to firm performance, how these components create cash flows, and how the components can be quantified in terms of the effect of improvements in health and safety for future scenarios (Paez, 2013).

3.8.2 Incident Rates and the Experience Modification Rate

In terms of values that provide health and safety data that can be measured, Almond (2013) presents incident rates and the experience modification rate as defined by CFR Part 1904 for OSHA. Incident rates are either a Recordable Incident Rate (RIR) that encompasses all recordable injuries or a Lost Time Case Rate (LTCR) that is only for incidents that involve lost workdays (Almond, 2013). The equation for calculating the RIR is total recordable number of injuries and illnesses times 200,000 divided by the number of hours worked by all employees. The equation for calculating LTCR is the total number of injuries and illnesses resulting in lost workdays times 200,000 divided by the total number of hours worked by all employees (Almond, 2013). The Experience Modification Rate (EMR) is calculated by insurance companies to evaluate a firm's safety performance. The average industry EMR is 1.0. An EMR greater than 1.0 means that an insurance company has paid workers' compensation claims above the industry average. An EMR less than 1.0 means an insurance company has paid workers' compensation claims below the industry average (Almond, 2013). Though the RIR, LTCR, and EMR provide insurance companies with firm safety performance data, these values are not direct methods for translating the cost of occupational injuries and diseases into impacts on profitability but are data points on a continuum that can be used as a financial justification for firms to integrate health and safety investments into their financial business strategy.

3.8.3 Financial Impact of Occupational Injuries and Disease

The research by Leigh (as cited by Paez, 2013) shows that occupational injuries and disease carry a huge financial impact. Paez (2013) reports that researchers have "acknowledged that health and safety intervention program costs have implications beyond health costs and are a contributor to the increased performance of different organizations" (p. 9). However, the focus of occupational health and safety research has been "understanding the cost of accidents and their effect on the operational costs of the firm" rather than how occupational health and safety programs, which have been shown to be "financially sound" can be incorporated into "the operation goals of the firm," (Paez, 2013, p. 13).

3.8.3.1 Occupational illness and injury medical and indirect costs. Paez (2013) presents a comprehensive study by Leigh that estimates the financial impact of occupational illness and injuries in the United States with the costs sorted into medical costs and indirect costs. The primary data sources for the comprehensive study were from 2007. The data sources were the U.S. Bureau of Labor Statistics, the Centers for Disease Control and Prevention, and the National Council on Compensation Insurance. Leigh (2011) used a sensitivity analysis "to test the effects of most consequential assumptions, and used epidemiological evidence for diseases attributable to workplace exposures" (p. 16).

3.8.3.1.1 Annual direct and indirect medical costs—Diseases, fatal and non-fatal injuries. Paez (2013) reports that the results Leigh obtained for the "annual number of fatal and non-fatal injuries was estimated to exceed 8.56 million injuries, with direct medical costs of $46.26 Billion and indirect costs of $139.89 Billion" (p. 16). For annual disease, more than 516,000 incidents were identified "with direct medical costs of $36.98 Billion" (p. 16). Thus, based on the sensitivity analysis, the combined costs of injuries and diseases ranged from $145 Billion to $401 Billion, with more than 73% of the costs being indirect (Paez, 2013). Paez (2013) further cites research by Leigh that ranks "the magnitude of the costs of occupational injuries and diseases similar to those of cancer and higher than those of diabetes or chronic obstructive pulmonary disease (COPD)" (p. 16), but without concerted focus that should be received by occupational injuries and disease with costs of a magnitude comparable to diabetes and COPD.

3.8.3.2 Opportunity to reduce work-related illness and injuries through preventative measures. Paez (2013) reports that Leigh refers to these findings as "evidence of the opportunity for firms to reduce significantly work-related illness and injuries through the application of preventative measures" (p. 16). The most significant outcomes cited supporting these findings was of ergonomic improvement research by Lahiri, Gold, and Levenstein (as cited by Paez, 2013), which showed a net-cost model that "consisted of a reduction of health costs, lost time, and an increase of productivity that ranged from 5 to 85 times the cost of the intervention" (p. 8). Regardless of increased performance results from health and safety interventions, Almond (2013) emphasizes the moral obligation to not knowingly expose fellow human beings to health hazards. Unfortunately, as Almond (2013) presents, there is a standing question as to whether or not construction workers meet the definition of "general public" as presented in the 2007 Code of Ethics for the National Society of Professional Engineers that calls for the "safety, health, and welfare of the general public." So, although the ways in which the cost of occupational health and safety has historically affected firms has been demonstrated in the research, according to Paez (2013), what the research has failed to show is how the prevention of health and safety accidents is good for business as well as society.

3.8.3.3 Progressive owner involvement in health and safety implementation. Almond (2013) also discusses costs and how owners are becoming progressively more involved in implementing health and safety practices. The first costs Almond discusses are the obvious effect of the injury on the worker and his/her family. Then, Almond discusses costs such as the employer's loss of valuable man-hours as a result of the injury, the potential impact on workers' compensation rates, the potential for OSHA fines, the impact on the firm's safety record, the potential for litigation, the lost productivity, the potential for an on-site safety investigation that may result in fines for unrelated violations, to a loss of reputation from a poor public perception of the firm. Owners are becoming increasingly involved because greater litigation (Huang & Hinze, 2006) is bringing to light the responsibility and direct influence owners have on construction project health and safety performance. Hence, as a result of the direct and indirect impacts of health and safety consequences, it behooves firms truly interested in remaining competitive and looking for opportunities to increase their profitability to invest in health and safety beyond required compliance or the prevention of liability (Almond, 2013).

3.8.4 Avoiding Addressing Occupational Injuries and Illnesses Is Not a Sustainable Business Strategy for Increasing Profitability

Overall, regardless of moral perspective, there is a core message, whether one is looking at actual medical costs or indirect costs resulting from injuries or illnesses as cited by Paez (2013) or examining potential consequences with unknown or greatly varying financial costs as presented by Almond (2013). The core message is that avoiding or neglecting to directly address occupational injuries or illnesses with costs of a magnitude comparable to diabetes or COPD, when opportunities exist to significantly reduce work-related illnesses and injuries, is not a sustainable business strategy for increasing profitability because it is like leaving money on the contract table.

3.9 Current State of Practices and Perceptions Regarding Health and Safety

The United States Department of Labor's Occupational Health and Safety Administration (OSHA) has a Directorate of Construction, whose mission is: "To serve as OSHA's principal source for standards, regulations, policy, programs and assistance to OSHA, other Federal Agencies, the construction industry, and the general public with respect to occupational safety and health" (OSHA, n.d., para. 1). Of the activities of the Directorate of Construction's Office of Construction Services and Office of Construction Standards and Guidance ranging from consultation and information on construction standards, keeping abreast of workplace technological developments, and legal sufficiency to coordinating with and providing assistance to the other regulatory agencies on the implementation and enforcement of major construction laws and standards, only nine of the 35 activities mention occupational health or illness. These nine activities emphasize compliance and inspections rather than prevention (OSHA, n.d.); they are:

1) compliance;
2) standards;
3) maintaining technical liaison with the construction industry in the technology involved in construction safety and health programs to evaluate new techniques and recommend those most effective and efficient for OSHA application;
4) developing comprehensive programs for construction occupational health compliance and incident investigation activities;
5) coordinating OSHA policy regarding construction occupational injury and illness statistics;

6) advising and consulting with key OSHA officials on safety and health issues for policy level decision making;
7) coordinating targeting strategy for directing construction safety and health inspections by Federal OSHA and States with high rates or large numbers of occupational fatalities injuries and illnesses;
8) conducting specialized surveys using quantitative or statistical methods to facilitate research on specific construction safety and health issues;
9) to maintaining liaison with NIOSH and BLS to obtain construction injury and illness data.

The current state regarding health and safety within construction can benefit from a shift to prevention, where prevention can potentially decrease the "large numbers of occupational fatalities injuries and illnesses" that are surveyed by Federal and State OSHA using statistical methods (OSHA, n.d.). The OSHA hierarchy of controls for aiding in controlling workplace hazards associated with chemical and toxic substances is reviewed in the following section.

3.9.1 OSHA Hierarchy of Controls

The OSHA Hierarchy of Controls (Figure 10) aids in controlling workplace hazards associated with chemical hazards and toxic substances (OSHA, n.d.). According to OSHA (n.d.), the fundamental method of protecting workers is to control exposures to chemical hazards and toxic substances. Hierarchy of Controls is a means of determining how to implement feasible and effective controls. The long-standing policy for engineering and work practice for OSHA (n.d.) is that "controls must be the primary means used to reduce employee exposure to toxic chemicals, as far as feasible, and that respiratory protection is required to be used when engineering or work practice controls are infeasible or while they are being implemented" (para. 1).

OSHA (n.d.) also states that, where possible, 1) elimination or 2) substitution is the most desirable, followed by 3) engineering controls and 4) administrative controls, and where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls, then 5) personal protection equipment, which is the least desirable (Tables 5 and 5a).

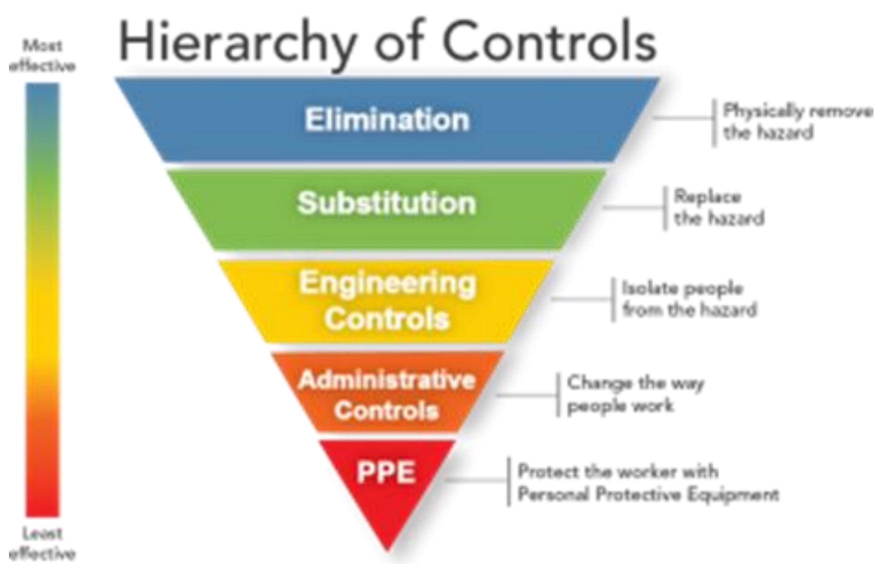

Figure 10. OSHA Hierarchy of Controls. (OSHA, n.d.)

Table 5

OSHA Hierarchy of Controls

Type of Control	**Examples**
Elimination/Substitution	• Substitute with safer alternatives. [See Transitioning to Safer Chemicals: A Toolkit for Employers and Workers]
Engineering Controls: (implement physical change to the workplace, which eliminates/reduces the hazard on the job/task)	• Change process to minimize contact with hazardous chemicals. • Isolate or enclose the process. • Use of wet methods to reduce generation of dusts or other particulates. • General dilution ventilation. • Use fume hoods.
Administrative and Work Practice Controls: (establish efficient processes or procedures)	• Rotate job assignments. • Adjust work schedules so that workers are not overexposed to a hazardous chemical.

(continued)

Personal Protective Equipment: (use protection to reduce exposure to risk factors)	• Use chemical protective clothing. • Wear respiratory protection. [See the Respiratory Protection Safety and Health Topics page] • Use gloves. • Wear eye protection.

Note. Adapted from OSHA, n.d.

3.9.2 The Present Challenge of Addressing Health Issues: Exposure to Symptoms/Illness Onset

As of now, health issues in construction remain challenging to address because of the lag-time between exposure to hazards and the onset of health issues, which likely manifest only after workers have retired or moved to another job. This asynchrony makes it particularly challenging to develop meaningful regulatory baselines for construction health hazards (NORA, 2008). In practice, controlling exposure to silica is difficult due to the variability of project environments and their unique sets of pathogens (Leigh, 2001). Additionally, the variability in worker attitudes toward preventative methods to minimize exposure to hazards, such as personal protective equipment, coupled with the metrics established to quantify worker utility or productivity, further complicate logistical implementation of protective and compensatory measures.

3.9.3 Bridging the Gap Between Research And Practice Communities

NORA's (2008) Strategic Goals 8 and 12 focus on deficiencies of health and safety regulations in construction. These goals aim to "reduce injury and illness among groups of construction craft workers through improved understanding of why groups of workers experience disproportionate risks in construction work and expanding the availability and use of effective interventions" (NORA, 2008, para. #). Improving the understanding of the disproportionate risk requires health studies beyond the present health studies relegated to industrial hygiene and epidemiological studies (Steenland et al., 2003).

Expanding knowledge regarding worker health issues in construction is important given the myriad potential hazards in construction work. There are populations of trade workers at disproportionate risk for acquiring work-related health problems, and the United States General Accounting Office (1996) reports that causes of disparate risk can be attributed to dangerous job assignments, inexperience, age, inadequate training (compounded by language and cultural differences), immigration status, racial and ethnic discrimination, and job insecurity, especially for workers employed in nonstandard work arrangements (NORA, 2008). These groups are more likely to accept unsafe or toxic working environments. To understand the potential barriers to improving workplace health and safety, these populations must be further studied.

Moreover, NORA (2008) has discovered that inaccurate longitudinal data renders it impossible to accurately evaluate existing data in order to directly determine the impact of interventions on worker health. Furthermore, the methods used to remedy factors contributing to health disparities in construction cannot be detrimental or discriminatory toward the at-risk groups. Instead, they must reach beyond personal worker characteristics to thoughtful examinations of formal and informal policies, work norms, subcontracting practices, and social influences on health disparities in construction so that research is designed and conducted in a manner that supports equity in resources, benefits, and opportunities that include evaluation of public policies (NORA, 2008).

3.9.3.1 Non-traditional approaches to addressing health concerns. Accomplishing the above will require non-traditional research methodologies, such as partnering with community or worker organizations and other groups who are not affiliated with employers in order to elucidate the conditions necessary for unequal risk to be evaluated. In addition, cross-disciplinary research with traditional public health scientists, sociologists, ethnographers, and other social researchers may need to be employed to gain an understanding of these issues from multiple perspectives (NORA, 2008). Appendix F presents NORA's Strategic Goals 8 and 12 for identifying gaps between research and practice.

A non-traditional approach is also the reexamining of the OSHA hierarchy of controls with regard to dealing with health hazard exposures. Planning and design of work is often conducted prior to the involvement of occupational health and safety experts. However, during the planning and design of a job is where the largest opportunity to eliminate/substitute hazards may be found.

3.10 Challenges and New Directions for Regulatory Enforcement

Every year, more than four million workers are seriously injured or made ill by exposure to toxic agents. Crucially, 14 workers die on the job every day (OSHA, 2008). OSHA shares the responsibility of regulating safe and healthy workplaces with other agencies such as the Department of Labor. By law, employers are responsible for ensuring that workplaces are safe and free of recognized hazards, regardless of employee classification. However, it is OSHA's sole authority to make sure workplaces are secure and healthy by helping to build workplace cultures that promote safety.

A major challenge in doing so is ensuring that responsible employers, who invest in protecting their workers, are not undercut by irresponsible employers who put short-term gains ahead of the health and safety of their employees (U.S. Department of Labor, 2010). Responsible employers are potentially undercut by irresponsible employers via low bidding for jobs. Irresponsible employers can often put in a low bid for a job because they intentionally avoid paying overhead costs like preventative health and safety measures.

Another major roadblock is OSHA's budget for only 2,000 inspectors, which is a small number considering these inspectors are responsible for the health and safety of 130 million workers on 7 million worksites around the country (U.S. Department of Labor, 2010). Furthermore, the U.S. Department of Labor (2010) finds that compared to other regulatory agencies, OSHA's fines are not a strong deterrent for unethical behavior. OSHA's maximum fine for a serious violation is $12,471 per violation (OSHA, n.d.); whereas, $350,000 is the top penalty for other federal agencies. OSHA's maximum criminal penalty for a standard misdemeanor is up to six months in jail, while other federal criminal penalties have up to a one-year prison sentence (U.S. Department of Labor, 2010).

Weakly enforced legislation, such as fall protection, is also a challenge in improving the workplace environment. These sheepish federal regulations affect

OSHA's ability to protect workers from retaliation and discrimination when employees voice concerns over health and safety (U.S. Department of Labor, 2010). Thus, outdated and otherwise limited occupational exposure standards for materials and environments, in conjunction with a slow and resource-intensive regulatory process, make issuing new and severely needed regulations very difficult and time-consuming. Appendix G presents key areas in which OSHA has requested assistance from stakeholders and other agencies to address.

CHAPTER 4: RESEARCH METHODOLOGY

The mixed research methods employed in this study is comprised of both qualitative and quantitative methods. Figure 11 shows the research methodology employed in this study.

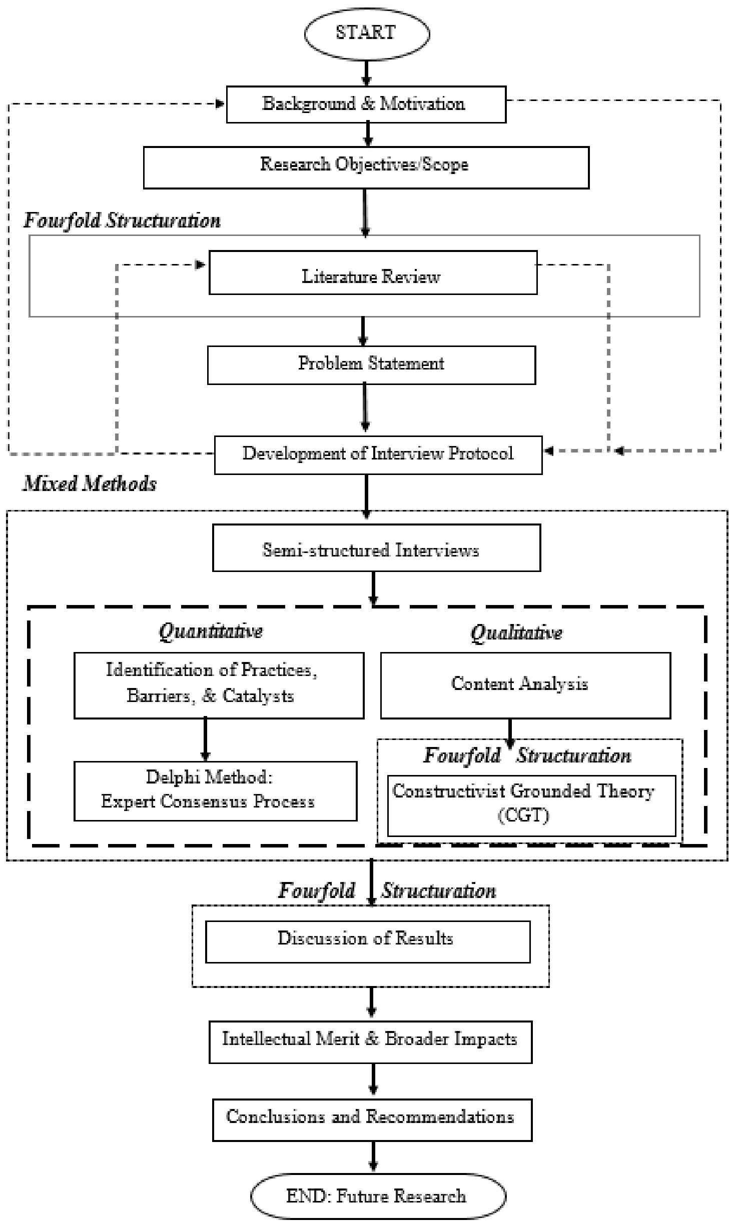

Figure 11. Research methodology.

The background and motivation, research objectives and scope, fourfold structuration framework, literature review and problem statement of the research methodology are presented in Chapters 1 to 3. This chapter focuses on the mixed methods of this study.

4.1 Mixed Methods Research

This study combines qualitative and quantitative protocols in a mixed methods, *concurrent nested* research approach. Creswell (2003) describes a concurrent nested methodology as one that prioritizes either quantitative or qualitative data, while the other is "nested" within the study to address a different subset of questions or to seek information from a different perspective. Here, qualitative interview data is considered the primary data source for the development of quantitative surveys. The qualitative codes developed from the interview data are used to construct a *grounded theory*, which Bryant and Charmaz (2007) define as a qualitative inquiry used to build theory through a systematic, inductive, and comparative process.

Grounded theory is characterized by *theoretical sampling*, in which an analyst collects, codes, and analyzes data according to emergent needs and ideas generated from each new addition to the dataset. In conjunction, *constant comparative analysis* ensures saturation of relevant categories (Glaser & Strauss, 1967). Relevant categories are developed by distinguishing whether a dataset is qualitative or quantitative in nature. The method of constant comparative analysis within the relevant categories is used to determine a saturation point for responses, at which no new responses emerge for a question/category (Kumar, 2005).

Furthermore, because researchers are never truly impartial when conducting research, their biases must be considered as an inevitable part of the outcome measures (Appleton, 1997; de Laine, 1997; Guba & Lincoln, 1989; Stratton, 1997). Therefore, a constructivist grounded theoretical framework is selected for this study. In constructivism, researchers, in their “humanness,” acknowledge and account for their biases as part of the research by embracing a subjective interrelationship between the researcher and participant and the co-construction of meaning (Hayes & Oppenheim, 1997; Pidgeon & Henwood, 1997).

The goals of this mixed methods research are as follows: 1) to develop a constructivist grounded theory to explain how conditions within the construction industry allow companies to ignore workers’ concerns regarding cumulative health hazards, and 2) to identify practices, barriers to, and catalysts for mitigating or eliminating workers’ exposure to cumulative health hazards.

4.2 Data Collection

For this mixed methods study to determine the practices, barriers to, and catalysts for the prevention practices for health hazard exposures, data is collected from participants that have personal experience with or have observed the cumulative health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders. Experience with the health hazards is a primary inclusion criterion for the research participants.

4.2.1 Sampling Strategy

Because the criterion of personal experience with or observation of the cumulative health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders is specific, purposive sampling—a sampling method in which members are sought after because they belong to a particular group—and expert sampling—a sampling method in which only high quality participants are considered for inclusion in the study—are chosen for this research (Kumar, 2005).

All participants had personal work experience with continual exposure to health hazards on construction sites or were involved in efforts to mitigate or eliminate exposures. The data sampling strategy is to develop the concepts/constructs for this research from the personal descriptions/narratives/experiences with the health hazards collected via semi-structured interviews conducted with the construction workers and with the health and safety experts.

4.3 Selection Criteria of Participants

Two separate groups are interviewed for this study. The first group consists of retired construction workers who have worked in both large and small owner/contractor construction organizations representing union and non-union labor models, as well as experience owning their own small-to-medium-sized trade companies.

The qualification criteria for construction craft workers are as follows:

1) Retired with 10+ years of experience in both union and non-union labor models.
2) Availability and willingness to share experience.
3) Clear understanding and strong interest in health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders.

The second group consists of experienced occupational health and safety experts who have had previous experience providing health and safety expertise to both owners and contractors of construction industry organizations. The qualification criteria for the health and safety experts are as follows:

1) Current affiliation with an owner or contractor with 500+ employees or, alternatively, current consultancy for health and safety for construction industry organizations.
2) Upper management or senior position in health and/or safety (a requirement only for experts affiliated with owner/contractor organizations).
3) A minimum of 10 years of total work experience in construction and/or occupational health and safety, or 4 years of similar experience and a college degree in health, safety, and/or hygiene.
4) Clear understanding and strong interest in the topic of study.
5) Geographical spread and balance between contractor and owner perspectives and experiences.

4.3.1 AZ Chapter of Bricklayers and Allied Craft Workers

Group 1 consists of 11 career or retired construction workers, including an apprentice instructor and tradesman, organizer, and union leader. The volunteers are all members of both the Arizona chapter of Bricklayers and Allied Craft Workers (BAC #3) and the International Union of Bricklayers and Allied Craft Workers, the union instrumental in passing new OSHA regulations for crystalline silica.

4.3.2 Owner/Contractor Occupational Health and Safety Experts

Group 2 consists of a panel of occupational health and safety experts with an executive role at leading owner and contractor organizations. The health and safety experts represent a heterogeneous and diverse set of organizations, which actually belong to a highly diverse and extremely defragmented industry. The diverse perspectives of the experts on prevention mechanisms, practices, and barriers, as well as their vision, experience, and understanding are leveraged for this research.

4.4 Participant Consent

All participants are English speakers, so translated letters of collaboration/consent are not required. Research participants submitted signed letters of consent on their organization's letterhead. These letters are kept for 2 years after the completion of the study. Minors are not eligible to participate in the study; therefore, parental consent notices are not required. Appendix H shows a template of the required participant letter of consent.

4.5 Development of Interview Protocol

A previously recorded discussion with a nationally recognized occupational health and safety expert, literature review, and the NORA agenda for the proactive assessment and prevention of construction worker exposure to cumulative health hazards are used to develop the open interview protocol/interview guide. The previously recorded discussion highlighted the expert's thoughts and concerns regarding the present state of prevention practices and construction climate with regard to hazard exposures, as well as focuses on the expert's thoughts regarding actions that can potentially have the greatest positive impact for motivating the industry to address the long-standing health concerns of construction trade workers in a concerted manner. The literature review provides details surrounding those gaps, like those relating to knowledge regarding existing and accessible data or sources that employers can use to develop costs versus benefits for proactively addressing the long-standing health concerns of construction trade workers. The NORA agenda highlights the present gaps with regard to existing knowledge and practice for the four health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders. For example, the NORA agenda points to factors such as worker and management behaviors and attitudes as impacting the ability to effectively drive and implement prevention practices. Appendix I presents the complete NORA derived semi-structured interview guide for craft and OSH experts used throughout the data collection process. The interview questions are divided into two sections 1) Current Practices and 2) Factors and Interventions, which are presented below:

Current Practices

1) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive the prevention of long-standing hazard of noise and hearing loss?
2) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive the prevention of long-standing hazard of silica exposure?
3) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive the prevention of long-standing hazard of welding fumes?

4) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive the prevention of long-standing hazard of musculoskeletal disorders?

Factors and Interventions

5) What are the key negative individual /worker factors that prevent the proactive adoption of measures that would protect workers from the four cumulative health hazards?
6) What are the key interventions at individual /worker level that would lead to the proactive adoption of measures against the four cumulative health hazards?
7) What are the key organizational factors that compromise the proactive adoption of measures against the four cumulative health hazards?
8) In your expert opinion, what are the key interventions at organizational level that would lead to the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?
9) In your expert opinion, what are the key policy and industry factors that compromise the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?
10) In your expert opinion, what are the key interventions at policy and industry level that could lead to the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?
11) What is the monetary relationship (e.g., business case) between positive and negative construction health and safety cultures in regards to the four cumulative hazards?

12) To the best of your knowledge, what data or sources can be available to quantitatively document a cost to benefit associated with the prevention of the four health hazards? Any ideas?

4.6 Semi-Structured Interviews

A pilot interview is conducted with a participant from Group 1, AZ Chapter of Bricklayers and Allied Craft Workers. The feedback is used to revise and develop the final questions for the semi-structured interviews. Semi-structured interviews are used because they permit the interviewee to respond to and focus freely on their experiences with the issues discussed. Additionally, semi-structured interviews enable the interviewer the option of probing further into responses. Permission to record the craft workers is obtained both via telephone conversation with craft workers and confirmation from their union's legal representative. Permission to record the occupational health and safety experts is obtained via an electronic consent form submitted to the principal investigator on the interviewee's company letterhead.

The semi-structured interviews with the Arizona Chapter of Bricklayers and Allied Craft Workers, as well as the occupational health and safety experts, are conducted in-person and over the telephone. Interviews are recorded using an electronic call recorder application. Rev.com is used as a professional transcription service.

The construction craft worker interviews are each between 60 and 90 minutes. For the OSH interviews, the principal investigator spends the first 20–30 minutes explaining the interview protocol and expectations.

The goal of the interviews is to produce enough descriptive information to identify barriers to the implementation of preventative and compensatory health practices. The specific objectives sought via the semi-structured interviews are as follows:

1) Identification of practices for the promotion and adoption of positive health practices within the construction industry that can mitigate or eliminate exposing craft workers to cumulative health hazards.
2) Identification barriers to and catalysts for proactively assessing and adopting measures against cumulative health hazards.

4.7 Qualitative Research Method

The major advancement in grounded theory, relevant to this study, is the development of constructivist grounded theory, which emphasizes that an individual's experiences are complex and have multi-dimensional ramifications over time (Charmaz, 2006). These experiences garner a strong fit with topics of inquiry and help to develop a theory based on data, not just logic. In doing so, constructivist grounded theory balances the inclination to derive meaning from data with the investigator's responsibility to remain objective (Charmaz, 2006).

Charmaz's constructivist grounded theory is chosen for this research because the experiences of construction craft workers and occupational health and safety experts require an interpretive approach to analysis, with more flexible guidelines than rigid procedures, in order to extract meaningful theories from the data. Furthermore, the central role of the researcher to determine categories and question the data—as well as bring personal values, experiences, and priorities into the analysis through his or her interpretations of the data—is best be achieved through a constructivist grounded theory (Creswell, 2007).

4.7.1 Content Analysis of Interviews

Professional transcriptions of the recorded semi-structured interviews from Rev.com are analyzed for commonalities and differences in identified barriers and catalysts to the implementation of practices and preventative mechanisms for protecting workers from exposure to cumulative health hazards. Correlations and inconsistencies in the data are classified, sorted, and arranged by identifying trends and cross-examining the data based on a coding process for categorizing responses.

4.7.2 Constructivist Grounded Theory Development

The fundamental tenets of a grounded theory, according to O'Reilly et al. (2012), are in its analytic guidelines:

1. Constant comparative method: simultaneous coding and analysis of data.
2. Theoretical coding: systematically making sense of the data by categorizing and grouping similar items.
3. Theoretical sampling: logically gathering data based on earlier data and utilizing the researcher's analytical thinking.
4. Theoretical saturation: gathering complete and verified data until new data no longer produces new categories for analysis.
5. Theoretical sensitivity: recognizing and distinguishing between data that gives relevant meaning to the emerging theory and those that do not (p. 248).

Though grounded theory has evolved since it was first introduced, Charmaz's constructivist grounded theory emphasizes the intricacy and multiple realities of individual experience. This methodology emerges through the following characteristics: 1) a strong fit with topics of inquiry; 2) fundamental tenets that produce theory based on data, not just logic; 3) emphasis on balancing the inclination of meaning making with the investigator's responsibility to base an understanding of the knowledge on data; and 4) highlighting the need for the investigator to be ever mindful of the delicate interplay between the data and the meaning he or she derives from it (Charmaz, 2006).

4.7.3 Coding Process for Constructivist Grounded Theory Development

A constant comparative grounded theory approach to analysis (Charmaz, 2006) of open coding, axial coding, and selective coding is used to conduct the data analyses for this study. For the qualitative research portion, three construction craft worker and three occupational health and safety expert interviews are chosen because the subjects' experiences and leadership positions rendered them most likely to yield new insights into why construction craft workers are exposed to cumulative health hazards. From this data, existing barriers for the mitigation or elimination of these exposures are identified. The following steps describe the data analysis process of this study:

1) Data pulling: Data pulling involved transferring the selected sub-groups of interviews and importing them into a Microsoft Excel spreadsheet. To determine what data would be pulled, the transcripts of the interviews are analyzed word by word, line by line, and sentence by sentence etcetera for a core concept. The core concept is pulled and entered into the Excel spreadsheet column titled Pulled Data.
2) Open coding: Open codes are developed for each row of pulled data. The open codes are developed by focusing on the research question(s). The main idea of

the pulled data that relates most directly to the research question(s) is/are what is/are used as the open code for that row of pulled data.

3) Axial coding: Axial codes are developed by examining the open codes developed. Open codes that the researcher perceived as having similar core concepts are grouped. Then the groups of codes are analyzed as a whole to find the core concept contained within each group. The core concept found for each group of codes is then the axial code.

4) Selective coding: Selective codes are developed in a similar fashion to axial codes. The axial codes are again grouped by similar or related core concepts as determined by the researcher's perspective. To facilitate the grouping of the axial codes, a reusable and adhesive white board is purchased and placed on an empty wall. The individual axial codes are then analyzed one at a time and pasted on the white board on the wall until all codes are sorted. Once all the axial codes are sorted by similar core concepts each group is named with a selective code.

4.7.3.1 Code development examples. The following (Tables 6–6b) present three examples of the selective code development process. The explanation of how the different open codes cluster together to form the axial codes and how the different axial codes cluster together to form the selective code is presented after the table.

Table 6

Example 1 of the Selective Code Development Process

#	Transcript Excerpt	Open Code	Axial Code	Selective Code
1.	From limited open shop organizations the message was “Employees are your enemies.”	Open shop message was “Employees are your enemies.”	Shift Employees As Enemies Mindset	Culture of Employee Mistrust
	Open shop associations created a culture of mistrust toward employees.	Open shop created culture of mistrust toward employees	Negative Industry Culture to Workers	
3.	Culture of workers is that workers are a nuisance if they request personal protections.	Construction culture perceives workers as nuisance if ask for protections	Culture of Employee Mistrust	

Table 6a

Example 2 of the Selective Code Development Process

#	**Transcript Excerpt**	**Open Code**	**Axial Code**	**Selective Code**
4.	Mid and upper management is central to developing effective communications with sub-contractors.	Mid and upper management central to effective communications	Mid-Level Managers Central to Communication	Mid-Level Management Commun-ication
5.	Use influence of mid-level managers to keep health and safety processes and communication in check and clear.	Mid-Level manager influence needed to keep communication in check and clear	Mid-Level Managers Influence Communication	
6.	Mid-level managers can influence helping move things forward regarding risk management and risk mitigation.	Mid-Level managers influence risk management and risk mitigation	Mid-Level Managers Influence Risk	

Table 6b

Example 3 of the Selective Code Development Process

#	Transcript Excerpt	Open Code	Axial Code	Selective Code
7.	Message needs to shift to "Employees as Assets"	Shift mindset to employees as assets	Employees as Assets Mindset	
8.	Owner mindset has to be focused on healthy employees as assets	Focus on employees as assets	Healthy Employee as Asset Mindset	Employees as Assets
9.	Employees are every bit as important as the equipment for a company	Employees as important as equipment for a company	Employees Important like Equipment	

4.7.3.1.1 Open coding. The open, axial, and selective codes presented in the above table were developed in the following manner. Starting with the first three transcript excerpts, "From limited open shop organizations the message was "Employees are your enemies," "Open shop associations created a culture of mistrust toward employees," and "Culture of workers is that workers are a nuisance if they request personal protections," each is examined for its central concept. The central concept is the main idea or theme that is within the excerpt. There may be many concepts within an excerpt, but the one that most directly relates to the research question(s), and/or the one containing the majority of the other categories is the one used to develop an open code. The central concept of the first excerpt revolved around a message of distrust for employees. Thus, for the first transcript excerpt, the open code is, "Open shop message was 'Employees are your enemies.'" Respectively, for the second and third transcript excerpts, the open codes are, "Open shop created culture of mistrust toward employees" and "Construction culture perceives workers as nuisance if ask for protections." Similar to the transcript excerpts, open codes may (still) contain multiple related categories. Open code development is a narrowing or filtering of categories contained within a transcript excerpt into a specific category, a filtering process that identifies the potential categories contained within each data fragment by exploring the potential relationships between and among the categories to ensure that the content contained within each category is unique. At the level of open codes, though categories have unique contents, the data fragment still contains other less directly relevant categories to the research question(s). 881open codes are developed. Open coding consists of eight steps (Charmez, 2006, p. 49):

1) Read the entire document.

2) Re-read the text line by line to determine the start and stop of the fragment.

3) Ask if and why this fragment is meaningful as a whole.

4) Decide whether the fragment is relevant to the research.

5) Make up a code/name for the fragment.

6) Give this name/code to the fragment.

7) Read and code all similar fragments within the document.

8) Compare various fragment topics to determine naming consistency with topics.

4.7.3.1.2 Axial coding. To further filter and elevate the data most directly related to the research question(s), the open codes are examined and then clustered into groups that highlight similar core concepts. The further filtering of the clustered open codes for concepts that directly relate to the research question(s) develop the axial codes.

Axial coding, according to (Charmaz, 2006), refers to a process performed after open coding that makes connections between categories to reconstruct data in new ways. This process is more abstract because the data reconstruction encompasses several individual categories. Charmaz (2006) says that "Axial coding relates categories to subcategories, specifies the properties and dimensions of a category, and reassembles the data fractured during initial coding to give coherence to the emerging analysis" (p. 62). From 881 open codes, 721 axial codes are generated. Axial coding consists of eight steps (Charmez, 2006):

1) Create as many open codes as required to sufficiently cover the data.
2) Validate proper fragment coding. Assign the proper code to each fragment.
3) Merge categories with similar or duplicate content.
4) Analyze data fragments for similarities and differences to ascertain proper coding.
5) Subdivide categories if a category contains more than one concept.
6) Look for distinguishing evidence for main codes and sub-codes. Assign sub-codes to main codes.
7) Determine if from the assigned fragment a detailed description can be created for the category. Collect more data if a detailed description cannot be created.
8) Continue thinking about the data and coding.

Axial coding is deemed complete when distinctions between main codes and sub-codes are established and clear distinctions can be made between the contents of the categories (Charmaz, 2006). Several axial codes rise to the level of selective codes because they are determined to be a core category. An example is the axial code of "Change takes time." There are no other axial codes that referred to time and change together. Thus, this axial code is deemed to be a core category and rises to the level of selective code.

4.7.3.1.3 Selective coding. The next step after axial coding is the development of selective codes. Selective codes are developed by printing out the axial codes and one by one taping the axial codes up on a wall dry erase board. Organizing the axial codes one by one on a wall allows the researcher to view the codes more easily and to better discern the axial code groupings by related concepts. Thus, a similar process of looking for connections between the categories in order to integrate and reconstruct the data is followed in the development of selective codes. For the first three transcript excerpts, the axial codes of "Shift Employees as Enemies Mindset," "Negative Industry Culture to Workers," and "Culture of Employee Mistrust" develop into the selective code, "Culture of Employee Mistrust." Whereas, transcript excerpts four to six and seven to nine develop into the selective codes of "Mid-Level Management Communication," and "Employees as Assets," respectively. The selective code of "Culture of Employee Mistrust" is chosen because it expresses the concept continually present from the transcript excerpt through the axial codes of "Enemies and Mistrust." Similarly, for the remaining examples, the selective codes are chosen because these codes hold within them the respective concepts of "communication" and "assets" that are also present from the transcript excerpt through the axial codes. From 721 axial codes, 172 selective codes are developed. The process of selective coding is the end of the analysis phase (Charmez, 2006, p. 68). When the following questions can be answered, it can be said it is understood as to how the pieces fit together:

1) What are themes that have repeatedly been observed?
2) The main message brought across by the participants is?
3) What is the relationship between various relevant themes?
4) Of the description and understanding of the participant's perspective and behavior, what is important?
5) Phenomenon A emerges under which circumstances?
6) Experience B is facilitated by?
7) Phenomenon C is influenced by?
8) Event D is absent when?

Appendix J contains two code tables. The first table of Appendix J shows excerpts from the interview data through the development of the axial codes. The second table of Appendix J shows the axial codes grouped by similar concepts and the resulting 172 selective codes. Once the axial code groups are named via a selective code, a theory organizing the selective codes is developed. The constructivist grounded theory development is explained in detail in Chapter 5.

4.8 Quantitative Research Method

The first step of the quantitative research method to achieve the objectives of identifying the practices for improving the health and safety conditions within the construction industry, as well as identifying the barriers to and catalysts for the practices, is to conduct a content analysis of the occupational health and safety experts interview data.

4.8.1 Identification of Health and Safety Practices, Barriers and Catalysts

The interview data of the occupational health and safety experts is examined for 1) practices that promoted health and safety for the four main health hazards of concern to NORA: welding fumes, crystalline silica, noise, and musculoskeletal disorders; 2) worker, industry, and organizational barriers; and 3) worker, industry, and organizational catalysts for the four NORA hazards. Via a similar coding process for developing the qualitative codes and in conjunction with knowledge from the literature review and NORA agenda, practices, barriers, and catalysts for the implementation of health practices in construction are developed for the Delphi Surveys (Appendix K.) The practices, barriers, and catalysts are explained in detail in Chapter 6.

4.8.2 Development of Survey Questions

The survey questions focus on validating, via the opinion of the occupational health and safety experts, whether the list of identified practices, barriers, and catalysts for the health hazards of welding fumes, noise, crystalline silica, and musculoskeletal disorders is complete. Qualtrics—a qualitative software that enables survey construction, distribution, and results—is used to build the surveys. Personalized survey links are used to distribute the surveys and facilitate response tracking.

The surveys are distributed only to the 11 occupational health and safety experts interviewed, because the quantitative portion of this research is based on the opinions of experts employed in organizations with 500+ employees. Organizations with 500+ employees are the focus because they are large capital companies that can be drivers for change within the construction industry—drivers that can shift the accepted behaviors of mid-to-smaller companies wanting to do business with these large asset organizations.

Additionally, many of the craft worker participants do not have access to a computer. Thus, with the surveys distributed via email, not having access to a computer is a constraint for obtaining feedback from the craft workers within the research schedule.

4.8.3 Delphi Method

The surveys are distributed to occupational health and safety experts via a consensus process known as the Delphi Method. The Delphi Method, widely used for business forecasting, is a structured communication technique based on the principle that decisions from a structured group of experts are more accurate than those from unstructured groups (Linstone & Turoff, 1975).

The Delphi Method, according to Linstone and Turoff (1975) is best when the number of experts is limited from 8 to 12 participants. Limiting the expert number reduces opportunities for psychological conflicts and communication constraints among the research participants (Turoff, 1975). To account for potential attrition, 16 OSH experts are invited to participate. All experts remain anonymous, even after completion of the final report. This prevents any expert from dominating other experts. Chapter 6 provides a detailed review of the Delphi Method process within this research.

4.8.3.1 Survey question consensus process. Structured information flow through three rounds of electronic surveys controls the interactions among participants. Participants comment on their responses, the responses of others, and on the progress of the panel as a whole. This provides more flexibility with less tendency for conformance, because participants can revise their comments at any time.

4.8.3.2 Data validation. To validate priorities or patterns to the responses from the first survey round, two additional rounds of surveys are emailed to the Delphi Method participants. Thus, each participant receives a total of three surveys, with each follow-up survey based on the results of the previous survey.

After each survey, response results are made available to the survey participants via an electronic repository. The electronic repository is configured so that participant access to the repository remains anonymous. Participants are encouraged to revise their previous answers based on the responses of other panel members. The expectation is that as participants revise their answers, the range of answers would decrease and converge toward an optimal answer (Linstone & Turoff, 1975). The stop criterion for this research is the completion of three survey rounds.

4.8.3.3 Data limitations. Methodologically, this study is bounded by using mixed methods to translate qualitative interview data into quantitative data. Part of the challenge in doing so is that there is a small percentage of the sample population with sufficient accessibility, amenability, and required experience for participating in the study. Moreover, the sample population is limited to craft workers in the Arizona Chapter Bricklayers and Allied Craft Workers Union, because these workers have been consistently exposed to each of the four major cumulative health hazards of interest to NORA.

Conversely, greater geographic and experiential diversity is reflected in the sample occupational health and safety expert population. Thus, their input has greater generalizability. The participants within both the craft workers and occupational health and safety participants, however, are mainly White men; a diversity of gender and ethnic perspectives is not reflected in this study.

CHAPTER 5: EMERGED CONSTRUCTIVIST GROUNDED THEORY/MODEL

From the qualitative content analysis of three construction trade workers, whose experience and position identified them as leaders within their profession, and three occupational health and safety experts, whose interviews, based on the impression of the researcher, demonstrate a greater depth of experience and understanding of the long-standing health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders, this chapter presents the following: 1) the constructivist grounded theory or construction cosmos model that emerges from the content analysis of the interviews, 2) how the emerged model supports the research objectives, 3) the role of the identified barriers to and catalysts for health and safety practices within the emerged model, and 4) the answer to the research question(s) from a qualitative perspective.

5.1 Emerged Constructivist Grounded Theory

As an engineer familiar with quantitative theories, when my committee member and qualitative researcher, Dr. Mirka Koro-Ljungberg, said I needed to develop a conceptual model or "picture" that represented the relationships of the selective codes that emerged, my first thought was "huh"? My second thought was "A picture, how do I do that?" My third thought was "God help me."

As I mentioned in Chapter 1, I did not think my interest and studies of indigenous knowledge could have any relationship to the state of the health practices and climate within the construction industry. However, again the higher power that led me to ASU proved me wrong. As I explored possible ways of explaining the data relationships, I got intuitive "nudges" to explore Buddhist mandalas and the Native American medicine wheel. My intuition told me that if I could understand how mandalas and the Native

American medicine wheel held within them universal knowledge that is understood to this day within various indigenous systems, then I would be able to understand how to express the relationships in my construction (data) universe. Moreover, I would be creating a bridge between indigenous knowledge systems and Western left-brain thinking, something I did not think was possible for explaining health practices and climate within construction.

5.1.1 Merging of East and West Thought Systems

In the following paragraphs, I present an example of a Buddhist mandala to help the reader understand how to use the conceptual model that emerged from this research. A Buddhist mandala, as a symmetrical representation of the cosmos or any concept or idea that an individual wants to contemplate, can take many forms. Each mandala image is a unique imaginary palace contemplated during meditation that represents the universe where "each object in the palace has significance, representing an aspect of wisdom or reminding the meditator of a guiding principle…. The mandala's purpose is to help transform ordinary minds into enlightened ones and to assist with healing," (Sacred Mandala, 2009, para. 3). For example, in Figure 12, the Medicine Buddha Mandala for Healing, the parasol and the sword are objects imagined by the creator of this mandala as necessary for healing and protection from negative mental factors like ignorance.

5.1.1.1 Mandala—Tool for conscious awareness. I chose the healing mandala as an example because "healing" is what is needed within the construction "universe/cosmos"—healing with regard to the health issues faced by workers exposed to hazards and the health consequences resulting from the exposures, regardless of their cause; the healing needed for mindsets limiting potential opportunities for creative solutions; the healing needed to loosen the grip of the fear of negative impacts to profits that continue traditional patterns for industry decisions; and the healing needed to allow the inflow of other ideas to challenges faced within the construction industry.

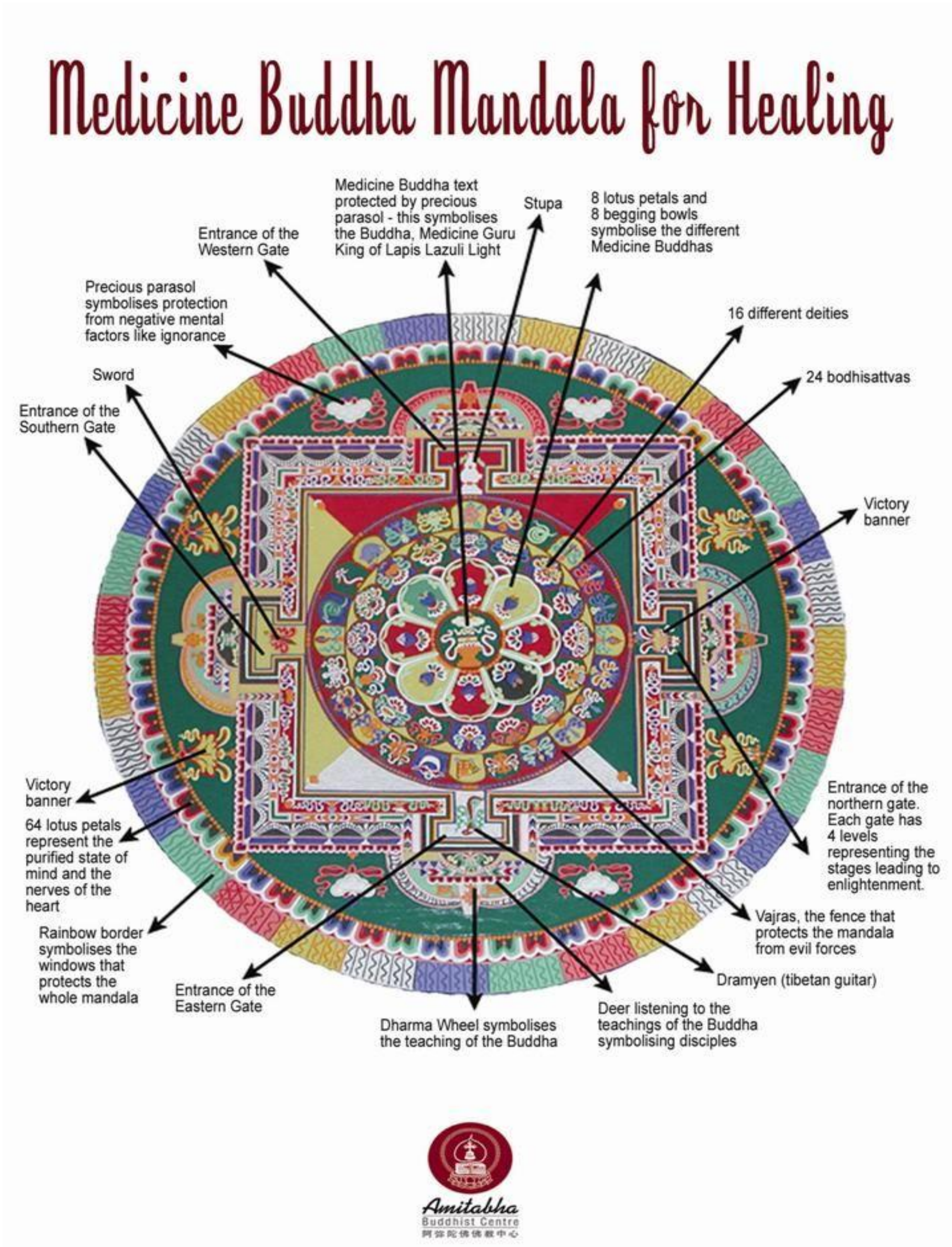

Figure 12: Medicine Buddha Mandala for Healing (Sacred Mandala, 2009).

5.1.1.1.1 Mandalas and the construction universe/cosmos. So, based on the ideas of balance and symmetry found in mandalas, I play with versions of the conceptual model, but none of my previous images are able to hold and express all the data relationships. My challenge for representing the construction universe or cosmos is how to represent the selective codes in a cohesive manner that shows the data is from a dynamic rather than a static system (i.e., the construction industry). The construction industry changes with the focus of its leadership as well as economic/market supply and demand forces. Therefore, because the construction industry is dynamic, my conceptual model also needs to be dynamic.

With over 180 selective codes and a sleepless night of waking up every two hours with greater and greater detailed images popping up in my mind, the conceptual model presented in this section is what emerged. Though I now had a conceptual model, I felt something was missing or rather there was something I yet didn't see with regard to how the selective codes related to each other. I found that "something" in a 3-hour lecture given in 2005 by Ian Xel Lungold explaining how the Mayan calendar is a tool for consciousness transformation.

5.1.2 Selective Codes and Consciousness Transformation

After understanding the concepts of consciousness transformation as explained by Lungold (2005), even the "orphan" one or two individual codes that don't seem to fit—and which are tempting to throw away because maybe they are "wrong"—found a "home." The physical representation of the relationships among the selective codes is completely organized within 5 minutes, and organized in a manner more elegantly than I thought possible. So, now that I intuitively understand how my conceptual model holds all the selective codes, my quest is to understand what my conceptual model, comprised of four sections, is called. The idea of four parts of a whole is present in Buddhist mandalas and the Native American medicine wheel. Intuitively because four-part representations are not new, I figured it must have a name. But, how do I find the name of sometime that I don't know what to call?

5.1.2.1 Fourfold structuration and selective code relationships. Fourfold structuration is not an obvious name. During a summer dissertation writing camp, Dr. Mark Lussier, Professor and Chair of the Department of English at Arizona State University, lectured on the benefits of meditation and mentioned he wrote several books on Buddhism. I figured since mandalas are meditation tools and I want to further understand how Buddhist mandalas are physical tools for understanding the focus of a meditation, Dr. Mark Lussier, is an accessible and obvious choice.

The few hours I meet with Dr. Lussier are invaluable. During our discussion Dr. Lussier provided the term fourfold structuration for describing "thinking in fours." From top down and side views, respectively, Figures 13 and 14 depict the conceptual model I developed for physically representing the relationships among the selective codes regarding the state of the health practices and climate within construction. The dynamic aspect of the conceptual model is expressed via clockwise and counterclockwise arrows that represent the efficiencies or catalysts and the inefficiencies/barriers in the system. How the model works is explained in the following section.

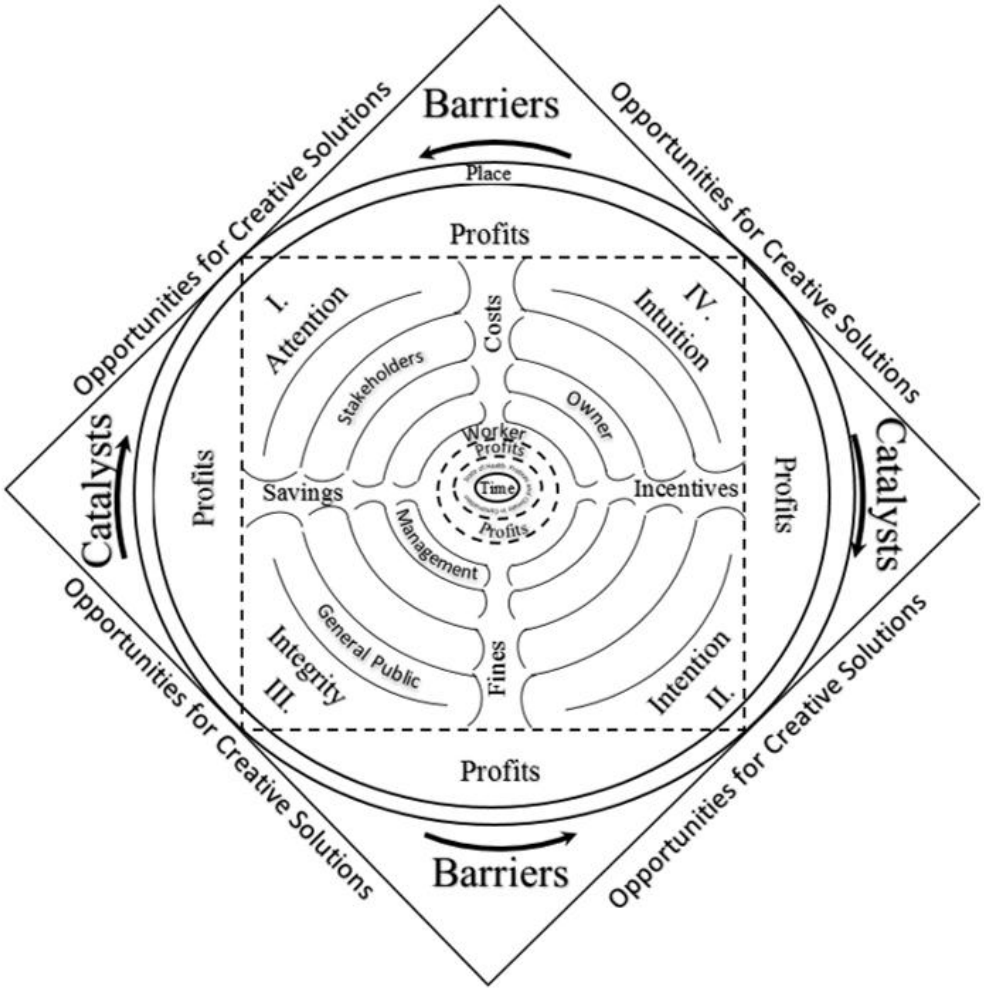

Figure 13. Top-down view of the conceptual model of the Emerged Constructivist Grounded Theory for the State of the Health Practices and Climate within Construction.

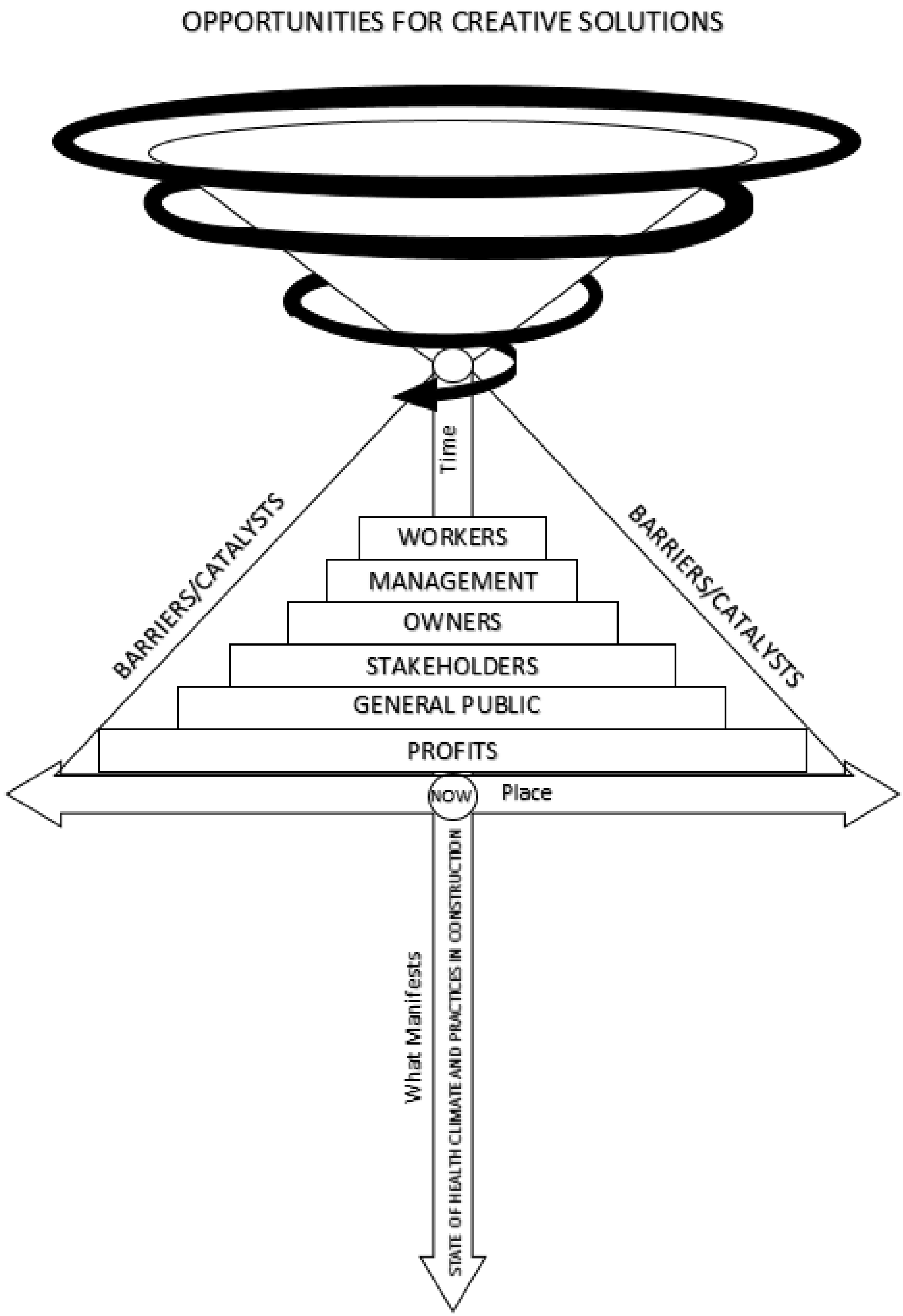

Figure 14. Side view of the conceptual model of the Emerged Constructivist Grounded Theory for the State of the Health Practices and Climate within Construction.

5.2 How the Model Works

Figures 15 and 16 identify the image components/selective codes that emerged from the interview data content analysis. Tables 7–7h describe each selective code and the selective codes organized under each quadrant: I) Attention, II) Intention, III) Integrity, and IV) Intuition are found in Appendix L.

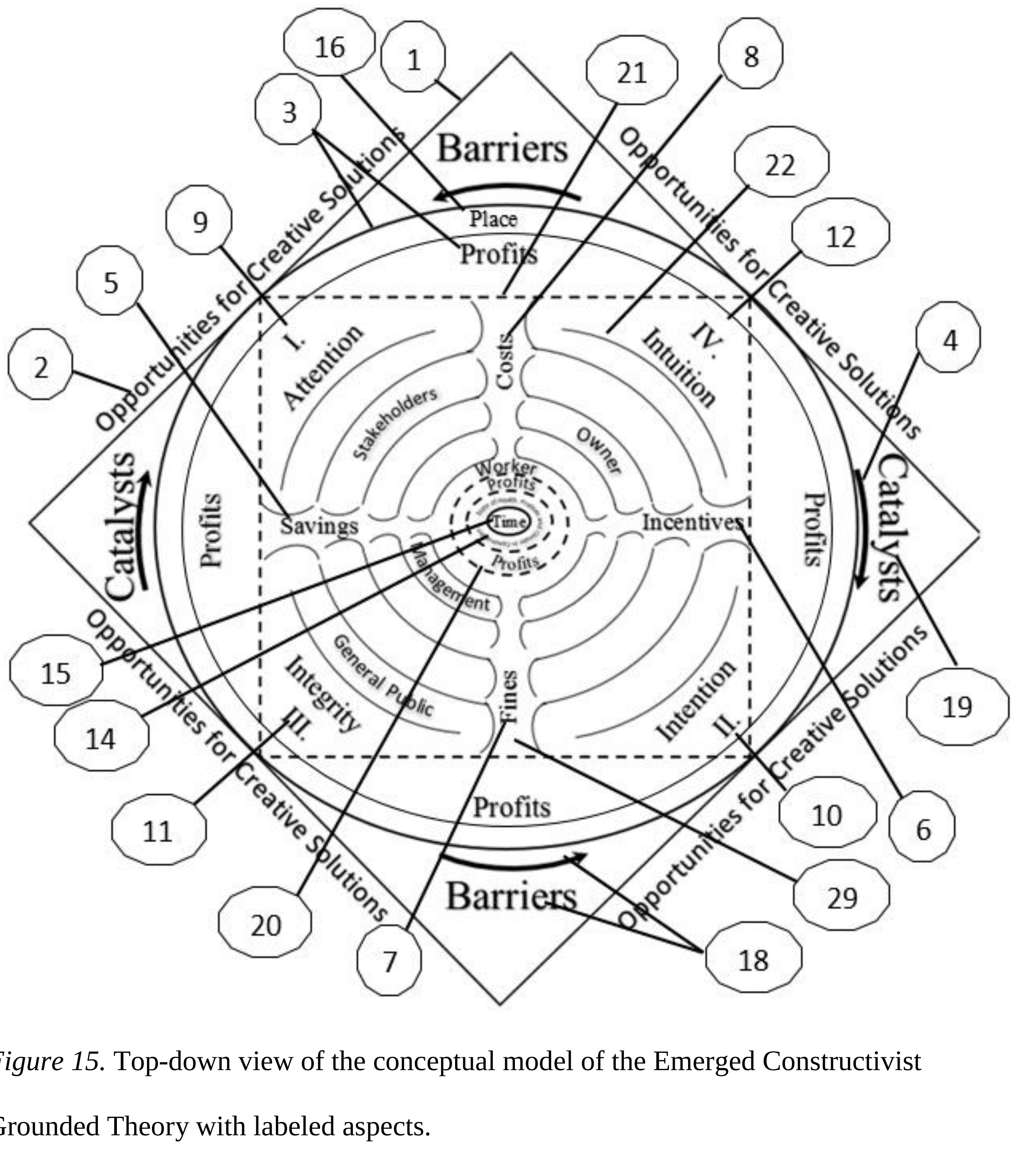

Figure 15. Top-down view of the conceptual model of the Emerged Constructivist Grounded Theory with labeled aspects.

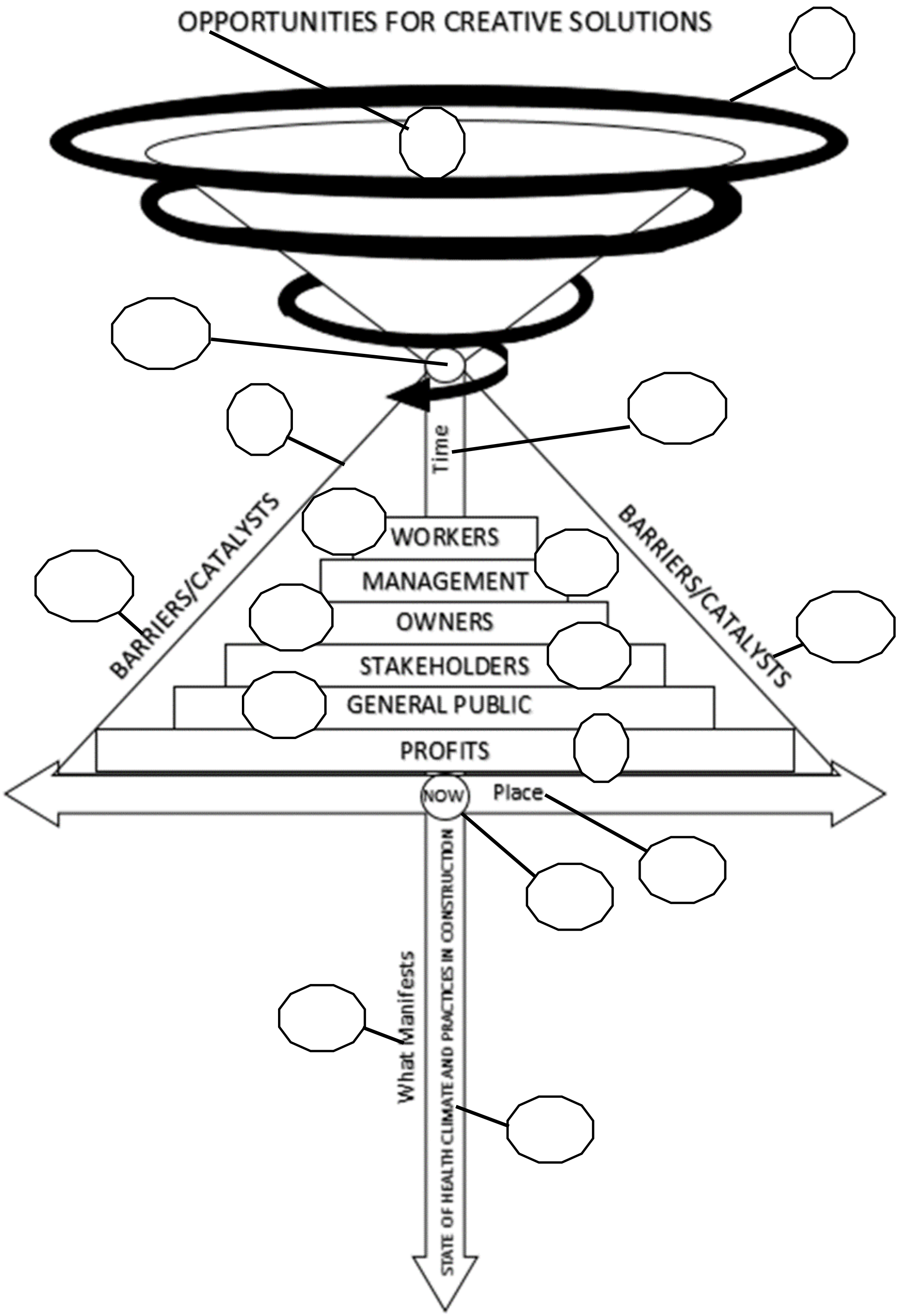

Figure 16. Side view of the conceptual model of the Emerged Constructivist Grounded Theory with labeled aspects.

Table 7

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	Selective Code	Code Description
1	N/A	Model boundary that separates the construction cosmos from the space that contains all possibilities for creative solutions. Outer large square.
2	Opportunities for Creative Solutions	All possibilities for solutions to the challenges facing the construction industry regarding the four hazards of concern to NORA.
3	Profits	The fundamental reason for a business. To make money (i.e., profits). Profits are often perceived as being negatively impacted by the implementation of health and safety protocols.
4	System Power Source	Drivers such as economic, social, and political that are responsible for the supply and demand cycles of the construction industry.
5	Savings	Discounts or reductions on the normal price of a commodity or service. One aspect of the Path of Balance.

Table 7a

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	**Selective Code**	**Code Description**
6	Incentives	Motivations for workers, management, owners, stakeholders, and general public for promoting certain behaviors or business practices. The second aspect of the Path of Balance.
7	Fines	Penalties paid for the lack of proper adherence to health and safety regulations. One aspect of the Path of Imbalance.
8	Costs	The price for acquiring a commodity or service. Or, the reduction in the amount of profits earned in exchange for acquiring a commodity or service. The second aspect of the Path of Imbalance.
9	Attention (-)	Attention represents the mental aspect of the fourfold structuration of the emerged grounded theory. However, the (-) symbol means that the attention is unfocused. Therefore, the axial codes categorized under this selective code are areas that, because they have not received focused attention, have resulted in health practices and climate deficits within the construction industry.

Table 7b

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	**Selective Code**	**Code Description**
10	Intention (Focused Attention)	Intention represents the emotional aspect of fourfold structuration of the theory. When attention is focused, that focus becomes the intention. Thus, what the worker, management, owner, stakeholder, and general public focus their attention to makes their intention a reality that will be manifested via the fourfold structuration. The axial codes under this selective code represent positive outcomes from the focused attention given these topics by the construction industry.
11	Integrity (+)	Integrity (+) represents the physical/action aspect of the emerged grounded theory. The (+) symbol means the action aspect of the fourfold is executed via commonly interpreted high standards (i.e., health and safety practices and other business aspects performed via legal/regulatory standards). The axial codes under this selective code represent positive actions or behaviors.

Table 7c

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	**Selective Code**	**Code Description**
11	Integrity (-)	Integrity (-) represents the physical or action aspect of the fourfold structuration of the emerged grounded theory. The (-) symbol means that the physical or action aspect of the fourfold structuration is executed via what are commonly interpreted as low standards (i.e., health and safety practices and other business aspects are performed via illegal or below regulatory standards). Hence, the axial codes under this selective code represent negative actions or behaviors that have been used the construction industry to reach outcomes.
12	Intuition	Intuition represents the spiritual aspect of the fourfold structuration of the emerged grounded theory. An example of intuition is the “knowing” or “gut feeling” a worker has about a job or project that has been acquired over years of performing his/her trade.

Table 7d

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	**Selective Code**	**Code Description**
13	What Manifests	What Manifests represents the central aspect of the fourfold structuration. The four aspects of the fourfold structuration determine what manifests or the outcome. Hence, what manifests or the outcome represented by this core aspect of the fourfold structuration is the resulting state of the health practices and climate within construction.
14	State of Health Practices and Climate	The focus of this research. Understanding the state of health practices and climate within construction regarding the impact(s) on worker health. This is the outcome that is measured at the intersection of Time and Place.
15	Change Takes Time	Time is the measurement for material change. Thus, within this fourfold structuration model of the grounded theory representing the state of health practices and climate within construction, via time is how changes to the state of health practices and climate within construction are evaluated.

Table 7e

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	Selective Code	Code Description
16	Place	Place. Represents the location at which what manifests or the outcome is measured. Each construction project represents a component of the overall construction industry that is represented by the grounded theory model. Similar to how cells (projects) together make up a human being (overall construction industry).
17	Now	Now. The intersection of place at each moment of passing time.
18	Barriers	System inefficiencies. Barriers move counter clockwise to the system flow and slow the system down, limiting mindsets that reduce profits and increase wastes is an example of a barrier.
19	Catalysts	Aspects that increase system efficiency. Catalysts move clockwise with the system. A tailwind for an airplane that results in the reduction of flight time and thus fuel expenditure is an example of a catalyst.

Table 7f

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	Selective Code	Code Description
20	N/A	Permeable inner profit hub boundary. Allows profit flow throughout the system, between the financial Paths of Balance and Imbalance, and into the "Now" state of health practices and climate. Profits determine capital available for investing in health. The dashed boundary of the inner profit hub represents the profits directly related to the billable hours of the worker.
21	N/A	Dashed boundary between system profits and four quadrants. Permeable boundary represents ebbs and flows between each quadrant and influence of actions on profits flows between the financial Path of Balance and Imbalance that result.
22	N/A	Boundary of the internal open systems of the worker, management, owner, stakeholders, and general public contained within the theory. The open boundaries represent the ability of the overall system profits to move between the financial paths.

Table 7g

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	Selective Code	Code Description
23	Worker	The trade workers who generate the profits for a company via their billable hours. The aspect following the dashed boundary for the inner profit hub. An internal system of the overall construction cosmos.
24	Management	Management is an internal system of the construction cosmos that oversees the worker's labor. It communicates the goals of the owner/company leadership via the work direction.
25	Owner	An owner is a system internal to the construction cosmos that is the origin of the work direction management communicates to workers.
26	Stakeholders	Systems internal to the construction cosmos. The systems are public and private entities with an interest in the construction cosmos and all its aspects. Examples are government-regulating agencies such as the Occupational Health and Safety Administration (OSHA), General Contractors of America, and trade unions.

Table 7h

Selective Codes of the Emerged Constructivist Grounded Theory

Theory Aspect	**Selective Code**	**Code Description**
27	General Public	General Public is an internal system within the construction cosmos. Users of constructed projects that do not overlap with the other internal systems of the construction cosmos are examples of the general public.
28	N/A	Funnel/Entry point for a Creative Solution from the space containing all possibilities.
29	N/A	Open system entry/exit point from where profits of the Path of Balance and Path of Imbalance flow. Entry/exit points are found on both sides of both financial paths demonstrating an open system.

5.2.1 Selective Code Relationships with the Model

In Figure 15, the (1) construction universe boundary is represented by an outer square. This outer boundary separates the construction universe and all infinite possibilities. The (28) point at which all infinite possibilities or (2) opportunities for creative solutions enter into the square boundary of the construction universe is also intersected by (15) time. The possibility for improved health practices and climate within construction was described by a retired bricklayer with over 30 years of experience as

“…not a lost cause at all. I think it’s a matter of creativity.” The axle for this dynamic construction system is (15) time. Time is the axle or axis because it takes time to generate profits. All actions and/or inactions of the construction universe revolve around time, because nothing happens instantaneously. Time or schedule is one of the main three components of the project management triad: budget, quality, and schedule or time. The schedule or time often drives the budget and the level of craftsmanship or quality that can be achieved. Hence, as another retired bricklayer stated,

> Money drives the bus….If they’re making money, it doesn’t make any difference whether they’re doing it the right way or the wrong way….Everything comes down to the buck in the end, unfortunately. That’s the reality of life; it all comes down to the dollar.

Thus, time is central to the reality the bricklayer speaks of because if work can be completed in less time, then other projects can begin and more profits can be generated for the company. Time is the reason I am researching the four NORA main health hazards of concern: welding fumes, crystalline silica, noise, and musculoskeletal disorders. These health hazards are described as long-standing, because the construction industry has been aware of their impact to worker health for some time. Moreover, time is a main factor in the development of adverse worker health. Adverse health outcomes of workers do not result from one exposure. Rather, adverse health outcomes can result from one exposure one time, several exposures over a short period of time, and/or several exposures over long periods of time. Time is needed to determine if a worker becomes ill. The time between worker hazard exposures to illness onset is called lag-time. This lag-time is what the construction industry has used to their advantage. Because it takes time for the illnesses to develop, by the time a worker realizes he/she is ill they do not have a process by which to track where they may have been exposed to the hazard that may have caused the illness. Time, therefore, like its placement in the model, is central to the data. It is central to the data because it is what needs to pass before any signs and symptoms of worker illness appear. It is central because it is what drives the budget or financial aspects of the work and what determines the level of craftsmanship that can be put into a project, for better craftsmanship takes time, as opposed to craftsmanship with less attention to detail. Time connects all the other aspects within the model. For, without time as the axle, the system would be static rather than dynamic. Time is what makes the system dynamic. Time represents the evolution of the system and the opportunities presented for change at each revolution of the system.

5.2.1.1 Profits as a foundation. The faster a project can be completed, the sooner a company can see a profit. As a business, a construction company exists to make a profit. For this reason, the foundation of the construction universe is shown as (3) profits or money. Time intersects this foundation, represented by a circle within the larger square that is the construction universe boundary, because profits are generated through the passage of time. The completion of a project requires time, and the company will only see a profit when the required amount of time for a project to be completed has passed. Thus, as one craft worker stated, the “enemy of safety is time.” Time is the enemy of safety because when safety considerations are not incorporated into the planning and job analysis, then the setup time for organizing and executing safety considerations, such as respirators that require worker training, is not considered and impacts or extends the project schedule. The project schedule depends upon the contract type, for example a firm fixed price contract versus a time and materials contract. The main difference between a firm fixed price contract and a time and materials contract is that with a firm fixed price if the cost of project goes over what the contractor is paid, the contractor is not paid for the additional cost. Conversely, with a time and materials contract, the contractor can bill the project owner for all of the time and materials that are required to complete the project. Thus, many project owners prefer firm fixed price contracts because the financial liability for completing the project is transferred to the contractor. Therefore, with the financial liability transferred, contractors want to complete a project as quickly as possible, because the longer a project takes, the lower the contractor's profit. Hence, unless safety has been incorporated into the negotiated firm fixed contract price, and sometimes even when it is, a less scrupulous contractor will not implement safety measures so it can pocket the money set aside for safety as well as labor costs that are saved from not having to pay the additional time it would take the workers to set up safety precautions. The following quote by a craft worker exemplifies the above example, "The only thing that motivates them is money. Really large company owner's interest is mainly the bottom line at the expense of the health of its worker health and safety."

5.2.1.1.1 Profits in the now. Lungold (2005) speaks of the relationship between (16) place and time, where the intersection of place and time is (17) "now." Because construction happens at a physical location, in a certain state or country and at a certain time or schedule, without place and time, there cannot be a "now" and, therefore, no project to generate profits.

Place also determines the circumstances or risk factors workers face. For example, is the place where trades people are working with hazardous materials an enclosed space or is it an open-air location? An enclosed space where welding activities are conducted will require ventilation systems or fans to either pull the welding fumes out of the air or away from the worker. An enclosed space may potentially require greater financial investments in order to set up the safety considerations. Whereas, if the location is an open-air location, then potentially the air currents of the day can be used to dissipate the fumes and organize the work so that the worker is less exposed to the fumes. For this reason, place is important; it is what determines many of the parameters and frames how health hazards are addressed. Or, as one retired bricklayer highlighted,

> Like I say here in Clark County, Nevada, we do have dust regulations. You're not supposed to create any dust on job sites when they start a new project here. You have to go to the county and buy a dust permit. That pays for these dust police that tour the job sites and walk around and make sure none of that is going on.

So, depending upon the location, there are certain requirements for dealing with hazards such as dust. Often, it is not solely to protect the workers but because the issue, for example that of dust, is already an existing problem, and if it is not addressed on a worksite, the hazard will be extremely out of control. Accordingly, a location where there is not an already existing dust problem probably will not have dust police. This demonstrates how "place" sets up the circumstances under which certain hazards are addressed.

As stated above, the intersection of time and place manifest the (17) "now" or the state of health practices and climate in construction. The "now" state of health practices and climate within construction is described by an occupational health and safety expert with over ten years of experience as follows:

> …less than five percent of all the leaders that graduate, let's just say May, from engineering, management, all these construction... All these folks that are going to go out and lead the world, construction companies. Less than five percent of them have any specific safety and health education. And if it is, it's crappy. It's an OSHA 10-hour course which is compliance-based. It's not risk-based."

Thus, with regard to the concept of "now," what the previous quote is saying is that the amount of time needed to evolve the industry's consciousness to a level of maturity where visible actions, such as the academic preparation of tomorrow's construction leaders with knowledge regarding health hazards, is not presently sufficient. Our physical location and chronological place in the evolution of our awareness with regard to health hazards determines the climate and practices we see within the construction industry now.

5.2.2 System Power Source—Business Structure Impacts

The (4) system power source for the profits that flow into the construction universe/system are the economic, social, and political influences on the supply and demand cycles of the construction industry. These influences, as well as the decisions and behaviors of the construction industry leadership, drive the flow and determine the rate at which the construction system turns. For example, an occupational safety and health (OSH) expert with over 10 years of experience described what he does to influence construction health practices and climate:

> If I want to have something change within an organization, I don't talk to the safety people, I talk to the executive, the president, the owner, with very good support from the safety team and the management to say, "This is what we're seeing, here's our research, here's our expectations."

Another occupational health and safety expert stated,

> When it comes down to it, it's not about the budget, it's about the individuals that actually have to go out and do the work....it's not so much just the practices, but it's actually the way that the business is structured that's creating a lot of the opportunities for people to put workers at risk….Business owner's ethics and morals define the overall culture of an organization.

The quotes indicate, about the system power source, that the opportunities that put workers at risk are about awareness of the issues. If the economic, social, and political forces as well as construction leadership are unaware of how their business structure/operations create the risks, then responsibility for the risks cannot be expected. This highlights the needs for an understanding of how the business structure results in the manifested health consequences. I see the fourfold structuration process as a tool for industry to start to understand how its actions and business structure have set the industry up to fail with regard to protecting workers from health hazards by thinking that either the worker is protected or a profit is made. This potential either/or situation manifests as a result of what has initially been set up by the industry/company. If the industry or a company structure themselves in a manner that does not set up safety and profits as an either/or outcome, then creative new ideas for setting up an "and" outcome can manifest. The idea that it is either safety or profits already sets the expectation that both cannot be done. Whereas, if the expectation is set that both safety and profits can be achieved, then that outcome is where the attention will be focused (i.e., become the desired intention).

5.2.3 Indigenous Paths of Balance and Imbalance—Profit Inflows and Outflows

Connecting the circle—representing profits—and the axle—representing time—are perpendicular financial flows, which borrow from the indigenous concepts of (financial) Paths of Balance and Imbalance. (5) Savings and (6) Incentives are the financial Path of Balance, and (7) Fines and (8) Costs are the financial Path of Imbalance. An OSH expert describes the Path of (Financial) Balance as follows:

> I know a lot of contract companies that I work with, they give their safety managers awards based on safety activities, and those rewards are not based on individual incident rates but based on reporting rates. If you work X amount of hours, you should have X amount reports. That's what they actually based that on. You have the top-level management encouraging the folks in the field to report things and not cover it up, because they know that they're getting a bonus off of it. You're not hiding incidents and you're not discouraging folks from reporting. There's a cost savings or an incentive program on that aspect.

This quote represents the Path of Financial Balance because, as is stated, the top-level management is encouraging the reporting of field activities. Bonuses are given for reporting outcomes, which incentivizes an atmosphere of transparency and not of suppression. A balance is created between the reality of the environment and true costs required to operate safely. On the other hand, with the Path of (Financial) Imbalance, an OSH expert states the following motivates companies to follow proper health and safety practices:

> A big driver is the regulatory requirements. I might push and push to have something, a standard, and it won't happen until it becomes a regulatory requirement. That's a big driver. Any fines or litigation costs are drivers for getting them to do the right thing.

This quote represents the Path of Imbalance because it highlights how an external force acting upon the existing business structure is required for the proper health and safety practices to be followed. Litigation costs and fines are what drive health and safety practices in the Path of Imbalance rather than the potential for increased profitability, as is possible through the Path of Balance. Thus, through the Path of Imbalance, profit is attained from cutting corners and not being fined or litigated against for these safety shortcuts. Conversely, through the Path of Balance, profits are obtained through reputation for health and safety practices that attract higher skilled (i.e., more productive workers). This allows the company to increase their project load and subsequently its profits.

5.2.3.1 Intersection of profits and now. The inner aspects of the Paths of Balance and Imbalance merge at an (20) inner profit hub. The inner profit hub is the component through which the axle of time passes and connects the financial Paths of Balance and Imbalance to the larger profit wheel to create the framework for a dynamic construction universe/system. The inner hub has a dashed circle to show that profit flows impact the "now" state of health practices and climate in construction that manifest. An OSH expert, with 25 years of experience as a safety expert and extensive experience on Department of Defense sites, describes the interest of owners to pursue health and safety efforts as follows:

> Yeah, that's what I found when I was talking to like all the craft workers, the unions, they always came down to profits. It was like, how will doing these practices impact profits? Basically it was if you can show, just like what you said, if you can show the contractor, whether it's a union contractor or an open-shop contractor, that these practices wouldn't impact their profit or that these practices could increase their productivity, hence their profitability, then they would be more apt to doing them. Other than that, it basically came down to whose profits, you know, the productivity. If the owner or contractor felt it would impact their productivity, they wouldn't do it.

The inner profit hub is represented by two dashed lines. The inner profit hub surrounding the axle of time is significant because it represents that profits are generated over time. Work needs to be performed to earn the profits. The inner line of the profit hub closest to the State of Health Practices and Climate in Construction is dashed because it represents the influence that profits have on the state of the health practices that manifest. Throughout the interviews, I repeatedly heard the theme that it is the needed capital that holds companies back from investing in health and safety practices. If a company has the required capital, then the health and safety investments would be prioritized. The outer line of the inner profit hub is dashed because it represents the connection of the worker to a company's profitability. For it is the number of worker billable hours that determines a company's profitability. Moreover, the healthier a worker, the more productive he/she can be. Thus, it is ironic that worker health and safety are not always prioritized, since worker health is inextricably linked to productivity.

5.2.4 Human Components of the Emerged Model

The financial paths meet at each side of the (21) dashed inner-square containing the four quadrants. The dashed line of the inner square represents the permeability of the profits to flow around the quadrants. The (22) open circles of the internal system components of the (23) worker, (24) management, (25) owner, (26) stakeholders, and (27) general public represent the ability of these internal construction cosmos systems to impact the ebb and flow of the financial paths of balance and imbalance of the overall construction system profits. These internal human systems are the construction universe components that bring the industry to life. They influence changes in the state of the present health practices and climate within construction each moment in time and at every interaction with other components. For example, an OSH expert who is an 18-year corporate safety manager and worked in a medical field for a number of years prior to getting into safety and construction describes the influence of owners on a company's profitability as follows:

> I think it's interesting that you mentioned the profits and the cost before and that we all know businesses are in business to make money. I find it interesting that the owners are standoff-ish, some, not all, but some are standoff-ish at a place in the project that influences their potential profitability. I think these owners are aware of how they can increase their profitability by actually being aware of the contracts and the cost benefits to them. By understanding the different aspects of their contracts that might be a way that owners...It's interesting. This is where their profits are potentially greatest, and yet, some of them choose to stand away. I would think that if you're really interested in making money, then know exactly

> what's in your contract and where you could potentially increase your profits throughout your project.

What this quote is expressing is that there are existing opportunities that are not being tapped into by project owners. There are additional profit opportunities at the worker, management, owner, stakeholder, and general public level that are not being tapped into because there is a hesitation on the part of the project owner. There is potentially any number of reasons a project owner is hesitant. I think it's the "if it's not broken don't fix it" mindset. I recall an interviewee saying something to the effect that as long as what they are doing is profitable, then some project owners are not interested in profits they didn't make. They are only concerned by the fact that they make profits. Without the ability to trace profitability directly to contract provisions and worker health, then the additional profits that can be gained from addressing health and safety issues remains an invisible visibility. The visibility aspect comes from that fact that the potential for increased profits can be seen. The mental framework is the idea that contract provisions or other attention allows the possibilities for increased profits to be visible. However, the opportunities for the construction industry/project owners to grow beyond their present level of profitability can happen only when there is enough courage to explore beyond the presently entrenched mindsets of "if it's not broken don't fix it". The lack of formal cost/benefit measuring standards also keeps the possibilities for increased profits invisible. Without empirically established standards, possibilities cannot become actual facts and, thus, stagnate any intentions for increased profits through attention to contract provisions and health and safety practices within the second quadrant, never able to move into integrity or intuition until the courage necessary for breaking out of the comfort zone is found (Kuilman, 2013).

5.2.5 The Space in Between Profits and Losses

The space between the financial paths of balance and imbalance are where the quadrants—(9) I. Attention, (10) II. Intention, (11) III. Integrity, and (12) IV. Intuition—containing the actions that influence the profit flow are found. The profit flow through the financial paths of balance and imbalance is analogous to the liquid inside a construction level. The bubble contained in the level fluid dictates the direction of the misalignment. The (22) open circles that contain the internal system components of the construction system show that the profit flow into the financial paths bordering each quadrant are a result of the actions taken by the internal system components within each quadrant.

5.2.5.1 Lack of attention to long-standing health concerns. The first quadrant contains items that have resulted from a lack of attention to these issues by the construction industry. For example, an OSH expert stated that "If they were to pay more attention to the health and safety, they can actually end up being more profitable." Issues lacking attention that if addressed could increase profitability are: cross trade hazard exposures, worker deaths, and absent hazard control plans. Attention is bordered by savings from the path of balance, and costs from the path of imbalance. As a communication process, attention represents outcomes that are vague because, for example, trade hazard exposures are a topic that may not be in the awareness of many workers. Workers may receive training regarding hazards, but they may not recognize a hazard if it does not present itself in the manner in which it was presented in the training.

Thus, within quadrant I, worker actions can result in savings if the worker is productive, or in costs if due to inexperience or lack of attention to the job, rework is required. Similarly at the management, owner, stakeholder, and general public levels, actions taken or not taken can result in either savings or costs depending upon the attention given the actions.

5.2.5.2 Blinded focus on making profits. Quadrant II contains items that result from focused attention. Examples of intention with regard to health hazards in construction are: union apprenticeship career training, the removal of health hazards such as asbestos, and the development of health protocols. An example of intention provided by an OSH expert is as follows:

> The only thing that motivates them is money. That's true. Once they get into that contractor mentality. They get their license, start a business. There's no, to be very frank with you, there's no way to change their minds or nothing. Their mind is set when they get started. If they get started with bad...intentions.

5.2.5.2.1 Intention as a process of healing. Dictionary.com (n.d.) defines intention as "an act or instance of determining mentally upon some action or result," and "purpose or attitude toward the effect of one's actions or conduct," and/or "the act or fact of intending." I am surprised to see that intention is also defined by Dictionary.com (n.d.) as "a manner or process of healing, as in the healing of a lesion or fracture without granulation (healing by first intention) or the healing of a wound by granulation after suppuration (healing by second intention)." I wanted to see how intention is defined so I can understand how it relates to the manifested state of the health practices and climate within construction. And, from the craft worker's quote about a contractor's starting mindset, the craft worker's statement matches well with how intention is defined.

5.2.5.2.2 Healthy workers equal healthy profits. I feel that the synonyms given for intention by Dictionary.com speak volumes. Dictionary.com synonyms for intention of goal, intention, intent, or purpose "all refer to a wish that one means to carry out." Where "intention is the general word," "intent is chiefly legal or literary," and "purpose implies having a goal or determination to achieve something." To me, the definition and synonyms of intention speak volumes because the etymology of intention says that intention is the "noun of action from intendere 'to turn one's attention,' literally "to stretch out." Hence, intention is a stretching out, evolving, or moving beyond attention into a space that speaks of purpose or determination to achieve something. Or, when referred to medicine: "an aim that guides action," or "process by which or the manner in which a wound heals."

I believe the fact that intention has a medical definition is important for this research, because the focus of this research is the manifested state of the health outcomes of construction trades workers. Adverse health outcomes have resulted from the blinded focus by the construction industry on making profits, when little attention is paid to the fact that if its workers are sick and dying then there will be no profits. Thus, since intention is what follows attention, it makes sense that the actions that follow intention are based on the goal wanting to be achieved. And, from the craft worker's quote above that emphasizes how money is what motivates the contractor, improved health practices and climate within the construction industry are attainable. It is attainable if how the money is made shifts and includes protecting those that generate the profits. The conceptual model is a thought tool for beginning the shift.

5.2.5.2.3 Actions have consequences. I find it interesting that intention has a medical definition. There is no denying that adverse health outcomes have resulted in sick, injured, and dead workers. This is when the construction industry realizes that actions do have consequences. Though, the consequences are manageable because they are based upon the actions/processes the construction industry has chosen as guides for its behaviors regarding the long-standing health concerns of its workers. The construction industry's present model is making money *or* protecting worker health. However, by purposefully shifting to a new model emphasizing the making of money *and* protecting of worker health, then the visible, yet presently invisible increases in profitability -- because they do not exist yet, and thus cannot be measured -- can begin to manifest. Moreover, hopefully the adoption of the new *"and"* model by all of the industry will incentivize the ushering in of a new era and evolution with regard to the exposure of workers to health hazard.

5.2.5.2.4 Intentional actions and improved worker health. Intention is bordered by the path of balance or incentives, and the path of imbalance or fines. As I have presented above, intention represents actions that have been purposefully undertaken, for example, the removal of asbestos from construction materials and the removal of lead from gasoline. Through intentional actions, issues lacking attention can be identified. Improved health status resulting from intentional actions to protect the worker can result in increased worker productivity (Viscusi & Evans, 1990). Intentional actions that protect the worker will also result in decreased fines for health and safety violations.

These intentional actions allow more profits to flow through the incentives branch of the path of balance and increasing the foundation of profits on which the industry is constructed. Though I found it interesting that intention had a medically based definition, what I really liked is how the definition of intention as the “purpose or attitude toward the effect of one's actions or conduct” sets up the introduction for quadrant III, integrity (Dictionary.com, n.d.).

5.2.5.3 Intent of action and integrity. The Merriam-Webster dictionary defines integrity as “firm adherence to a code of especially moral or artistic values: incorruptibility; an unimpaired condition: soundness; or the quality or state of being complete or undivided: completeness” (Merriam-Webster, n.d.). Integrity is bordered by the path of imbalance or fines and the path of balance or savings. Quadrant III contains actions that demonstrate both sound integrity and unethical integrity. An example of sound integrity is honest wage practices, where workers meeting all requirements by the IRS to be full time employees are classified as such. An example of unethical integrity is the falsification of worker qualifications to win a contract. A retired bricklayer describes the integrity by which intentions are executed as follows:

> What I’ve often found and what I keep seeing is that it comes down to this business ethics and the morals of the owners. If the owners choose to do the right things then everything else... You’ll usually find that there’s some effort being done to protect the workers. Then we don’t find them changing the classification of the workers so that they can pocket the money.

Whereas, intention is the “attitude toward the effect of one’s actions or conduct,” integrity is the effect of one’s actions or conduct.

Thus, at each quadrant the integrity of the attention and intention affect the path into which the profits flow. The integrity quadrant is bordered by the path of balance or savings, and the path of imbalance or fines. The integrity of the actions addressing health issues is communicated in their effect. For example, providing Spanish-only speaking masons an English pamphlet on silica hazards does not qualify as an action of integrity. The action of handing out the pamphlet qualifies as attention to the need to communicate hazard information. But, because the communication is one that cannot be understood by the workers, the attitude toward the actions shows that the action lacks integrity. Thus, providing pamphlets in a language that workers cannot understand is an example of unethical integrity. This action is unethical because since the workers cannot understand the hazard information, the possibility the action will have a positive effect on worker health is minimal. On the other hand, an action of providing the pamphlet in Spanish would qualify as an effort of ethical integrity. This would be ethical integrity because the action of providing the hazard information in a language the workers understand has a greater chance of having a positive effect on worker health. The impact of integrity cannot be measured until quadrant IV.

5.2.5.4 Experience knows when the shoe will fit. The final quadrant is intuition. Intuition is where the actions of previous quadrants can be measured to determine their impacts on the overall system efficiency. Intuition is the inner knowing a worker, manager, or stakeholder possesses from their experience with their work. An example is when a carpenter or mason looks at a landscape and then looks at a design blueprint and automatically can pinpoint areas of conflict between the two. No physical measuring is done, yet the carpenter or mason "knows," and when an actual measurement is taken, the carpenter or mason is correct. This inner "knowing" comes from experience and is a valuable source of solutions for many challenges faced within the construction industry. It is knowledge that can only be acquired from interacting with the work. A retired bricklayer describes the challenges with regard to health and safety practices as a symptom of the following:

> The architect was aware of how it needed to look. I think you're hitting the nail on the head too. I think the newer generation, a lot of people haven't had the experience of putting their hands on the things that they designed.

The quadrant of intuition is where the impacts of, for example cross trade hazards, can be measured. Through the experience a carpenter or mason has with his/her trade he/she can know the amount of waste/dust that will be created on a job. The expert knows how many people are needed and how many tools are required. Via their experience, the carpenter or mason knows, for example, the number of workers, and hence, respirators or other protective equipment that will be needed to do work. Intuition is the culmination of the other quadrants because it solidifies what was abstract in the other quadrants into something measurable. Measurement also allows aspects contained within the example of cross-trade hazards to come to light, aspects that can only be highlighted when quadrant IV is reached. An example of an aspect that can only be highlighted when intuition is reached follows: five workers may be needed for a job. However, until it is known that two of the workers are women, additional considerations potentially needed for determining the availability of properly fitting protective equipment for the women may not be visible.

5.2.5.4.1 Loss of industry knowledge and impacts to profitability. Another example of intuition is the transfer of industry knowledge from experienced workers to newer workers. Knowledge transfer can be measured via worker productivity. If knowledge from experienced workers is dismissed, this knowledge is lost. Losing this knowledge may cost the industry many times more money to train newer workers than it would cost to take additional time to complete a job with an experienced worker training a newer worker. The following quote by a retired bricklayer with extensive union business experience describes the potential costs of losing industry knowledge:

> It's incredible; just one worker costs a company just in a minor accident. I saw it years ago and I was trying to find it and I can't find it, but it was just like a little spreadsheet that shows what one injury to one worker causes a company over a year. Not including fines, just loss of productivity, the loss of the worker not being there, the medical costs, their insurance premiums, their experience modification (EMOD) rating, all that stuff. It's amazing. A broken leg all the sudden can cost the company a couple hundred grand in a year, one worker. It's incredible, that stuff.

Newer workers, without the guidance of experienced workers, in effect need to "rediscover" techniques that increase their productivity while being less productive until the moment the techniques lost from the experienced workers are "relearned." The opportunity to move into the future with greater efficiency by building on the techniques of experienced workers is long in the time it takes the newer workers to "rediscover" the past. Profits are lost during this lag-time for the reinvention of the wheel. Moving through intuition spirals the focus back to attention and allows the communication process to begin again. And, similar to the previous quadrants, intuition is bordered by the path of balance or incentives and the path of imbalance or costs. The path through which the profits flow depends upon the intention or “attitude toward one’s actions or conduct” and the integrity or effect of one’s actions or conduct.

5.3 A Balanced System is More Efficient

The quadrants of the conceptual model are like fan blades. The weight of each blade determines if the system wobbles or is balanced. Imbalanced blades can result from various causes. The weight of the blades bending the blades over time, lose connections, human intervention, and misaligned blades are main causes of a system imbalance (Ceiling Fans, n.d.). The profit flows within the construction system can be described as resulting from a combination of the weight of the blades causing a misalignment over time and human intervention. The concept of weight imbalance and human intervention describes the profit flow because, for example, the lack of attention paid to certain issues will cause quadrant I to be “heavier” or full of issues that need attention. Until issues are given focused attention, the issues cannot move onto the next quadrant. With quadrant I heavier than the other blades, the profits will flow in the direction of quadrant I. The profits flow in that direction because the aspects represented by the other three quadrants do not yet exist for all the issues not paid attention to in quadrant I. Thus, in effect, it can be said that not paying attention to issues is profitable. However, in terms of an overall system, there is only a finite amount of time before the imbalance will cause the system to go off the rails. This is witnessed via our increasing consciousness regarding the adverse illnesses and injuries workers are suffering and the increasing worker shortages manifesting as consequence to the suffering.

5.3.1 Which Is Cheaper Paying for Health Practices or Paying Fines

In addition to the leveling off among the four quadrants, there is an additional leveling off that occurs within the heaviest quadrant. Within the quadrant, the second leveling occurs between the paths of balance and imbalance. For example, quadrant I contains the selective code, Targeted Enforcement. Targeted Enforcement refers to the concept that regulatory agencies focus on larger construction companies over small- to mid-sized companies for potential violations because larger companies can afford to pay larger fines. These fines are a revenue stream for regulatory agencies. An OSH expert describes targeted enforcement as follows:

> Oh, yeah. Ask an OSHA guy, and he'll tell you. They'll enforce max fines to bigger contractors because they know that they've got deeper pockets. I'm buddies with some OSHA guys and they'll absolutely tell you that's the truth, that they're a self-funded entity of the government, and how they generate revenue is by citations. They will absolutely, a larger contractor with something deeper pockets, issue a heavier fine than a small guy with maybe not deep pockets. That's an absolute truth.

Hence, the quote is referring to the fact that if a large company neglects to pay attention to an issue, the consequence for its negligence is that the potential costs or fines the company will have to pay will be higher because of the targeted enforcement.

5.3.1.1 Unseen savings from investing in health practices. On the contrary, if the large company is aware that Target Enforcement is a reality, then this awareness may motivate the company to pay greater attention to health and safety issues. Issues, though they cost the company a portion of its profits to address, may in fact result in savings from not having to pay fines that may be greater than the potential investment needed to pay attention to the issues. Additionally, by paying attention to an issue, a company may have other savings, such as lowered worker sick days, and by paying attention to health issues, cumulatively the savings may potentially add up to more than the investment needed to address the health hazard(s) in the first place. The quote, therefore, serves to illuminate the fact that there are resource limitations for OSHA and that depending upon a compliance-based model as is the present model with OSHA is not realistic for policing the construction industry. It is unrealistic for reasons like the fact that more than three quarters of the industry is exempt from OSHA reporting and that even if these establishments were not exempt, OSHA in its present form does not have the resources as a self-funding agency to investigate and enforce its regulations. Changing the funding structure for OSHA would require an overhaul of the funding mechanism. However, as government agency funding is a complex process influenced by the political, economic, and social climate of the times, this is a discussion I will leave for another researcher to explore.

5.3.1.2 System inefficiencies reduce system flow. For this qualitative conceptual model, the inefficiencies are analogous to the (18) barriers of the quantitative model. Assuming an efficient system moves in a clockwise direction, barriers are inefficiencies that slow the system down. Barriers move counter clockwise to the system. Examples of barriers are the continued use of traditional decisions to address new challenges and the lack of gender diversity within an industry. These barriers represent the exclusion of opportunities for creative solutions to address the challenges faced by the construction industry. The barrier of tradition is described by an OSH expert as follows:

"The union in my opinion is in the best position to enforce what's right on their projects. What their biggest obstacle is, is tradition. I think that's a huge consideration." This quote highlights that opportunities to address the challenges faced by the construction industry are available through organizations like the trade unions. However, even within these organizations, the industry needs to get out of its own way. In other words, it needs to stop doing the same things and then expecting different results.

5.3.1.2.1 Human agendas and desired outcomes impact system flow. It is known that clock pendulums after some time synchronize. The reason synchronization is achieved is because of the sound pulses that travel through the wall from clock to clock. The pulses interfere with the swings of the pendulums and eventually cause them to synchronize (Choi, 2015). For this conceptual model, human behavior is what interferes with the system efficiency. But, unlike a fan blade that gives off a pulse or signal, such as noise or heat that alerts to the existence of an inefficiency, human systems like the construction industry demonstrate imbalances in different ways. For this conceptual model, human agendas and the desired outcomes are the inefficiencies that skew the natural flow or homeostasis of a balanced system. So, similar to noise or heat produced by an inefficient mechanical system, for this conceptual model, the directional flow of the profits signals there are inefficiencies present within the conceptual model. Unlike the pulses of the clock swings through the walls that eventually synchronize, because construction is a human endeavor, which is complex in and of itself, most likely even the most efficient systems will never reach 100%.

5.3.1.3 Expediting the integration of preventative health practices. An aspect that increases system efficiency is a (19) catalyst. A tailwind for an airplane is an example of a catalyst, because the tailwind increases the speed of the plane without the plane expending additional fuel. Catalysts for this construction universe developed from this research and expanded upon later in this research are Available Capital, Lessons Learned Programs, Inclusion of Contract Health Provisions, Health Hazard Awareness and Education, Clear Return on Investment, Continued Leadership Commitment, Job Coaching from Experienced Workers, Apprenticeship Programs, Media Exposure (Reputation), Worker Accountability/Attitude, and Worker Recognition/Appreciation because they can expedite the integration of creative solutions. An OSH expert with extensive insurance experience describes the following as a catalyst for the construction industry:

> I think we have a great great great opportunity starting yesterday, two years ago, five years ago. To start to integrate technology into not only the productivity, the way jobs are done, the way jobs are operated, the way jobs are communicated, but the safety of jobs as well. I'm watching more and more where people walking around with an iPad instead of a piece of paper. They're walking around. They can pull up the building, the model. They can do it in 3D. They can see different sketches. They can see automatic change orders that come immediately to their computer. I see these technology issues that with the younger millennials that are coming in that are going to help things not only become clearer faster, more productive.

This quote serves to highlight how with the interaction of the experience of the workers and the innovative technologies of the younger generations, solutions to challenges faced on projects can be addressed more quickly. It shows that every day of every moment on every project there are opportunities to try new ideas. The industry needs to prepare for the technological expectations the younger generations will have for the work. Moreover, most of the training the younger generations are receiving is heavily technology based. And, if the construction industry does not invest in upgrading its technological infrastructure, the divide between the older generations and the newer generations will grow rather than come together, which may create even more hazardous health and safety circumstances within the construction industry.

5.4 The Conceptual Model as a Template for the Construction Industry

The conceptual model is a template for what is happening in the construction cosmos. The increased number of worker illnesses and deaths, as well as the shortage of skilled labor, have not manifested out of a vacuum. The interactions of all the components represented in the model have created the present state of health practices and climate within the construction industry. Like a Buddhist mandala, the image can be used to look at the construction industry as a whole, at an individual construction company, or by an individual person to unearth the unconscious/unintentional actions that are manifesting in misaligned financial goals/outcomes. For example, a company that desires to be more profitable, but presently is experiencing fines for violations, increases in payroll costs, and decreases in worker moral, can use this tool to identify the root-causes of the misalignment between its action(s) and its desired financial goals. Misalignments that impact profits can be identified with this tool, such as 1) the lack of hazards education and paths for workers to gain more skills; 2) the treatment of workers as disposable; 3) not prioritizing safety; 4) blaming workers for their lack of knowledge regarding hazards; 5) the treating of worker health as a checking off of a box more than a truly concerted effort to address the hazards; 6) and the exclusion of women and non-English speaking skilled worker. This would facilitate a company's ability to target actions that can generate the most change/impact with the resources available to the company in the direction the company desires for its financial outcome. Moreover, this conceptual model of interconnected pathways as opposed to simple lines/strings of connection, not only shows cause and effect but also shows how there are multiple paths for reaching goals. The conceptual model allows a transcendence of left-brain logic that limits creativity to linear mental processes and allows access to the artistic functions of the right brain that governs the imagination, the source for creative solutions, which many experts stated is needed for addressing the challenges to the long-standing health concerns of construction trade workers.

5.4.1 A Thought Tool for Understanding the Present State of Worker Illness and Death in Construction

As stated the conceptual model is a template for what is happening in the construction cosmos. For example, in the present state of the health practices and climate within the construction industry, it is known that there is an unacceptable number of worker illnesses and deaths. The conceptual model can be used to understand how the present state of the increased number of worker illness and deaths has manifested. In other words, the conceptual model can be used to facilitate a root-cause analysis. The analysis can start in a reverse engineering fashion, or rather, start at the end and trace the events back to the beginning.

5.4.1.1 Starting with the outcome in mind. Starting with the outcome of worker deaths and working backwards, the intersection of time and place or "now" can be examined. Place and time or where and when set the now for what manifests. So, for the example of examining a worker death, once the place and time of the death occurred is known, then the circumstances present at the place of the death can be examined. And, because this is a root cause analysis rather than starting in quadrant I (attention), quadrant IV (intuition) becomes the start. Intuition can help uncover if other workers had previously reported concerns regarding unsafe circumstances. What was done with the information and how the concern was addressed can then give insight as to where a gap in the safety and health protocols exists. There is a project management triad of schedule (time), budget (profits), and quality (worker skill). Using the conceptual model to examine the legs of the triad at each level—worker, owner, management, stakeholder, and general public—an evaluation can be done to determine if gaps exist on each of these levels that somehow contributed to the worker death.

Hard and truthful answers need to be given for the possibility of oversight to previously reported unsafe conditions, such as whether immediate financial gain is prioritized over the potential fines and/or costs to the company or whether agreeing to an unrealistic schedule unduly fatigues workers and creates circumstances where their physical capabilities are reduced. Any number of questions pertaining to the circumstances can be asked. The stage set by the circumstances of time and place are what help set the scope or boundary for the questions most likely to uncover the roots of the circumstances.

5.4.1.1.1 Exploring the why, what, when, where, and how of the present health state in construction. The questions then asked within quadrant III pertain to the integrity of the present actions toward worker health and safety. For example, determining if there is or isn't a health and safety program can be a first step. If there is a program, are the protocols adequate? For each answer given to a question arising from the intersection of time and place or "now," the questions of why, what, when, where, how, and who need to be explored. The following is an example of how the model can be used to ask these questions. 1) Starting at the worker circle, who is the worker that died? 2) At the management level, who was supervising the worker? 3) At the owner level, where does the ultimate liability for the death rest? 4) At the stakeholder level, were there are any stakeholders who may be directly or indirectly affected by the death? Can any of these stakeholders be engaged to prevent future deaths? 5) At the general public level, can someone potentially identify supporters for the undertaking of improving the health practices and climate that may be found in other industries that had previously experienced similar challenges? For each who answer, the questions of what, why, when, where, and how need to be asked until the answers seem to be exhausted. The level of exhaustion is determined by the individual or individuals performing the root cause analysis. The only requirements to developing the questions and answers are a sincere, honest, open assessment of the circumstances and a willingness to accept potentially unfavorable truths about the circumstances that allowed the worker death to happen. Once answers in quadrant III seem to be repeating or there is a sense the information (potentially for the present moment) is exhausted, then it is a sign to move into quadrant II.

5.4.1.2 Finding the intention within the present behaviors impacting worker health. For all the answers to the questions asked in quadrants IV and III that respectively pertain to the intuition and integrity of the circumstances that resulted in a worker death, the intention of the behaviors that resulted in the death will be found. Again, looking at the project management triad of schedule (time), budget (profits), and quality (worker skill) as a starting point; the following example provides a reference for how to find the intention within the behaviors. Examining the budget leg of the triad, a question about the value of the selected material that was used that resulted in the worker's death can be asked. With regard to the failed material, questions about whether or not this was a replacement material, because the regularly used material was unavailable can be explored. Reasons behind why the regularly used material was unavailable can be asked; and if the material was not a replacement material, it can be asked if this batch was defective. If the material was defective then possibly the liability for the death falls on the manufacturer. Questions about cost can also be asked. Questions about whether or not cost was a reason for using a replacement material and, if indeed the material that failed was not the regularly used material. One may also ask questions regarding whether or not the reliability of the material was considered. If the material was known to be unreliable and the material's potential to harm the worker was simply not given any attention. If no consideration was given beyond price, as a result of the worker's death, what considerations that have been brought to light need to be included in procurement and acquisition considerations for the purchase of materials. Again, any number of questions pertaining to the circumstances can be asked. But what, more importantly, is needed is a sincere, honest, and open assessment of the circumstances that allowed worker death to result.

5.4.1.3 Unknown circumstances impacting worker health. Quadrant I holds the invisible invisibility, or in the case of the worker death, it can be said that the worker’s death could not have been foreseen. It was an unknown unknown. However, as we have been going around the conceptual model, we have learned that, though quadrant I holds unknown unknowns, a total unknowing of the potential for this worker’s death is not completely truthful. The project most likely was not the first construction project by the entity engaged in the work. Therefore, information regarding worker concerns for their safety and health on previous projects was more than likely somewhere in the company’s records. Questions regarding the level of attention and intention to address the previously noted circumstances of concern need to be given serious exploration by the entity’s leadership. What if it is the leadership (e.g., the owner) who does not want to concern itself with workers issues? Then that is when the other components of the construction cosmos, such as other workers, external stakeholders, and general public, need to be tapped into to make change happen. An example of this is the recent passing of a new OSHA regulation regarding crystalline silica. The loud unified voice of trade organizations, such as the Union of International Bricklayers and Allied Craft Workers, was instrumental in getting the new standard passed. Again, any number of questions pertaining to the circumstances can be asked, but, a sincere, honest, open assessment of the circumstances and a willingness to accept a potentially unfavorable truth about the integrity of leadership actions that allowed these circumstances to exist must be present in the analysis.

5.4.1.4 Ignoring an issue does not make it go away. The lack of attention to an issue stops the influx of new ideas for addressing the issue. A creative and potentially simple way of mitigating or removing a safety and/or health issue can never come to fruition if the issue is continually ignored. Unwillingness to sincerely address an issue solely because of the assumption of unproven financial costs is an example of a barrier that limits improvements. Impacts to profitability are a main reason I heard in the interviews for why health and safety issues are not addressed. However, as stated in the literature review, when an issue was addressed, there was the potential of a 5–85% return on the investment. The great potential return on investment can hopefully be enough of a catalyst or incentive to motivate exploring possibly realistic financial solutions. As attention is paid to issues and improvements are made on the solutions, great returns are possible—not solely financial returns, but reputational and social returns as well. However, by not paying attention to issues with the excuse of "it costs too much," the real cost of how much a company is losing in profits will remain an invisible invisibility. In other words, the potential 5–85% increased profits that can result from an investment that addresses the issue will never flow through the four quadrants and manifest as additional profits.

5.4.1.5 Gauging the impact of previous actions on productivity. Throughout the conceptual model, profits are flowing in and out and in between the financial paths of balance, savings and incentives, and the financial path of imbalance (fines and costs) depending upon the answers to the questions asked throughout the four quadrants. Real quantities for savings from previous investments, and/or increases in productivity from the implementation of new programs, and/or the losses from finds, and/or the costs from poorly planned projects can be used as gauges for how the decisions/previous actions undertaken are reflected directly in the direction of the profit flows.

5.4.1.6 Courageous and bold new actions. The analysis can explore the impact of the behaviors and decisions at each level from the worker to the general public. A benefit of a root cause analysis is that by moving in reverse order through the construction cosmos, the answers and financial flows are known. As a tool, the conceptual model provides a visual where, at each level and movement throughout the model, the "dead ends" of the maze can be considered behaviors or enlightenment about behaviors that have continually led to a path of imbalance. The answers are all in the circumstances that manifested in the worker's death. We need to be astute enough to recognize the question for the answer that is in front of us. We need to be courageous enough to take responsibility and bold enough to try new things.

5.4.2 A Thought Tool for Envisioning the Future State of Worker Health in Construction

As shown above, when a worker's death is traced back to the root-cause, the analysis eventually spirals back to quadrant I. Quadrant I is important because the level of attention paid, for example to a previous worker death, determines whether or not creative ideas for mitigating or preventing future deaths come into the boundaries of the conceptual model containing the construction system. A continual lack of attention to issues such as worker deaths has resulted in the accumulation of issues within quadrant I and creates an imbalance. Thus, the blade of the system represented by quadrant I perturbs the efficiency of the system rotation. Moreover, within quadrant I, the resulting financial outcomes of the lack of attention to issues such as worker deaths need to be realistically assessed to determine the costs versus savings. For example, assuming a safety program or protocol is not in place for the circumstances under which the worker died, what are the financial reasons for this lack? Assuming the reasons are based solely on available capital, is there an established baseline that needs to be reached in order to prioritize health and safety investments? Are the savings gained by the company/industry not addressing a previous worker death less than, equal to, or greater than the losses? Previous outcomes can be useful for establishing financial baselines. And, more likely than not, the baseline will need to be tweaked until upper control limits and lower control limits for the ratio of investments in health and safety to profits are established.

5.4.2.1 Asking courage and bold questions regarding worker health. To most effectively use this tool to forecast an outcome, an issue known to have lacked sincere attention needs to be determined by the user(s). The user(s) need to be prepared to ask difficult questions of themselves. For example, starting in quadrant I, examine how the actions at each level from the worker to general stakeholders influences the level of attention paid to an issue. Only when the user(s) can honestly reach a consensus that they are focusing their attention on the issue can the user(s) move into quadrant II, intention, for intention results from focused attention. And, if the attention in quadrant I is not truly focused on addressing the issue, then intention can never be reached. Furthermore, again as issues continue to accumulate in quadrant I, the system will eventually be too imbalanced, and like a washing machine with an imbalanced load, the construction system will make horrible screeching noises and eventually spin off the system railings and break.

5.4.2.2 True intentions: Purposeful health practices or required compliance. With attention focused on addressing a long-standing issue, the spotlight turns to determining if the intention is to truly address the issue or simply check off a required compliance. The user(s) of the conceptual model will need to introspectively examine their motives and honestly state their intention(s). There is no judgment attached to either response, where one is good and other is bad. However, the sincerity of the intention will be reflected in what manifests financially as well as non-fiduciarily.

The level of courage to answer honestly the stated intention by the users of the conceptual model defines their integrity. Do they do the right thing when no one is looking or think no one is looking? Or, do they only do the right thing when they think someone is looking? The actions the users of the conceptual model do when no one is looking determine their level of integrity with regard to truly addressing the long-standing issues. Assessments of the short- and long-term savings versus potential fines for being caught doing the wrong thing when they think no one is looking need to be assessed. A truthful assessment determines how balanced the blade is within this quadrant of the overall construction system/conceptual model. What a truthful assessment is may not be the same for every company. The development of flexible cost/benefit assessment tools is something tremendously needed within the construction industry. And, though numbers are not present in the conceptual model, within the very naming of the model as conceptual—via the directional profit flows of the financial paths of balance and imbalance and creative imagination—the users of the model (e.g., individual, contractor, or company owner) can develop a conceptual baseline for how company actions are influencing profit flows.

5.4.2.3 Realistic expectations for addressing worker health. The expectation that everything needs to be perfect at each quadrant before moving on to the next one is not realistic. What is realistic is the expectation that the user(s) of the tool do their best assessment, which is solely subjective to each user. And, with the best assessment completed at each of the previous quadrants, the user(s) intuition or experiential knowledge becomes paramount at quadrant IV. Intuition or experiential knowledge becomes paramount at quadrant IV because it determines what results from the movement through the quadrants. For example, if user(s) of the conceptual model did their best assessments at each quadrant, then a potential outcome can be a program for Injury and Illness Tracking. This program can be used to develop leading trends rather than lagging trends regarding potential injuries and illness so that the injuries and illness can potentially be mitigated before they manifest.

5.4.3 Determining a Health Score for Prevention Practices

Recognizing that at each quadrant a perfect state is not a realistic expectation before moving onto the next quadrant, what a user can do is keep track or give themselves a self-determined score of how they feel they performed at each quadrant. To score their performance, because there are four quadrants, the highest rating possible at each quadrant is 25%. Where, the sum of all the quadrants is 100%, the base score for the overall construction cosmos and a perfectly efficient system. Thus, the user, prior to moving onto the next quadrant, scores their effort at their present quadrant based off the total of 25%. For example, if the user felt their effort was 15% of 25%, then 15% would be their score. Where the remaining 10% delta, is the percentage of barriers or inefficiencies present in the construction cosmos at that quadrant. In addition to determining the level of inefficiency present in each quadrant, if the user keeps track of the identified inefficiencies, then when the movement through all quadrants is complete, the user(s) will have a list of future issues/efforts that can be addressed to further improve the overall construction system efficiency. Thus, with the self-determined score complete for all quadrants, the user(s) can add up the scores to determine the overall efficiency score for the system. Moreover, the delta total for all quadrants and the identified inefficiencies at each quadrant can serve as a starting point for the next opportunity a user(s) may have for addressing long-standing issues regarding the health practices and climate within construction. For by examining the identified inefficiency via the process explained, the model can serve to work at both micro and macro levels.

5.4.3.1 Merging left and right brain thinking for more robust solutions. If the desired financial outcome for a company is not moving in the direction the company desires, this tool can facilitate the identification of actions that can generate the most change/impact with the resources available to the company. Using a conceptual model rather than a linear checklist also allows the users to visualize the interconnectedness of their chosen path and the potential financial consequences of those actions. This not only shows cause and effect, but also how multiple paths are present for reaching the financial goals. Linear lines and strings limit creativity, whereas, a conceptual model allows access to right-brain artistic functions that govern the imagination, the source for creative solutions, which is what many experts state is needed for addressing the challenges to the long-standing health concerns of construction trade workers.

CHAPTER 6: DELPHI METHOD—PRACTICES, BARRIERS, AND CATALYSTS

This research is an effort to address the existing disconnect between the impact of emerging health hazards on the workforce (e.g., Ruttenberg & Obando 2014; HSE 2012) and the current understanding/body of knowledge regarding the topic and the actual practices to assess and prevent such hazards in a large majority of organizations and project sites.

The objectives of this research focus on identifying practices for improving the health and safety conditions within the construction industry, as well as identifying the barriers and catalysts to the practices, and are achieved via three rounds of Delphi surveys.

6.1 Development of Practices Codes for Health Hazards

A similar analysis for determining the qualitative codes is completed on the occupational health and safety expert interviews to determine the practice codes, barriers to, and catalysts for the implementation of health practices in construction. The analysis identified words, sentences, paragraphs, and/or ideas used to develop the prevention practice codes used in the Delphi surveys. Upon completion of the analysis, the result is the development of the foundational constructs that are used to build the practice codes for each health hazard, as well as the barriers to and catalysts for the implementation of health practices on construction sites. Similar constructs found within each health hazard are revised to remove any overlap in the descriptions. Preventing overlap in the descriptions ensures that if a construct is present within more than one of the health hazards, then for each hazard the prevention practice is clearly associated with that specific hazard. The barriers to and catalysts for the implementation of health practices at construction sites are also similarly analyzed to prevent overlapping descriptions. Each health hazard of welding fumes, crystalline silica, noise, and musculoskeletal disorders used in the Delphi surveys have corresponding practice codes, barriers to, and catalysts for the implementation of health practices. The practices codes, barriers to, and catalysts for the implementation of health practices at construction sites developed over various iterations from the literature review and NORA agenda and used in the Delphi surveys are presented in Appendix K.

6.2 First Round Delphi Survey: Consensus on Practice Constructs

The goal of the first round of the Delphi surveys is to produce enough descriptive information, including examples and lessons learned, that lead to an initial set of practices that can drive industry organizations to such proactive assessment and prevention. The goal of the first round of the Delphi survey is achieved via a consensus process for the descriptions/names developed for the practice codes, barriers to, and catalysts for the implementation of health practices on construction sites. A consensus for the practices, barriers, and catalysts is sought after in order to remove or reduce ambiguity in their understanding, and hence, potential application. The first Delphi survey round questions with the identified practices, barriers and catalysts is found in Appendix M.

6.2.1 Survey Respondents

Eleven surveys are distributed and six experts complete the survey. Practice codes, barriers, and catalysts with two or more expert comments reflecting a discrepancy in the understanding or application of the practice are revised. The revisions are done by analyzing and consolidating the practice codes, barriers, and catalysts for the four health hazards with similar focus until the researcher deems the new description encompasses the comments presented by the panelists. Practice codes, barriers, and catalysts without comments suggesting any type of discrepancy in their understanding are left as presented in the first round of the Delphi survey. Appendix N presents the revised practice codes.

6.2.2 Predominant Survey Finding—Practices

The predominant finding is that the understanding of practice codes is based upon the experience of the panel member. Though all panelists are occupational health and safety experts, not all have the same level of experience with the four NORA hazards of concern. Therefore, codes with comments regarding clarification are revised with the intent of establishing a context that facilitates understanding the practice and its execution.

6.2.3 Predominant Survey Finding—Barriers

With regard to the descriptions/names developed for the barriers, only two barriers have any deviation from 100% acceptance. Temporary Labor (e.g., Day Laborers) has 83.33% or five respondents to 16.67% or one respondent out of the six total respondents, and Non-Functional PPE recorded 83.33% or five respondents to 16.67% or one respondent out of the six total respondents. All other barriers are approved with 100% agreement by all the panel experts. One panelist comments that the list is a “very comprehensive detailing of barriers; all possess some degree of barrier potential.”

With regard to additional potential barriers not captured, there is a 50-50 split of yes and no for the six respondents. The additional barriers are with regard to 1) the image of “the construction worker in grade schools and high schools” as “not a destination occupation." This barrier suggests that the industry is capable of focusing its effort in order to make construction work more appealing as a desirable profession as it was in the past; 2) the "lack of top management support for health-related programs". This barrier suggests that with safety tending to get more attention it creates a barrier for health issues to be addressed; 3) obesity is a barrier to success, and the social reluctance to speak about it further enables its major contributions to injuries. In the expert's opinion, injury rates, as a result of an obese workforce, will remain unresolved until the issue of obesity is directly addressed. The expert gives the example of when a 380-pound worker ascends a ladder as follows:

> The opportunities for failure include structural (ladder), tipping (gravity), and the impact of missing a step on the way down. Consider the effect of a 180-pound worker (expected weight) to be carrying two 100-pounds bags of material down that ladder, and we expect his or her ankle to take that load without something failing. Keeping the obese from working (specific activities where you must be fit) is the same motivator as those hoping to join the military. They will change their poor habits to gain entry to the workforce. Granted, not all obesity is from habit, some genetic, but regardless a contributor to an incident we do not discuss as a culture.

6.2.4 Predominant Survey Finding—Catalysts

With regard to the descriptions/names developed for the catalysts, the following three are the only without a 100% acceptance by the panel. The three are 1) Inclusion of Contract Health Provisions—66.67% or four respondents are in agreement versus 33.33% or two respondents not in agreement out of a total of six respondents; 2) Worker Voice(s) leveraged by Management—50.00% or three respondents are in agreement to 50.00% or three respondents not in agreement out of a total of six respondents; and 3) Media Exposure (Reputation)—50.00% or three respondents are in agreement to 50.00% or three respondents not in agreement out of a total of six respondents.

With regard to additional potential catalysts not captured, the split was five or 83.33% saying there are no additional catalysts to lists versus one or 16.67% of the respondents stating there are additional catalysts to be captured. The additional catalysts listed by the expert are 1) management accountability and attitude, 2) supervisory accountability and attitude, and 3) the use of technology and new construction methods such as LEAN, Building Information Modeling or BIM, and Sustainability.

6.2.5 Comprehensive List of Practices, Barriers, and Catalysts

Appendix O shows the final and complete list after expert comments and revisions of prevention practices, barriers, and catalysts were identified from the first round of the Delphi survey.

The comprehensive list presented in Appendix O is unique because, as of this research, it is the only known comprehensive list of practices spanning planning, design, construction, and work hygiene opportunities/practices. The current state of knowledge is mainly constrained to work hygiene with the focus on personal protective equipment (PPEs) and administrative and engineering controls only. Focusing solely on PPEs and controls highlights the present silo-type mindsets that are constraining and preventing visibility to opportunities to substitute and potentially eliminate exposure to hazards in the first place.

6.3 Second Round Delphi Survey: Characterization

Prior to the distribution of the second round of the Delphi survey (Appendix P), the panelists received a summary of the modified set of practices and a synopsis of responses from other experts. The second round of the Delphi survey queried the panelists' opinions regarding the practices, barriers, and catalysts defined in the first round of the Delphi survey.

6.3.1 Survey Respondents

Eleven surveys are distributed and eight experts complete the survey. Therefore, the second survey achieves the minimal number of eight participants, as stated by Linstone and Turoff (1975).

6.3.2 Predominant Survey Finding for Each Health Hazard

To determine their answers for the second survey round, the panelists are asked to consider both the feasibility and achievability of the practice and whether or not the practice is sustainable within their work environment. The panelists are asked to focus on the actual chance of implementation of the practice within their system. The predominant survey finding of round two is that for each practice to potentially impact exposure and/or elimination of each hazard it must be done through proper controls, both administrative and engineering, that govern how work is done. Proper administrative and engineering controls need to first be established in order for prevention practice(s) to be executed successfully. A complete list of the prevention practices for each health hazard is found in Appendix Q. The round two findings, where feasibility is the x-axis and implementation is the y-axis, are also presented graphically in Appendix Q. Practices located on the Excel graph with the greatest x-feasibility value and y-implementation value are identified and then categorized according to the OSHA hierarchy of controls. Each practice on the Excel graph is color coded based on the legend/color scheme of the OSHA hierarchy of controls figure below each graph. The color code of the OSHA hierarchy of controls figure represent the options from most effective to least effective for preventing or minimizing exposure to each health hazard. Respectively, these options are 1) elimination, 2) substitution, 3) engineering controls, 4) administrative controls, and 5) personal protective equipment (PPE).

6.3.2.1 Top practices identified for primary and secondary exposures. Overall, of the top five practices identified for both primary and secondary exposures, 20 are administrative controls, 14 are elimination, eight are engineering, three are personal protective equipment, and none are substitution. The practices with the most impact for protecting workers from primary and/or secondary exposures to health hazards are based on expert survey responses.

6.3.2.1.1 Survey findings for welding fumes. Table 8 lists the top five prevention practices for primary exposures identified for welding fumes.

Table 8

Top Five Prevention Practices Identified for Primary Exposures to Welding Fumes

Welding Fumes: Primary

No.	Prevention Practices	Hierarchy of Control
1.	Design of Alternative Connections and Components, e.g. Bolted Connections	Elimination
2.	Proper Ventilation	Elimination/ Administrative
3.	Fume Protection Barriers	Elimination/ Administrative
4.	Distancing On-site Welding Activities	Elimination/ Administrative
5.	Activity Sequencing (e.g., Activity planning and execution to minimize/reduce fume exposures)	Administrative

Table 9 lists the top five prevention practices for secondary exposures identified for welding fumes.

Table 9

Top Five Prevention Practices Identified for Secondary Exposures to Welding Fumes.

Welding Fumes: Secondary		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Modularization (e.g., offsite preassembly of components in controlled conditions)	Administrative/Elimination
2.	Design of Alternative Connections and Components (e.g. Bolted Connections)	Elimination
3.	Proper Ventilation	Elimination/Administrative
4.	Distancing On-site Welding Activities	Administrative/Elimination
5.	Fume Protection Barriers	Administrative/Elimination

6.3.2.2.2 Survey findings for crystalline silica. Table 10 lists the top five prevention practices for primary exposures identified for crystalline silica.

Table 10

Top Five Prevention Practices Identified for Primary Exposures to Crystalline Silica

Crystalline Silica: Primary		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	Elimination/ Administrative
2.	Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	Elimination/ Administrative
3.	Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method)	Administrative/ Engineering
4.	Isolation of Cutting Stations	Administrative/ Engineering
5.	Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	Administrative

Table 11 lists the top five prevention practices for secondary exposures identified for crystalline silica.

Table 11

Top Five Prevention Practices Identified for Secondary Exposures to Crystalline Silica

Crystalline Silica: Secondary		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method)	Administrative/ Engineering
2.	Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	Elimination/ Administrative
3.	Proper Ventilation and Filtering (e.g., HEPA)	Elimination/ Administration
4.	Isolation of Cutting Stations	Administrative/ Engineering
5.	Appropriate Respiratory Protection	Personal Protective Equipment

6.3.2.2.3 Survey findings for noise. Table 12 lists the top five prevention practices for primary exposures identified for noise.

Table 12

Top Five Prevention Practices Identified for Primary Exposures to Noise

Noise: Primary		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Equipment Shielding/Retrofitting (e.g., Noise Vibration/Insulation)	Engineering
2.	Exclusion Zones to Noisy Areas	Administrative/ Engineering
3.	Acoustic Sound Barriers	Elimination/ Engineering
4.	Appropriate Hearing Protection	Personal Protective Equipment
5.	Individual Worker Training of Proper PPEs Use/Fit	Administrative

Table 13 lists the top five prevention practices for secondary exposures identified for noise.

Table 13

Top Five Prevention Practices Identified for Secondary Exposures to Noise

Noise: Secondary		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Exclusion Zones to Noisy Areas	Administrative/Engineering
2.	Equipment Shielding/Retrofitting (e.g., Noise Vibration/Insulation)	Elimination/Engineering
3.	Appropriate Hearing Protection	Personal Protective Equipment
4.	Acoustic Sound Barriers	Elimination/Engineering
5.	Noise Hazard Training	Administrative

6.3.2.2.4 Survey findings for musculoskeletal disorders. Table 14 lists the top five prevention practices identified for musculoskeletal disorders.

Table 14

Top Five Prevention Practices Identified for Musculoskeletal Disorders.

Musculoskeletal Disorders		
No.	**Prevention Practices**	**Hierarchy of Control**
1.	Platforms for Elevated Work	Administrative/ Engineering
2.	On-Site Ergonomic Program (e.g., Flex and Stretch, Team lifting, Two-Step Lifting, etc.)	Administrative
3.	Early Recognition and Reporting of Musculoskeletal Symptoms	Administrative
4.	Planning and Site Layout (e.g., Reduction of Repetitive Motions and materials handling)	Administrative
5.	Health and Wellness Programs	Administrative

6.3.2.2 Planning and designing of work—Opportunities for greatest positive impact on worker health. Expert responses point to opportunities in the planning and designing of work as areas where worker health can be impacted in a manner that proactively addresses the long-standing health concerns. However, occupational health and safety experts are often not involved in the planning and determination of how work is performed. Therefore, in the planning and implementation of administrative controls, which have the greatest potential to impact the prevention of worker exposures to cumulative health hazards, is where occupational health and safety experts have the least involvement. The same constraints apply to elimination, engineering, and substitution, for often the engineering and planning happens outside of the scope of the responsibilities assigned to occupational health and safety experts. Similarly, occupational health and safety experts are not able to influence the substitution of hazardous materials for less hazardous ones due to this being outside the scope of their responsibilities. Generally, the procurement and acquisition of materials takes place prior to the involvement of occupational health and safety experts on a project.

Thus, the education of management and involvement of occupational health and safety experts from the beginning stages of a project can bring a conscious awareness of opportunities for increasing the health and safety of construction trade workers. This is a huge opportunity for increasing savings through increased project safety, as well via increased worker health. Involving occupational health and safety experts from the conception of a project to the turnover of the project is an opportunity for increasing profitability that has not been explored. Occupational health and safety experts are relegated to finding band aids for broken legs and sicknesses, literally and figuratively.

They are asked to solve problems whose origins are prior in the pipeline. Yet, the occupational safety and health experts do not have the position, influence, authority, or involvement in the beginning aspects of the project where the occupational health and safety experts could potentially have the greatest impact on worker health.

6.3.3 Predominant Survey Finding—Barriers

With regard to barriers in the second round of the Delphi survey, the panelists were asked for their opinion on the intensity of these barriers in preventing and/or opposing the implementation of the proposed practices. The intensity of the barriers in round two is paired with the frequency queried in round three (Appendix R) in order to determine via round three the top five barriers. Appendix R presents the third round of Delphi survey questions. Findings for the frequency versus intensity of a barrier that hinders the implementation of prevention practices, based on the expert panel member opinions, are presented in Appendix S.

6.3.4 Predominant Survey Finding—Catalysts

In the second round of the Delphi survey regarding the proposed catalysts, the panelists were asked for their opinion regarding the opportunity of the catalyst in enabling and/or accelerating the implementation of the proposed practices. The opportunity for implementing a catalyst is paired with frequency. In the third Delphi survey round is where the experts determine the enabling score for the catalysts. Findings for the frequency versus implementation of a catalyst that enables prevention practices, based on the expert panel member opinions, are presented in Appendix S.

6.4 Third Round of Delphi Survey

Round three of the Delphi Survey focuses on obtaining from the occupational health and safety experts their opinion on whether a practice identified for both primary and secondary exposures is more effective for preventing a primary exposure or more effective for preventing a secondary exposure or if the practice is equally effective for both primary and secondary exposures. Appendix R presents the third round Delphi survey questions.

6.4.1 Survey Respondents

Eleven surveys are distributed and eight experts complete the survey. Therefore, the second survey achieves the minimal number of eight participants, as stated by Linstone and Turoff (1975).

6.4.2 Predominant Survey Findings—Barriers and Catalysts

The third survey inquires about the frequency the health and safety experts encounter barriers with regard to the implementation of the prevention practices. The third survey also inquires about the frequency in which catalysts are encountered by the health and safety experts and facilitate the implementation of the proposed prevention practice. The complete list of the barriers and catalysts is presented in Appendix S along with graphic results of the third Delphi survey round.

6.4.2.1 Predominant survey findings—Barriers. Figure 17 illustrates the results of the third round of the Delphi surveys with regard to the frequency and intensity of the barriers to the implementation of prevention practices for the exposure to health hazards. Table 15 presents the top five barriers based on the frequency versus the intensity of the barriers that prevent the implementation of health practices and improved health climate on construction sites.

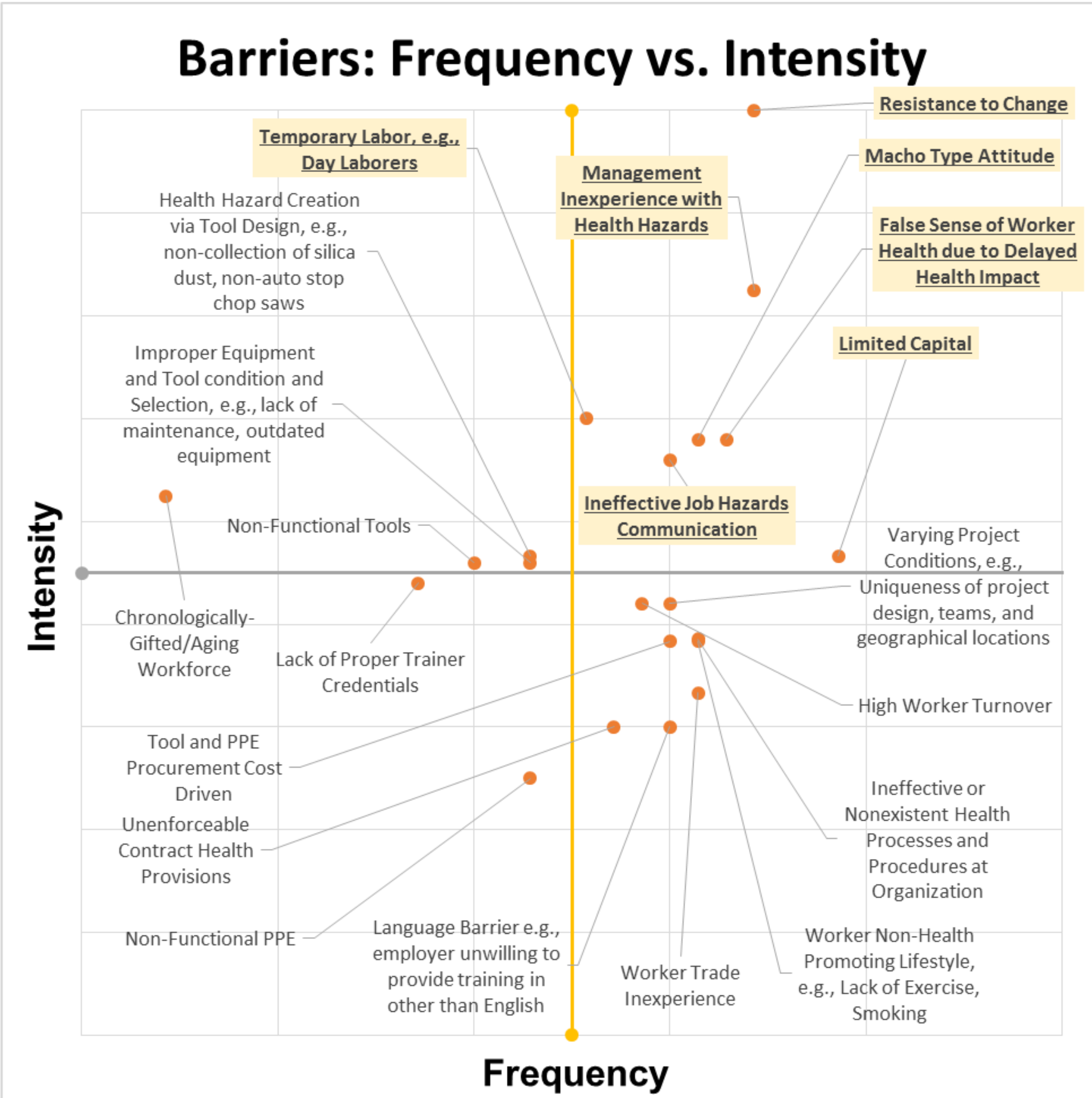

Figure 17. Illustration of the frequency versus intensity of barriers to the implementation of health hazard exposure prevention practices.

Table 15

Delphi Round Three: Top Five Barriers—Frequency versus Intensity

Barriers: Frequency versus Intensity	
No.	**Barrier**
1.	Resistance to Change
2.	Management Inexperience with Health Hazards
3.	Macho-Type Attitude
4.	False sense of Worker Health Due to Delayed Health Impact
5.	Ineffective Job Hazards Communication

6.4.2.2 Predominant survey findings—Catalysts. Figure 18 illustrates the results of the third round of the Delphi surveys with regard to the frequency and enabling of the catalysts to the implementation of prevention practices for the exposure to health hazards. Table 16 presents the top five catalysts based on the frequency versus the enabling of the catalysts to facilitate the implementation of health practices and the improvement of the health climate on construction sites.

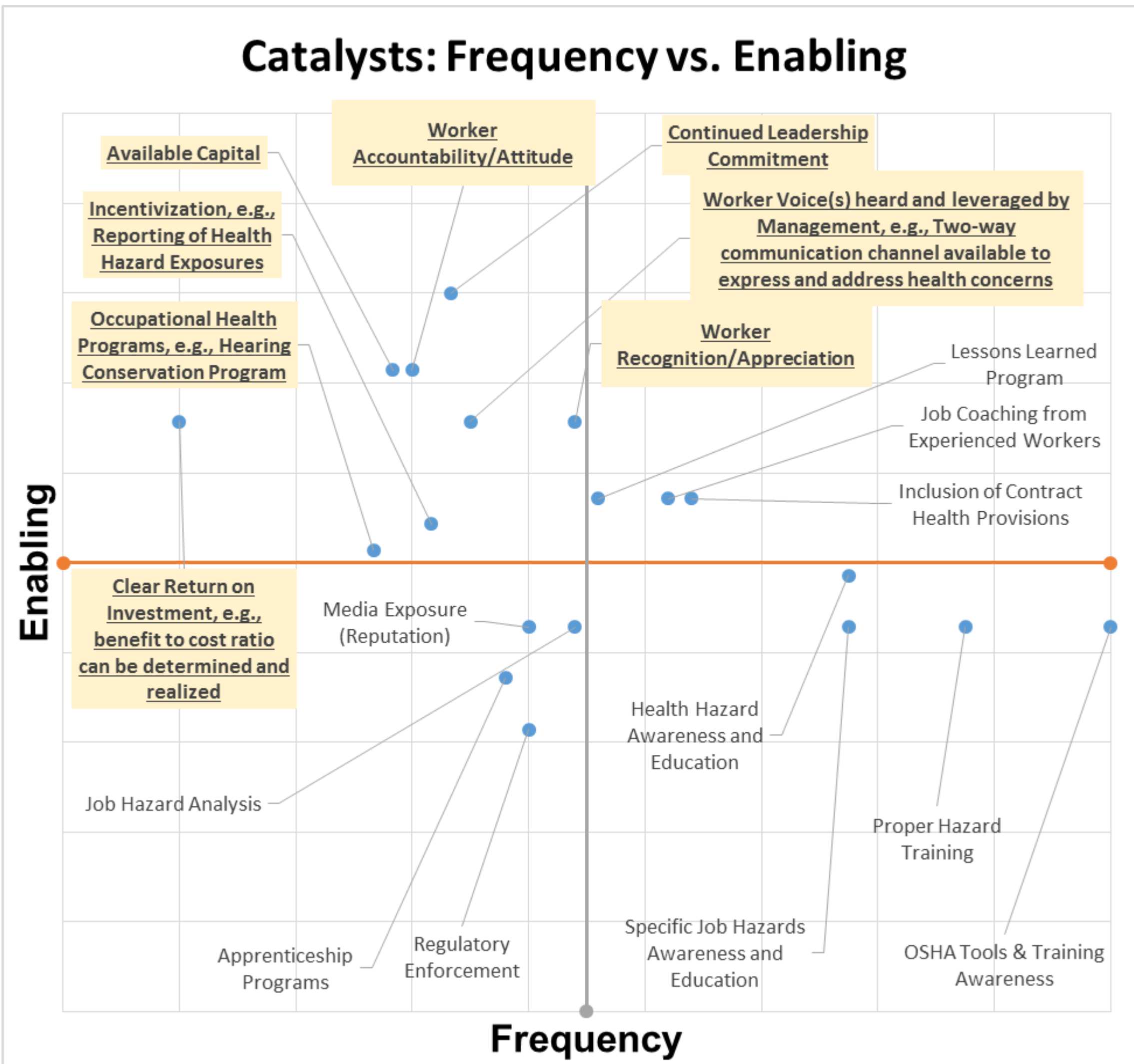

Figure 18. Illustration of the frequency versus enabling of catalysts to the implementation of health hazard exposure prevention practices.

Table 16

Delphi Round Three: Top Five Catalysts – Frequency versus Enabling

No.	**Catalyst**
1.	Continued Leadership Commitment
2.	Worker Accountability/Attitude
3.	Available Capital
4.	Incentivization
5.	Clear Return on Investments (e.g., benefit to cost ratio can be determined and realized)

CHAPTER 7: DISCUSSION OF RESULTS

How can the results from the developed constructivist grounded theory (CGT) and Delphi survey results be integrated? How do the results from the CGT and Delphi answer the research question(s) of: What role does worker health play within the construction industry? What is the general perception of construction trade workers regarding health practices and profitability within the construction industry? What are identifiable and quantifiable practices, barriers to, and catalysts for the improvement of worker health and health climate within construction for the long-standing health concerns of welding fumes, crystalline silica, noise, and musculoskeletal disorders?

The CGT and Delphi survey results are two sides of the same coin. The CGT is the overall framework for examining the construction industry and reminds us that the health concerns that have manifested are not something that is happening to the construction industry or to the worker. Rather, the adverse health issues and long-standing health concerns are manifestations resulting from the mindsets of all levels of the industry. Fourfold structuration holds this view by demonstrating that the core of an issue does not result out of nothingness. Rather, the core—or where an issue lies—is the collection of all the thoughts, words, actions, and character that have placed the industry on its present path. Hence, from the individually worker-owned company tradespeople (often young men) who choose not to implement proper health and safety measures because they have never experienced any adverse signs regarding their health—and even if they have, they blow the signs off—to the 500+ employee construction company to the construction project owner who prices work by not accounting for health and safety measures in order to have the lowest bid possible and win the project, to the general public, who's present esteem of the value of a construction worker's life can be improved, to that of the engineer who designed the project, the responsibility for the adverse health outcomes and long-standing health concerns is at all levels. Thus, the solutions for ameliorating the present circumstances of the lack of health practices and less than optimal health climate within construction are present all around. As what flows into the issue of health practices and climate within construction changes, then what manifests from the cumulative actions of all stakeholders within the construction will also change. Hence, the role worker health plays within the construction industry is that of an indicator. Worker health indicates the climate and level of attention health practices are receiving. The level of attention is seen via the number of sick and dying workers. The greater the number of sick and dying workers, the less it can be assumed that worker health is being focused upon within the construction industry.

Thus, what the CGT and Delphi survey results bring to light is the opportunity to view the present less-than-optimal health practices and climate within construction as part of a greater system or process. By creating a framework for viewing the construction industry and the present less-than-optimal health practices and climate as a process, this research takes abstract ideas regarding the responsibility of each level within the construction industry for worker health and offers a manner for quantifying the impacts via an already practiced and understood method within engineering, quality and/or process control.

7.1 Qualitative Research Method Provides a Holistic View of the Construction Industry

The CGT provides a holistic view for the construction industry. The selective code of barriers presented in the CGT is analogous to system inefficiencies. The lack of available skilled workers, increased rework, increased employer health premiums, decreased worker productivity, and many others can be viewed as process conformance issues. By viewing the present conditions via the lens of process control and taking each outcome and dissecting it individually to begin to identify and to name the aspects within each individual process, then the resulting process conformance issues can begin to be directly associated with known and quantifiable behaviors on all levels of the process. The CGT and Delphi surveys provide a new lens for viewing what have been perceived as abstract and unquantifiable outcomes now and allow a more tangible, less frightening, and more manageable mindset regarding the lack of health practices and climate within construction. The CGT and Delphi surveys show the importance of addressing long-standing health concerns because this research establishes opportunities for increased profitability by viewing the existing state as a familiar concept to the engineering world, process controls. A company most likely would not allow an out-of-control process, such as repeatedly cutting wood forms the wrong dimensions, to remain unaddressed, because each wrong cut relates to a form of process waste that ultimately is tied directly to profitability. Moreover, most companies are unaware that data regarding process conformance is already most likely available to them in one form or another within company records. Unfortunately, though more often than not, key performance indicators or metrics gathered by companies do not tie directly to the strategic goals and plans for the company. Therefore, good intentioned companies are missing an opportunity to fully maximize the resources they spend on gathering process conformance data because they are not gathering the appropriate data for determining how and where the air is leaking from the tires, or rather how profits are not getting into their coffers.

Overall, this research is a bridge for understanding how unaddressed health concerns are similar to continually allowing and not addressing for example, wood forms to be continually cut in the wrong dimensions (i.e., because both cut into profits). But, like how an inefficient window and an efficient one look the same for an Arizona resident in the summer until he/she gets their utility bill, the lack of health practices and climate in construction is like having an inefficient window. The difference, however, is that unlike an Arizona resident who gets his/her summer utility bill, because the construction industry never gets an actual utility bill, project owners and construction leaders are not fully aware of their self-deception with regard to the extent of profit losses the construction industry is suffering by not taking advantage the opportunity to increases profits via the integration of health and safety investments into the overall business planning and strategy.

7.1.1 The research Question and the Emerged CGT

The qualitative research question of "what is the general perception of construction trade workers regarding health practices and profitability within the construction industry?" is answered by the emerged constructivist grounded theory by providing a framework or communication tool for the root causes of the health maladies. The theory/model creates a framework or structure that allows the dynamic interactions of the workers, management, owners, stakeholders, and general public to be visualized. The model provides a dynamic structure that, by the incorporation of the barriers within the model, is more clearly visible as to how barriers hamper the implementation of health practices and climate within construction. The understanding of how barriers impact the construction industry and forward movement and/or evolution with regard to improved health practices facilitates the visibility of the barriers. With greater visibility and understanding of the barriers, then potentially the general perception that worker health is not congruent with profitability can be overcome through a focused attention given to addressing long-standing health concerns. Furthermore, the conceptual model illuminates how the outcomes of the present mindsets (e.g., adverse health outcomes and the shortage of skilled workers) will not be ignored, but rather, via economic and natural processes that demand balance, will force the industry to address the concerns.

7.1.2 The Emerged Conceptual Model and the Research Objectives

The emerged conceptual model achieves the research objectives of improving health and safety practices within the construction industry by 1) identifying and explaining barriers to improved health practices and climate, 2) identifying and discussing tactics to remove implementation barriers for improved health practices and climate, and 3) how catalysts facilitate the implementation of prevention practices.

The conceptual model identifies and explains barriers to improved health practices through the categorization of unseen or non-quantifiable actions via four communication quadrants. By dynamically allowing the tracing of actions taken to address the long-standing health concerns of construction trade workers, each quadrant explicitly communicates how the present state of the health practices and climate within the construction industry are consequences of the attention, intention, integrity, and intuition behind the actions. By providing a framework for making visible what is often unseen or perceived as non-quantifiable, the framework gives companies experiencing the health issues a useful tool for discussing and naming unconscious industry/company behaviors and cultures that may be the root of the issues.

7.1.3 Conceptual Model as a Visualization Tool for the Construction Industry

Though the conceptual model does not directly identify and discuss tactics for the removal of implementation barriers for improved health practices and climate, again through the categorization of unseen or non-quantifiable actions via the four communication quadrants, the conceptual model provides a visualization tool that can be used by the construction industry to imagine/strategically envision the outcomes of deliberately chosen tactics. Through the transcendence of linear left-brain logic that can be achieved only through imagery, the conceptual model allows access to right-brain creativity/imagination. Creativity is needed for developing new tactics that address the circumstances under which the construction industry has knowingly or unknowingly exposed workers to cumulative health hazards.

7.1.3.1. Fourfold structuration and control process states: Theoretical exercise. From a qualitative perspective, when looking at construction as a holistic process and utilizing the quantitative fourfold structuration of control process, the research objectives of improving health and safety practices within the construction industry can be achieved by 1) identifying prevention practices for the health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders, 2) identifying and explaining barriers to improved health practices and climate, 3) identifying and discussing tactics to remove implementation barriers for improved health practices and climate, and 4) how catalysts facilitate the implementation of prevention practices. Identified barriers are process inefficiencies that from a process control perspective are increasing the standard deviation in the performance of the overall construction operation(s). Whereas, tactics that remove implementation barriers can be viewed as increases in process efficiency (i.e., catalysts).

7.1.3.2 Barriers represent imbalances present in the construction system. Exposing workers knowingly or unknowingly to health hazards disrespects life, which is nature's predominant engineering and construction design. The conceptual model illuminates that the barriers to the improvement of health practices and climate within construction result from a violation of balance within the construction system on various levels. An out-of-balance system is inefficient. Inefficiencies identified for the qualitative CGT model can be likened to the barriers identified through the quantitative method. The model illuminates that the ultimate barriers to the prevention of exposures to health hazards, such as welding fumes, are the intentions and the integrity by which the actions to prevent the exposure of workers to health hazards are undertaken. For though the intention and integrity of actions cannot be quantified, via the results (e.g., sick and injured workers) they are intuitively known.

7.1.3.2.1 Barriers as deviations from efficiency. Therefore, viewing the construction industry from a balance or process control perspective, the main challenge is to communicate effectively to the construction industry how its present state of operating is potentially analogous to a system functioning at the threshold of an upper control limit and/or a lower control limit within a six sigma standard measure of deviation. The shortage of skilled workers, rework, and high turnover of workers, when viewed through a process control lens, are symptoms of an unstable process. Moreover, and excitingly, control processes fall into fourfold structuration, because control processes fall into one of four states: 1) the ideal, 2) the threshold, 3) the brink of chaos and 4) the state of chaos (Figure 19) (Berardinelli, n.d.).

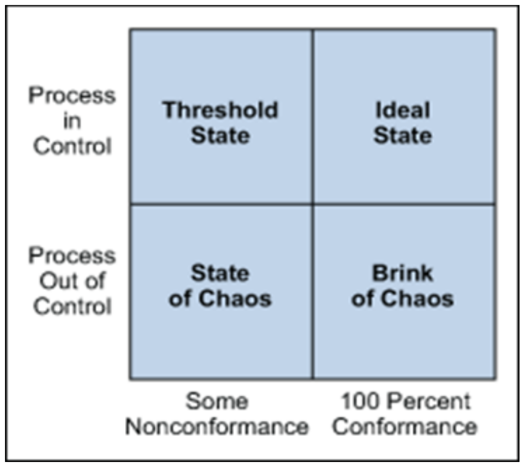

Figure 19. Four process states.

7.1.3.3 Variation is inherent in a process. Stable and in-control processes display common cause variation or variation that is inherent to the process. Based on past experiences, an in-control process and how the process varies can be predicted within limits. However, if the process is unstable, special cause variation or non-random variation from external factors is displayed by the process (Berardinelli, n.d.). Sections 7.1.4.1 Special cause variation and 7.1.4.2 Common cause variation provide further detail on the two types of process variation.

7.1.3.3.1 The ideal state. When a process operates in the *ideal state*, that process is in statistical control and produces 100% conformance. This process has proven stability and target performance over time; it is predictable and its output meets customer expectations (Berardinelli, n.d.). With regard to the fourfold structuration used to frame the construction cosmos, the ideal state is the north direction or visible visibility. Previous experience and/or the intuition of workers and office personnel are integrated and work to consistently meet customer expectations. The focused attention on utilizing knowledge surfaces as intentional and deliberate effort to meet customer expectations. This effort is perceived by the customer as a company with integrity because the customer can rely on the company to provide a consistent product.

7.1.3.3.2 The threshold state. A process that is in the *threshold state* is characterized by being in statistical control but still producing the occasional nonconformance. This type of process will produce a constant level of non-conformances and exhibits low capability. Although predictable, this process does not consistently meet customer needs (Berardinelli, n.d.). With regard to the fourfold structuration used to frame the construction cosmos, the threshold state is the east direction or visible invisibility. For example, there is the need to bridge the gap regarding health practices between academia and the construction industry. So the gap and the need to fill the gap are both visible or known. Yet, at the present moment the best actions to take to build the bridge are unknown or invisible. Or, with regard to a construction project, it cannot be certain as to what will cause a non-conformance. Regardless, a visible non-conformance will be found, even if the cause of the non-conformance is not available to the observer/company. Finding the cause of the non-conformance may be a reflection of the need for increased focused attention to work practices, and thus, be indicative of the integrity by which the company executes its efforts.

7.1.3.3.3 The brink of chaos state. The *brink of chaos state* reflects a process that is not in statistical control, but also is not producing defects. In other words, the process is unpredictable, but the outputs of the process still meet customer requirements (Berardinelli, n.d.). The lack of defects leads to a false sense of security, because processes in the brink of chaos state can produce non-conformances at any moment. It is only a matter of time. With regard to the fourfold structuration used to frame the construction cosmos, the west or invisible visibility relates to the false sense of security that the lack of defects and the ability to meet customer requirements can give a construction company. The customer receiving a product that meets their requirements is unaware of the behind-the-scenes chaos, because all they see is their final product. The chaotic state is a call to the construction company to give attention to their internal processes. The attention the company gives to determining how quickly unpredictable processes that are not producing defects will start to have signs of minor defects within the production output determines the integrity the company has with regard to ensuring they address known (visible) quality concerns. This state reflects that there are underlying processes happening that have not yet manifested into impacts to company profits. Thus, a system that is off balance but still generating profits is a visible sign that the system is not being provided the proper maintenance. For example, allowing the limited number of skilled trade workers to be exposed to health hazards and then not providing health benefits that would facilitate their own personal care but still expecting the workers to perform optimally when health care is not easily attained can lead to an unpredictable outcome of a worker becoming “suddenly” ill. A sudden illness can impact overall project schedule, budget, and quality, until someone of similar skill can be brought on. Searching for and training a worker of comparable skills brings other costs, financial and otherwise to the project. Hence, the potential for workers to become ill as a result of cumulative exposures to health hazards to the point they are unable to work is unpredictable at this moment. This, then, gives the false sense of (financial) security to a company operating in this fashion.

7.1.3.3.4 The state of chaos. The fourth process state is the *state of chaos*. Here, the process is not in statistical control and produces unpredictable levels of nonconformance (Berardinelli, n.d.). With regard to the fourfold structuration used to frame the construction cosmos, the south or invisible invisibility represents opportunities for improvement. The fact that workers are continuing to be exposed to health hazards that go unseen by the general public and by the workers themselves, as well as the fact that workers may not recognize that the bloody noses they are experiencing like in one of the experiences of a trade worker interviewed for this research are a result of their exposure to a health hazard, keeps the exposure "invisible." Additionally, exposing workers knowingly or unknowingly to health hazards calls attention to the need for greater scrutiny of the impact of exposing our fellow human beings to conditions that harm them. Knowingly exposing workers speaks volumes regarding the integrity of those responsible for the workers, and yet does not dismiss the personal responsibility of a worker to do his/her part to protect him/herself. Intuitively one can assume that working within, for example, a cloud of dust every day is not good for one's health, but when faced with financial obligations and responsibilities of their own, workers may not speak up for fear of reprisal. Moreover, the circumstances under which a worker operates, such as the culture and/or limited or non-existent opportunities to communicate their concerns, may be a limiting factor and explanation for why a worker accepts less-than-optimal health conditions. Overall, these unknown unknowns are opportunities for discovery and improvement.

7.1.3.4 All processes migrate toward chaos. All processes fall into one of these states at any given time but do not remain in that state. All processes migrate toward the state of chaos, yet when a company would have been better served by initiating an improvement plan/effort, such as at the brink of chaos or threshold state, this chance is missed because they are focused on traditional ways of doing business and efforts that thwarted failures to recognize the signs and symptoms of natural process degradation (Figure 20) (Berardinelli, n.d.). Thus, the conceptual model presented within this research and the identified barriers and catalysts to the implementation of health practices within the construction industry are providing a framework for translating long-standing health concerns and outcomes into quality control/process control language and concepts that can begin to move health concerns out of the south (invisible invisibility) position of this framework into the east (visible invisibility), the place of new beginnings.

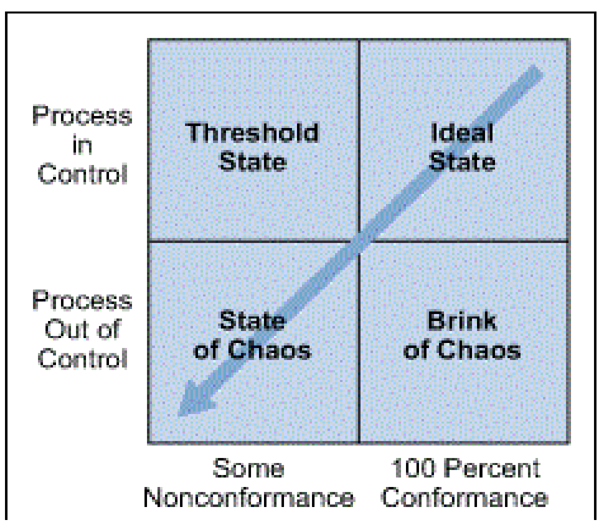

Figure 20. Natural process degradation.

7.1.4 Long-Standing Health Concerns in Construction and Process Control

There are two major sources of variation within processes. Leigh (2011) states a large part of the challenge of controlling exposures to cumulative health hazards is the variability of project environments, and hence, variability in exposures, as well as the variability in worker attitudes toward the use of control measures, such as personal protective equipment.

7.1.4.1 Special cause variation. In manufacturing or service environments, which are variable by nature, because the same outcomes do not always result, this first type of variation is known as special cause variation (BPI, 2016). It is known as special cause variation because the variation is caused by circumstances not normal or usual to the process. With special cause variations, because employees are closest to the process, they have the responsibility for finding and removing (if possible) the special causes of the process variation. Therefore, in order to ensure a process remains in control, employee/worker training is vital. For without proper training and education about a process, employees/workers cannot be empowered to address special cause variation and prevent losses.

7.1.4.2 Common cause variation. The second cause of variation is common cause variation. Common cause variation is variation inherent in the process as a result of how it was designed and is managed. Only by fundamentally changing the process can common cause variation be reduced. Moreover, because common cause variation is always present within a process, it is usually management's responsibility to address it (BPI, 2016). Therefore, in order to ensure a process remains in control, owner education/engagement is vital. For without owner engagement in its business processes, common cause variation cannot be addressed and preventable losses mitigated or removed.

In manufacturing, processes are “in control” if none of the eight rules of statistical control are violated (BPI, 2016). Table 17 lists the eight control chart rules indicating if there are patterns or special causes of variation present. Pictorial representations of the control chart rules follow (Figures 21–23).

Table 17

Control Chart Rules

Rule	Rule Name	Pattern
1	Beyond Limits	One or more points beyond the control limits
2	Zone A	2 out of 3 consecutive points in Zone A or beyond
3	Zone B	4 out of 5 consecutive points in Zone B or beyond
4	Zone C	7 or more consecutive points on one side of the average (in Zone C or beyond)
5	Trend	7 consecutive points trending up or trending down
6	Mixture	8 consecutive points with no points in Zone C
7	Stratification	15 consecutive points in Zone C
8	Over-control	14 consecutive points alternating up and down

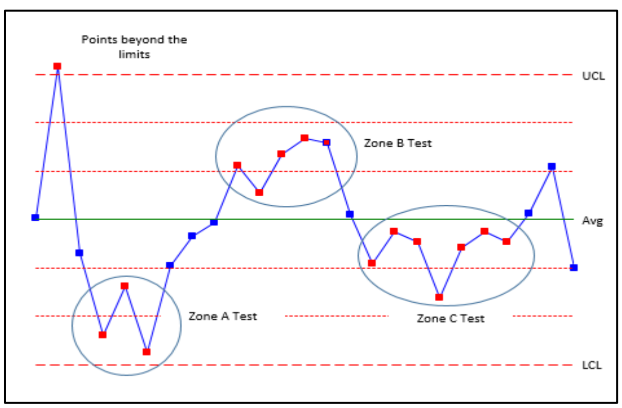

Figure 21. Control chart rules 1 to 4.

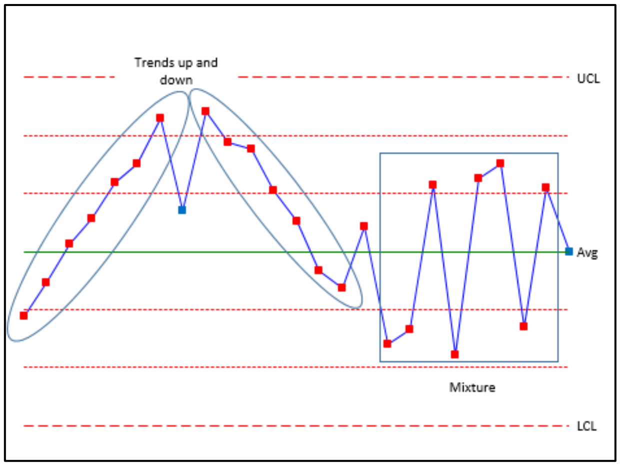

Figure 22. Control chart rules 5 to 6.

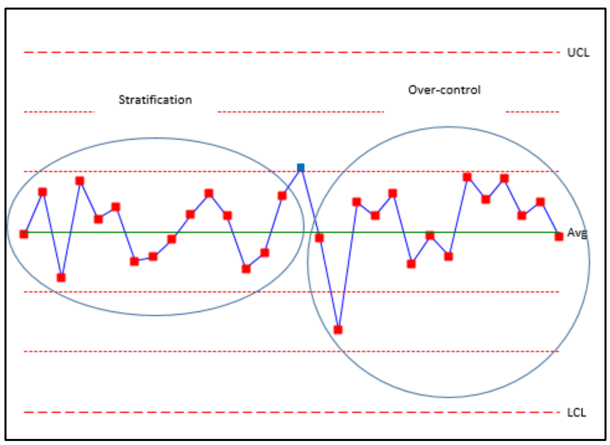

Figure 23. Control chart rules 7 to 8.

7.1.5 Qualitative Codes as Links to Process Rules and Possible Causes of Variation

Because qualitative data is not quantitative in nature, the control chart rules in Table 17 cannot be used directly to analyze the axial codes developed. The researcher chooses the axial codes rather than the selective codes as the level of coding to link to the process rules and possible causes of variation because the axial code level contains more descriptive details of the data than the broader view of the selective codes. For example, in the conceptual model, the selective code of attention summarizes the axial codes that represented the long-standing health issues of concern and their outcomes because of the lack of focused attention to them. The level of the axial code, because it contains additional descriptive data, facilitates the association of that level of qualitative coding to either possible common cause or potential special cause variations that would be more difficult to determine at the selective code level.

Table 18 lists the possible causes of special cause variations by pattern description used to analyze the axial codes and provides guidance for finding the possible reasons for the special causes by pattern type.

Table 18

Possible Causes of Out-of-Control Processes by Pattern Description (BPI, 2016)

Pattern Description	**Rules**	**Possible Causes**
Large shifts from the average	1, 2	New person doing the job Wrong setup; Measurement error Process step skipped Process step not completed Power failure Equipment breakdown
Small shifts from the average	3, 4	Raw material change; Change in work instruction Different measurement device/calibration Different shift Person gains greater skills in doing the job Change in maintenance program Change in setup procedure
Trends	5	Tooling wear Temperature effects (cooling, heating)
Mixtures	6	More than one process present (e.g. shifts, machines)
Stratifications	7	More than one process present (e.g. shifts, machines)
Over-control	8	Tampering by operator Alternating raw materials

7.1.5.1 **Translating process and productivity language into process wastes/costs.** Lean concepts identify eight classic sources of process waste (Figure 24). Lean concepts define waste as activities that do not add value in the transformation of raw materials and/or information into products or services that a customer or destination stakeholder is willing to pay for. Therefore, waste is anything that does not add value by consuming time, space, or other resources. Research by Zhao and Chua (2004) from the Department of Civil Engineering at National University of Singapore on construction activities and the relationship between productivity and non-value adding activities identified the average monthly man-hours lost as a result of waste due to rework, waiting, and idling (waste of intellect) (Table 19 and 19a). Hence, the eight classic sources of waste are a framework for identifying potential sources of opportunity costs (i.e., wastes from processes).

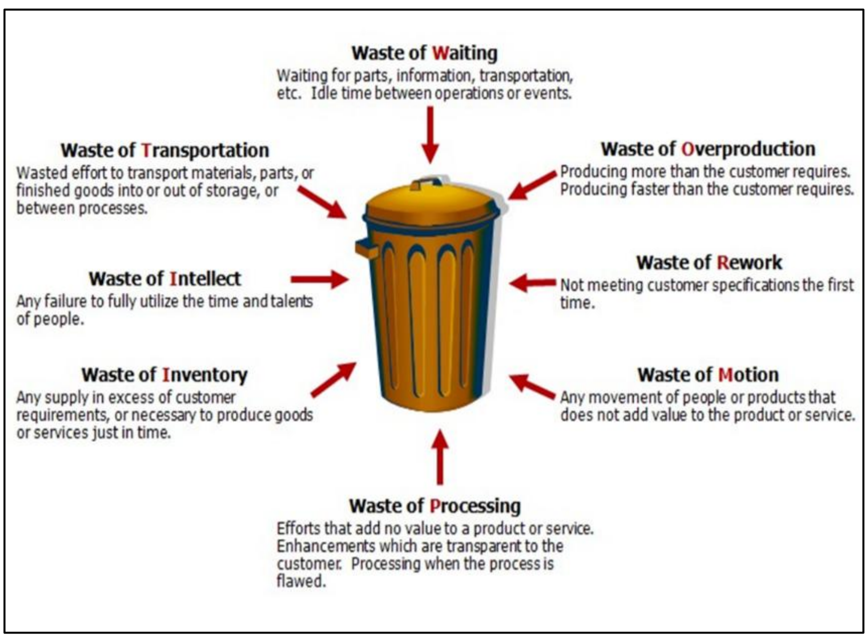

Figure 24. Eight classic sources of process waste (Galloway, 2014).

Table 19

Waste Sources on Site

Category of Waste	**Waste Sources**	**Average Monthly Man-Hours Lost (man-hour)**
Rework due to	Design Error	20.6
	Design Change	16.2
	Design Omission	6.4
	Field Error	15.6
Waiting due to	Wet Days	23.9
	Material Vendor Delay	16.4
	Underestimate to the Work	13.6
	Stock Problem	5.6
	Equipment Used by Other Crew	52.3
	Equipment was Spoiled	21.7
	Equipment Installation and Transportation	20.2
	Tools not Suitable	41.4
	Tools were Spoiled	22.2
	Instructions	6.5
	Inspections	31.8
	Drawing’s Reading	14.0
	Crews Interference	14.4

(continued)

Category of Waste	Waste Sources	Average Monthly Man-Hours Lost (man-hour)
	Congestion of the Site	18.3
	Lighting Problem	9.7
Idling due To	Worker No Enthusiasm	8.7

Note. Adapted from Zhao and Chua (2004)

An axial code is translatable into a process/possible cause variation and into process wastes by analyzing the code and associating it with a possible cause that is then associated with a process waste. For this discussion, the potential man-hour loss/opportunity cost of the process waste as determined from research by Zhao and Chua (2004) on construction activities and the relationship between productivity and non-value adding activities is used to associate qualitative data to quantitative costs for an assigned process waste. Table 20 shows examples of the process for associating an axial code to a statistical process rule/possible special cause process variation to a process waste and finally to a potential opportunity cost.

Table 20

Examples of Translating an Axial Code to a Process Rule/Possible Cause and Finally a Waste/Opportunity Cost

Axial Code	**Process Rules & Possible Causes**		**Process Waste**	**Potential Man-Hour Loss/Opportunity Cost**
Worker Skills Gap	3, 4	Person gains greater skills in doing the job	Intellect/Idling	8.7
Worker Skills Gap	8	Tampering by operator	Rework due to Field Error	15.6
Macho Mindsets	1, 2	Large shifts from the average	Rework due to Field Error	15.6
Macho Mindsets	6, 7	More than one process present (e.g., shifts, machines, raw materials)	Waiting due to Crews Interference	14.4
Sickness Lag-time	1, 2	Large shifts from the average	Idling: No Worker Enthusiasm	8.7
Sickness Lag-time	3, 4	Small shifts from the average	Rework due to Field Error	15.6

As previously stated, the eight classic sources of waste are a framework for identifying potential sources of opportunity costs. This framework provides a springboard for bringing into focus how long-standing health concerns are impacting productivity and hence profitability. For simply because long-standing health concerns have been argued as too difficult and abstract to quantify does not mean that the impacts to profitability are not happening. Or, analogously, because we don't feel the earth rotating, it doesn't mean that it isn't. And, the rotation is impacting our tides and even our own relationship to the earth with regard to gravity and other natural phenomena. Therefore, similarly within the construction cosmos, because events happening within that universe are not yet quantified or considered quantifiable by the industry does not mean those events are not having impacts to the system. Moreover, the further from a state of balance the construction system reaches, the greater the effort required to get it back to an equilibrium.

7.1.5.2 Productivity issues with different labor markets. The following are thoughts provided by my committee member, Dr. Oswald Chong, regarding the relevance of the above thought experiment to the United States' construction labor market. These comments reflect how geographic and demographic worker considerations impact potential productivity cost outputs. The comments are based on the article "Construction Delays in Hong Kong Civil Engineering Projects" by Lo, T.Y., Fung, I.W., Tung, K.C. (2006) regarding Hong Kong productivity:

The above thought experiment uses data from the Singapore construction industry, which relies entirely on foreign laborers. The Singapore construction industry relies entirely on foreign laborers because locals are not willing to become construction laborers. These laborers mostly work through work permits, because they do not plan to stay permanently. To qualify for permanent immigration status the workers are required to earn a technical qualification or diploma to certify their skills at one of the local technical schools. These issues seem analogous to the behavior toward worker training by open-shop operations and the apprenticeship training programs offered by union shops. Moreover, similar to how language is a barrier to safety and health practices at construction sites in the United States, a main barrier to most foreign laborers obtaining permanent immigration status in Singapore is that most are not fluent in one of the four official languages in Singapore—English, Mandarin, Malay and Tamil.

Dr. Chong further states that there is a significant difference between Hong Kong labor productivity/safety standards and the productivity/safety standards in Singapore. Singapore laws affecting the workforce's long-term health are not enforced by the contractors. Health regulations are not enforced in Singapore for similar reasons reported in this research for the United States construction industry. The main reason in Singapore, like the United States, is the heavy penalties contractors face regarding immediate injuries that they presently do not face over health. The fact that Hong Kong laborers consist of local and immigrant workers from China and India, who are not required to obtain technical qualifications before immigrating, raises Hong Kong's productivity and application of safety regulations above Singapore's. Hong Kong's productivity and application of safety regulations is higher than Singapore's because, the pool of workers in Hong Kong, as a result of being local or immigrants looking to stay, are familiar with the expected behaviors regarding productivity and safety. Singapore laborers' productivity is extremely low because the rapid turnover between trained and fresh workers hampers overall productivity and the application of safety regulations.

Thus, the level of impact to profitability with regard to worker behaviors and attitudes is positively or negatively affected depending upon the level of worker skills training and the expectations set upon the workforce by their leaders with regard to the importance of safety over health. Safety concerns take precedence because they are immediately apparent (e.g., a broken leg as opposed to health issues or lung cancer, which often has a potentially long lag-time before the on-set of symptoms).

Therefore, the changes in productivity levels, depending upon geographic and demographic worker considerations, will either increase or decrease the expected productivity losses of the thought experiment.

7.1.6 Key Qualitative Findings and the Research Question

The research question(s) of, "what role does worker health play within the construction industry? What is the general perception of construction trade workers regarding health practices and profitability within the construction industry? What are identifiable and quantifiable practices, barriers to, and catalysts for the improvement of worker health and health climate within construction for the long-standing health concerns of welding fumes, crystalline silica, noise, and musculoskeletal disorders?" are addressed by the emerged model by organizing the relationships among the practices, barriers to, and catalysts for improving the health of workers and overall health climate within the construction industry. The model demonstrates that prioritizing worker health and safety does not sacrifice profitability but rather can provide opportunities for companies to increase profitability. The model, via its four communication quadrants, demonstrates that profitability is directly tied to the aspects of attention, intention, integrity, and intuition, and that the necessary tools for improving health practices and climate within construction already exist in the hands of employers through the choices made regarding worker health. The challenge is overcoming the perception that long-standing health concerns are non-quantifiable or deemed "too expensive" without a verifiable cost analysis. This research provides a process employers can use to quantify long-standing health concerns and demonstrates there is untapped potential for growing profits while enhancing the health practices and climate within the construction industry.

7.1.6.1 Employers say health is too expensive to address. Employers have stated that the costs associated with addressing long-standing health concerns are a drain on their profitability and, thus, a main reason for not focusing more active attention on the concerns. However, by shifting their mindsets to view the cumulative exposures of workers to health hazards as natural process degradations, then the costs associated with addressing health and safety concerns can be viewed similarly to a line-item budgeting for the maintenance and operation of an important business component. Though human beings/workers are not commodities, via the perspective of natural process degradation, the health costs the construction industry needs to account as a result of decreased health due to cumulative hazard exposures and natural decreases in productivity due to aging (i.e., system inefficiencies) can be taken out of an abstract space and made more tangible for businesses. The health concerns and needs of workers are made more tangible by likening them to operation and maintenance costs for equipment and replacement that can be planned and budgeted for via accounting line items.

7.1.6.2 Understanding the link between healthy workers and the potential to increase profits.

Ultimately, it is not short-term profitability concerns that prevent the implementation of health practices but the need for increasing the understanding within the construction industry of how worker health is directly tied to productivity and profitability in overall business processes. Worker health is a main process that needs to be maintained as would any other process requiring quality control. By increasing the understanding of construction as a system with multiple components resting upon the foundation of profits—generated by workers, who are the assets most closely tied to the production of profits—then the disregard for any one worker's health can begin to be understood as equivalent to throwing a monkey wrench into a system of moving cogs and expecting nothing to happen. Maybe once or twice, luck may have the wrench fall and not get caught. However, the signs of the imbalance in this way of doing business are catching up with the industry. They are manifesting as the decreasing number of available skilled workers and utilization of unethical practices for documenting workers as a means to save profits cannot continue to be sustained without major system correction. What that will look like, remains to be seen.

7.2 Quantitative Research Method: Dynamics of the Impacts of Identified Practices, Barriers, and Catalysts on the Construction Industry

The motivation for this research is to address long-standing health concerns of construction trade workers. A way to address the long-standing health concerns and come full circle around the four quadrants is to begin shifting attention to health concerns from a linear perspective into a more dynamic and comprehensive approach. This dynamic and comprehensive approach can transcend the silos and, like the levels in the qualitative model depicting the workers, management, owners, stakeholders, and general public, these levels are not represented by closed circles (silos) but open/labyrinth-type paths that allow flow from one level to the next (fourfold thinking/structuration). This open-type thinking and vision with regard to a dynamic and comprehensive approach to cumulative health hazards is an opportunity to create lasting change.

7.2.1 Value of the Comprehensive List

The quantitative question of "what are identifiable and quantifiable practices, barriers to, and catalysts for the improvement of worker health and health climate within construction for the long-standing health concerns of welding fumes, crystalline silica, noise, and musculoskeletal disorders?" is answered by the comprehensive list of practices, barriers, and catalysts identified through this research. The value of the comprehensive list is that with this knowledge scientists and design and construction practitioners can tackle exposure from early project planning and potentially involve occupational health and safety experts from the start. The comprehensive list in Appendix O is the foundation for the results of the second and third Delphi method survey rounds. The results of the second and third rounds are based on the final comprehensive list of practices identified in round one of the Delphi method surveys. The results have a common theme that engineering and planning practices are regarded as less feasible by occupational health and safety experts. They are less feasible because occupational health and safety experts are traditionally not involved in the early stages of project planning and, therefore, are bound to work solely within the areas of responsibility to which they are assigned. Unfortunately, hazards are already present in those areas by that time. A significant opportunity is illuminated through this research for design and construction professionals. If they are progressive and courageous enough to step beyond traditional silo-thinking from early project planning stages, then effective and intentional actions have the potential to begin to change the state of health practices and climate within the construction industry with regard to long-standing worker health concerns. The present silo structure does not offer the opportunities for change. The opportunities for change are not available in the present structure because occupational health and safety experts are traditionally not involved in the planning and design of a project, and when the health and safety experts are brought in many of those design and planning opportunities to reduce exposures through the practices are already lost. These opportunities become invisible visibilities. Prior to this research, these opportunities were invisible invisibilities or unknown unknowns, but because of this research these opportunities are now known, yet the impact of the application of this finding remains to be seen, and thus, are invisible visibilities. So until the research findings are put into action, they will remain in the place of unknown knowns. There is no way to measure the impact these findings can have on the health of workers or the potential impacts to industry profitability. Until these practices are put into action and focused effort is placed to capture worker health trends in relationship to productivity in the places where the findings are implemented, then there can be no way to see or measure other possibilities. These other possibilities are in the place of visible invisibility. The notion that implementing these present findings is an opportunity for other findings is what illuminates the place of known unknowns. Possibilities can be imagined, but what they look like is not possible from the place the construction industry is at present.

7.2.2 Feasibility Versus Effectiveness of Practices

The graphs of the practices for welding fumes, crystalline silica, noise, and musculoskeletal disorders are in quadrants. The fourfold structuration of each graph relates to Figure 20 of the natural process of degradation for the four process states presented in the qualitative discussion. Natural process degradation of process states relates to the feasibility versus effectiveness of the practices because the practices in the lower left quadrant with low feasibility and low effectiveness can be said to be analogous to practices that are in a state of chaos.

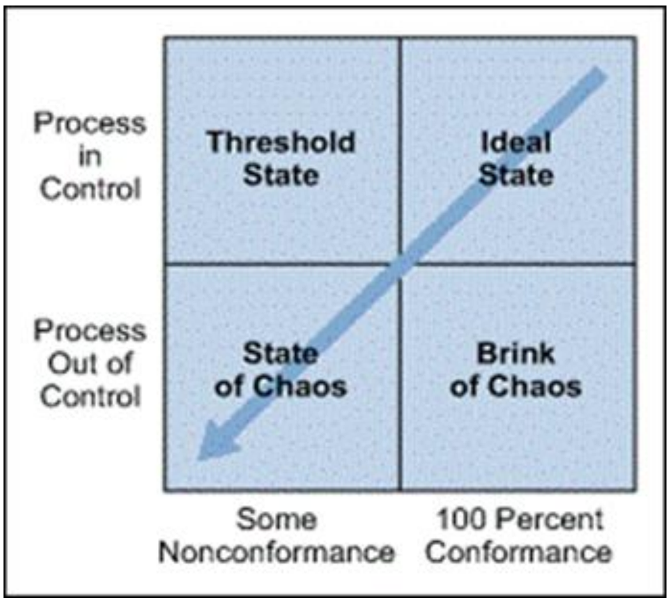

Figure 20. Natural process degradation. (Figure repeated from page 189.)

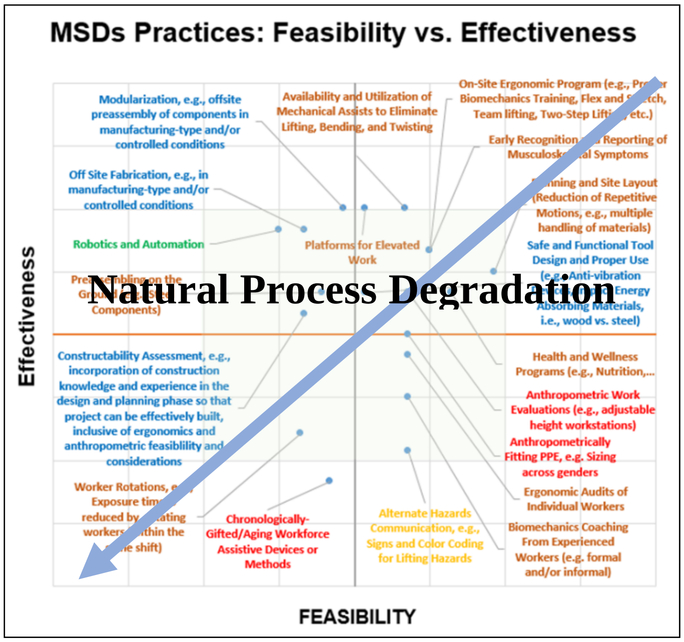

Figure 25. Example of feasibility versus effectiveness for practices.

The practices in this quadrant are not working, and potentially the workers are at their greatest exposure levels with regard to health hazards. This lower quadrant's state of chaos potentially represents processes used to address worker heath that are not in control and conformance or adherence to the processes or practices. Practices performed by the various levels of the industry or company from the worker to the owner that are not understood, executed, or promoted effectively. Practices found in the upper right quadrant are the practices that would be in the ideal state where they are feasible to implement and they are effective with regard to protecting worker health.

7.2.1.1 Common theme throughout the practices. A common theme throughout the feasibility versus effectiveness of practices for the health hazards of welding fumes, crystalline silica, noise, and musculoskeletal disorders is that engineering and planning practices are regarded as less feasible by occupational health and safety experts. Processes are considered in control in the top two quadrants. The top right quadrant is related more to work hygiene techniques, whereas the top left quadrant is related more to design and planning—areas where traditionally occupational health and safety experts do not participate. Interestingly, the top quadrants, in reference to the process state quadrants, are considered to be where processes are "in control." Moreover, the practices in these top two quadrants, in terms of effectiveness, depend more on design and planning than on hygiene. The bottom two quadrants, according to the natural process degradation illustration, is where processes are considered "out of control" to the occupational health and safety experts. These bottom quadrants represent when a project is already in execution. The greatest opportunity for preventing the hazard in the design and planning stages is passed.

7.2.2 Realm of Feasibility for Occupational Health and Safety Experts

Given that at present occupational health and safety experts are not traditionally involved in the design and planning of a project, it is consistent that, based on the feedback from the experts, the results of this research highlight the most feasible practices as those relating to personal protective equipment (PPEs) and administrative controls. The controls of personal protective equipment, such as respirators, goggles, and/or earmuffs, and administrative controls, such as training about a hazard, restricting access to areas in which particular hazard is present, and appropriate signs to identify specific hazards within an area, are implemented in reaction or response to a hazard. In other words the above means that the project is already in execution and the hazards are already present.

7.2.2.1 OSHA hierarchy of controls and feasibility of practices. The OSHA hierarchy of controls in the order of most effective to least effective is elimination, substitution, engineering, administrative, and personal protective equipment. Occupational health and safety experts, based on their responses in the surveys, say the most feasible practices for them are the personal protective and administrative controls. This suggests that the higher and most effective levels of the hierarchy of engineering, substitution, and elimination with regard to protecting worker health are the levels where occupational health and safety experts are not traditionally involved.

7.2.2.2 Shifting from the present state. From the interviews, the comments of "Education regarding health hazards is often overlooked in construction" and "Incentivizing folks to change depends on what intrinsically motivates them" embody the present challenge with regard to addressing long-standing health concerns of construction trade workers. If education regarding health hazards is not prioritized, then it will be difficult to motivate the acceptance of new behaviors like the involvement of occupational health and safety experts during the design and planning stages of a project. As the second comment states, what intrinsically motivates people incentivizes them to change. According to one interviewee, the "Intrinsic motivation of employers is needed to reduce or eliminate worker exposure to health hazards." So change happens when there is motivation, and the motivation commonly heard throughout the interviews from both the craft workers and occupational health and safety experts as the biggest motivator for change is profits. If, as one interviewee stated, "Cost is the main driver of decisions" in the industry, then the motivation for the industry to adopt the involvement of occupational health and safety experts during the design and planning stages of a project could potentially be to demonstrate how adopting this new approach is an opportunity to save on costs.

7.2.4 Frequency and Intensity of Barriers

Natural process degradation does not apply to barriers. For barriers are not processes, but are more generally considered mindsets. Barriers can be considered mindsets because they can represent a perspective from which the implementation of a prevention practice is viewed. If the perspective is that the prevention practice, for example, gets in the way (i.e., a barrier) of the goal of the employer, then the employer may not be agreeable to listening to ideas. The following interview excerpt presents the above in the words of an interviewee:

> First of all, I think that as a country, we're a pretty industrious country, and we're a country where we get in and get the job done. We do whatever it takes to get that job done. I think there's still a lot of that mindset out there, where you've been hired to do a job. As an employer, I want you to do that job, and I don't want to hear about your concerns. I don't want to hear about your complaints, because there are ten people in line behind you wanting this job. If you're not happy here, then I'll get rid of you, and I'll put the next guy in line in your job. I still think that [inaudible 00:37:57]. We've come a long ways, in terms of getting rid of that mindset, but I still think that there's a lot of employers out there who operate that way. "I'm here to make money, and if you complain, you're costing me money. I don't want to take the time to make sure that you've got a safe work environment, because that's going to cost me money.' Which obviously is the wrong way to look at things, because if you ... Yeah. If you create a safe work environment, you're avoiding injuries. You're avoiding illnesses. You're helping employees to be happy and more productive, etc, etc."

The graphic below is of the frequency and intensity of barriers for prevention practices (Figure 17).

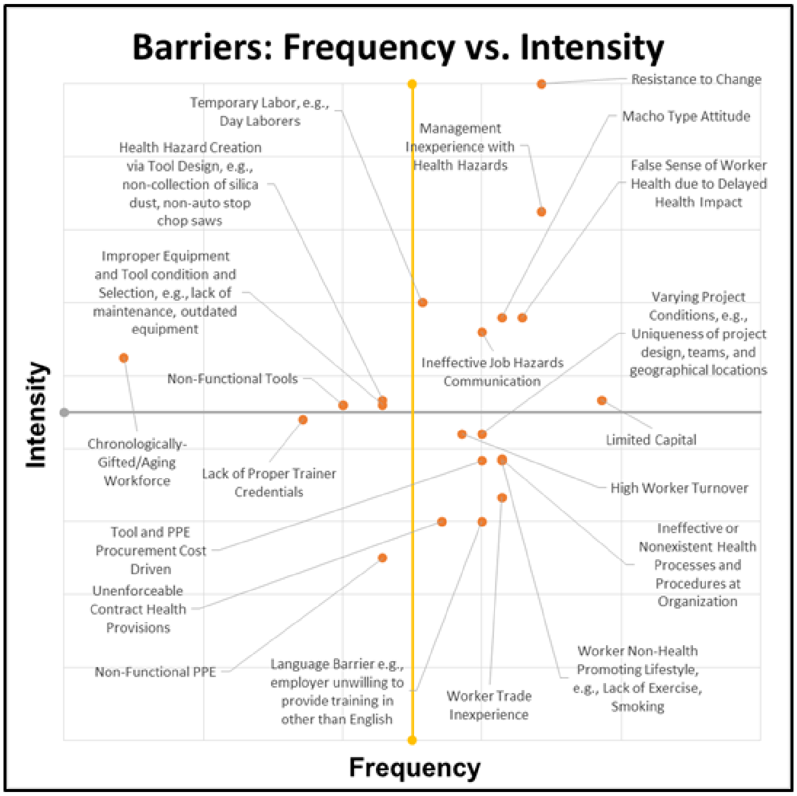

Figure 17. Illustration of the frequency versus intensity of barriers to the implementation of health hazard exposure prevention practices. (Figure repeated from page 174.)

Looking at the graphic of the frequency and intensity of barriers and specifically focusing on the top right quadrant, the most intense barriers that happen most frequently from most intense/frequent to least intense/frequent are 1) resistance to change, 2) management inexperience with health hazards, 3) temporary labor (e.g., day laborers), 4) false sense of worker health due to delayed health impact, 5) macho-type attitude, 6) ineffective job hazards communication, and 7) limited capital.

7.2.4.1 Root causes of the top right quadrant barriers. The illustration of the emerged constructivist grounded theory holds space for all levels of the construction industry from the worker to the general public.

7.2.4.1.1 Resistance to change. The top barrier to the implementation of health practices that applies to all levels of the industry is resistance to change. It applies to all levels because change is challenging for people. Change, according to one interviewee, is more effective if leadership is in charge:

> If I want to have something change within an organization, I don't talk to the safety people, I talk to the executive, the president, the owner, with very good support from the safety team and the management to say, "This is what we're seeing, here's our research, here's our expectations." You're going to hear a very strong theme from me.

Workers are motivated to change, according to another interviewee, by their paychecks:

> Just keep them informed on what we expect and what is required. The best thing I do is, if they do it a couple times then I'll just go up and say, "Grab your tools and go home." Sometimes it'll give them a couple of days and when they start losing money out of their paychecks then they change their attitudes.

7.2.4.1.2 Management inexperience with health hazards. The second barrier of management inexperience with health hazards can relate to the comment presented above about the need for education regarding health within construction. If there is a gap in education with regard to health hazards, then it can be understood as to why there may not be the motivation within the industry to address the hazards. If the overall industry climate is one of lack of knowledge/education, then it supports the idea/barrier that the industry leadership/management has inexperience with regard to the health hazards.

7.2.4.1.3 Temporary labor. Temporary labor (e.g., day laborers) is a barrier on various levels, including worker skills. As stated by an interviewee, “Labor Ready temporary employers create problems with worker skills.” Because day laborers are not affiliated with a union or are not an employee of an open-shop that may provide at least basic health hazard training, they may be ignorant to the connection between exposures to health hazards and the onset of adverse health consequences. This ignorance may then expose them and other workers to health dangers.

7.2.4.1.4 False sense of worker health due to delayed health impacts. False sense of worker health due to delayed health impacts is a main barrier that is difficult to address because as stated by a craft worker during an interview “intermittent exposures to health hazards allow young men to heal giving them a false sense of health.” Combine youth and its ability to heal quickly with the barrier of a macho-type attitude, then these workers are more likely, because of a “false sense of invincibility” and the continual performance of “ unsafe practices w/out injury,” to be a “barrier to the application of education regarding health and safety practices.” This is a barrier because, as one interviewee stated, “Young men do not consider health and safety because of the mentality of invincibility” and “physically endanger workers.” Developing adequate worker health recording procedures can potentially illuminate the number of workers who are impacted by exposures to health hazards. However, developing adequate records for health have similar challenges to that of developing accurate wage rate models as presented in the chapter on The Value of a Statistical Life (VSL). The similar challenges are 1) omitted variable bias or key worker characteristics, such as mixed risk preferences that are left out of commonly used labor data, 2) unseen job characteristics, and 3) endogeneity or the illusion of correlation. Developing adequate records also have the same challenges as the VSL of 1) misreporting, a will-full misrepresentation of the truth; 2) wrong recall, such as survey respondents not remembering particular pieces of information; 3) careless answers; 4) inadequate questions; and 5) interviewer effects, such as from an interviewer explaining instructions for a question differently to each interviewee.

7.2.4.1.5 Ineffective job hazards communication. The barrier of ineffective job hazards communication can point to the need for improved communication on multiple levels of the construction industry. However, the interaction between management and owners is important. One interviewee stated that "There needs to be better communication between the management and owners so that the owners can become more aware of the problems." Another interviewee stated that an awareness challenge with regard to health and safety for the smaller contractor is:

> the 15–20 minutes every morning [to discuss health and safety awareness] adds up to being nonproductive for us, and that hurts us. It comes down to money because we as a subcontractor in our industry, we have to get our jobs done as productive as possible. It makes us take longer to do the projects where subcontractors don't have some of the money that these larger contractors do.

7.2.4.1.6 Limited capital. Where capital may not be a limitation to larger companies, from the above comment, capital can be a limiting factor for the smaller company. It may impact access to or the ability to hire occupational health and safety to participate in the design and planning of projects. Capital limitations for smaller construction companies may be an opportunity for larger construction companies to be leaders in the industry by setting benchmarks for project designs and plans that have the involvement of occupational health and safety experts and can be shared with the smaller companies.

It is interesting to see limited capital as the least intense and least frequent barrier to the implementation of health practices, for limited capital is a reason cited for not investing in health and safety practices. Or, as stated by one interviewee, "Capital availability is a limiting factor for smaller companies to implement known health and safety practices." Though, another comment given by an interviewee supports the lower positioning of limited capital as a barrier and opens a question as to whether limited capital is truly a barrier: "Profits are priority over investing capital into health and safety processes and equipment." This second comment reflects on the intrinsic motivation and what incentivizes people to act in certain ways. Priority is the key word in the last comment because it can be inferred that capital is not limited, but rather health and safety processes and equipment are not viewed as capital investments but potential capital losses instead. Thus, they are not prioritized. Including health and safety experts in the design and planning stages of project development provides an opportunity for the experts to become involved in the ideal state of a process. This is the state where change is most possible and can potentially offer solutions to reduce or eliminate the need to purchase health and safety equipment and, hence, offer opportunities to save capital without risking worker health.

7.2.5 Frequency and Enabling of Catalysts

Natural process degradation does not apply to catalysts, for catalysts are not processes but are more generally considered mindsets. Catalysts can be considered mindsets because they can represent a perspective from which the implementation of a prevention practice is viewed. If the perspective is that the prevention practice supports the employer's goal of, for example, profits, then the employer may be agreeable to listening to ideas.

The graphic below is of the frequency and enabling of catalysts for prevention practices (Figure 18).

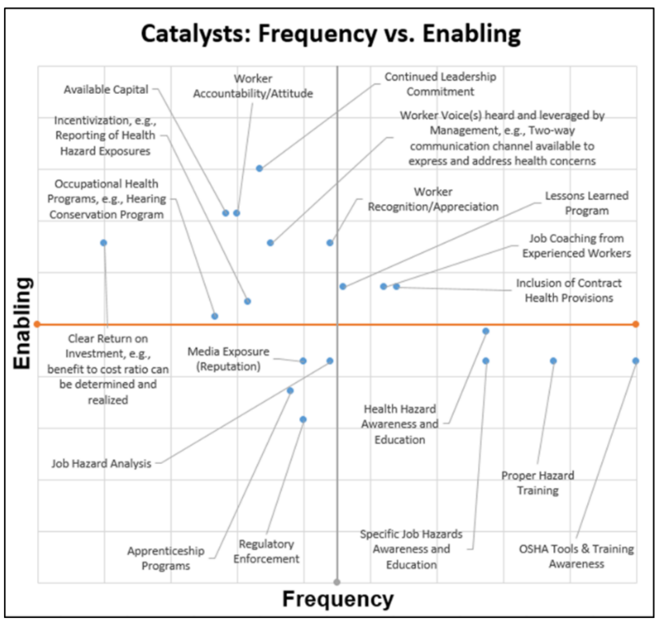

Figure 18. Illustration of the frequency versus enabling of catalysts to the implementation of health hazard exposure prevention practices. (Figure repeated from page 176.)

7.2.5.1 Most frequent and enabling catalysts. Looking at the graphic for the frequency and enabling of catalysts, the most enabling catalysts in order of most frequent and enabling are: 1) inclusion of contract health provisions, 2) job coaching from experienced workers, and 3) lessons learned program. It seems the most enabling catalysts have a low frequency of occurrence. On the other hand, the most enabling in order of most enabling with highest frequency are: 1) continued leadership commitment, 2) worker accountability/attitude, 3) available capital, 4) worker voice(s) heard and leveraged by management (e.g., two-way communication channel available to express and address health concerns), 4) worker recognition/appreciation, 5) incentivization (e.g., reporting of health hazard exposures), 6) occupational health programs (e.g. hearing conservation program), and 7) clear return on investment (e.g., benefit to cost ratio can be determine and realized).

7.2.5.1.1 Catalysts from the perspective of the worker. From the perspective of the worker, common threads within the most frequent and enabling catalysts are respect and the valuing of their work, and leadership commitment is an example of this. The London Olympics clearly demonstrates the committed leadership provided by an occupational health and safety expert because there were zero fatalities throughout the building of the needed infrastructure. It was the continued leadership through its actions and commitment to the workers that ensured the success. The occupational health and safety expert described the success as follows:

> There were a number of things that helped make that [London Olympics] successful. It was respect, communication, ongoing education, the use of color coding, the use of symbols, to make sure everyone was on the same page."

Respect is important and, as craft worker interviewee stated, is something that has reduced on the worksite over the last few decades:

> You have that in all the kids anyway, younger kids. They don't have respect for older people like they did maybe in the '30s and '40s. You've got to have respect for the older guys on the job when they say, "Hey, we're not going up there until they bring the ladders." The young guy is, "I can get up that scaffold." There's no respect for any of the older guys on the job.

7.2.5.1.2 Catalysts from the perspective of the company leadership. A clear return on investments is infrequent and enabling on the lower middle section of the top left quadrant. Available capital is slightly higher on the enabling axis but more frequent when compared to a clear return on investments, whereas occupational health programs are more frequent than returns on investment but less enabling than incentivized reporting of hazards and occupational health programs. The mindset or perspective from which return on capital investments is viewed determines how leadership works with these potential catalysts. The following statement from an occupational health and safety expert interviewee exemplifies the above:

> Hearing loss is quite gradual overtime and so you're putting potentially, a lot of money in some instances into minimizing the noise from an *engineering control standpoint*. The payback, it's going to take years actually and it might not even be realized. It should be, I think in my mind, viewed more as an investment in my workforce as opposed to something that I'm looking for return on my investment.

Engineering control standpoint is italicized because it supports the finding that the design and planning stage where the greatest impacts to reducing or eliminating health hazards is often not where health and safety experts are traditionally involved. An important idea in the above statement is also viewing the financing of programs as investments in the workforce. A healthy workforce can generate greater profits than one that cannot hear or one that is ill.

Leadership is motivated by the potential for profits, and they may hesitate if there is a risk of upsetting their present profits, even with the potential to generate more profits. The following statement from an interviewee describes the above as follows:

> They're looking at their books and if they're making money, they're not interested in making any changes here. It might upset everybody and maybe it'll change my bottom line here. Maybe if I tell these guys, "Hey, you've got to go to some classes or you got to do this or that, other than what they're used to doing." That might change everything. Even with the potential to generate greater profits, they don't want to upset the apple cart in a way. They're lazy probably.

So from this interviewee's perspective the motivation is not solely about profits, but rather what intrinsically motivates the leadership. The comment about laziness is important because it infers that though money/profits are a driver for decisions, ultimately there is an inner human facet at the core of what drives behaviors that resists movement toward greater profits even when the possibility of greater profits is visible.

7.3 The Human Being is the Core of the Fourfold

The human being and his/her inner facets are the core of the fourfold. Though profits may be a main driver of decisions, ultimately what drives decisions to pursue profits above all else is the inner integrity/character of an individual. Though companies and industries are not living beings, because companies and industries reflect the character of its leadership, it is important for all humans within the construction industry at all levels to recognize their contributions to the state of health practices and climate within construction. The present state of the health practices and climate within construction is a summation of all facets illustrated in the emerged conceptual model, and thus, it will take the actions of all levels of the construction industry to manifest or evolve the industry to a higher level of awareness/consciousness with regard to the impact of cumulative health hazards on the most important aspect of the industry, its people. Everyone is impacted when a worker is sick or dies, whether they directly realize it or not.

7.3.1 A Crossroad for the Construction Industry

The state of health practices and climate within construction are at a crossroads. The industry each day and at every moment can decide to stay on the same path that has brought it to its present reality. Or, the industry can choose each day and at every moment to choose a different path. In his book *The War of Art*, Steven Pressfield (2010) describes these choices as either the life lived or the life unlived within all human beings, where the ability to overcome resistance is the factor that determines which path is chosen. Pressfield (2010) states that resistance is the most toxic force on the planet and the "root of more unhappiness than poverty, disease and erectile dysfunction" (p. #). Resistance, according to Pressfield (2010), "stunts us and makes us less than we are and were born to be" (p. #). Each individual has within him/her an inner spirit, which according to Pressfield (2010) is his/her genius or potential.

7.3.2 Resistance Is an Unseen Force

Resistance may be the invisible force that is really keeping the construction industry at all levels from progressing and achieving the NORA strategic goals for the long-standing health concerns of construction trade workers. Resistance to change is the most intense and most frequent barrier identified in this research. It is a negative, repelling force that, though it cannot be seen, can be felt and prevents work from getting done (Pressfield, 2010).

7.3.3 Resistance Originates from Within

Management inexperience with health hazards, false sense of worker health due to delayed health impacts, ineffective job hazards communication, and limited capital exist because at some point in time a choice is made for all the present state of the issue to remain. These choices are made within the human elements that comprise the construction industry. Pressfield (2010) states that “resistance is not a peripheral opponent” (p. 8). Rather “resistance arises from within. It is self-generated and self-perpetuated. Resistance is the enemy within” (p. 8).

7.3.4 Resistance is a Shape-Shifter

A shape-shifter as defined by the Merriam-Webster dictionary (n.d.) is “one that seems able to change form or identity at will; especially: a mythical figure that can assume different forms (as of animals).” Resistance or excuses are an energetic form of a shape-shifter because it/they keep(s) an individual from doing his/her work. Pressfield (2010) states that resistance “will assume any form, if that’s what it takes to deceive you” (p. 10). Resistance, according to Pressfield (2010), “has no conscience” and “understands nothing but power” (p. 10). Statements that ring familiar to how the construction trade workers express profits are placed over their well-being and health.

7.3.5 Resistance Is Relentless and Impersonal

Resistance cannot be reasoned with and has only one objective, which is “to prevent us from doing our work” (Pressfield, 2010, p. 10). According to Pressfield, the nature of resistance is to be “an engine of destruction, programmed from the factory” (p. 10). Resistance doesn’t care who you are, so its attacks aren’t personal. Resistance is merely a force of nature that acts indifferently (Pressfield, 2010).

7.3.6 No More Excuses

Recognizing that resistance is an inevitable force of nature and that it is found within all human endeavors, and by intentionally focusing on addressing this most intense and most frequent barrier, then the construction industry can open the flood gates to opportunities for greater and more lasting change. This change can lead to creative solutions to addressing the four long-standing health concerns of construction trade workers of welding fumes, crystalline silica, noise, and musculoskeletal disorders.

7.4 Overcoming Resistance through Regulations

According to Porter (1995), “properly designed environmental standards can trigger innovations that lower that total cost of a product or improve its value” (p. 1). A common position with regard to health practices within construction is that the implementation of health practices is “too costly.” But, as explored in the previous section, the greatest “cost” may be the work that is left undone. Or, with regard to worker health, the greatest cost is the lives lost because somewhere someone with the authority to influence change or make change allowed his/her internal “enemy within” to deceive or shape-shift into excuses like implementing health practices is “too costly.” When excuses appear as a “peripheral opponent,” this is a way of conciliating or releasing those who can influence or make changes the responsibility of truly focusing attention or taking intentional action to address the long-standing health concerns of construction trade workers. Regulations, because they force companies to adopt changes, when properly designed, can then potentially trigger innovation (Porter, 1995).

7.4.1 Resource productivity

In order to remain competitive companies are constantly innovating to "lower the total cost of a product or improve its value" (Porter, 1995, p. 120). Innovative solutions allow companies to "use a range of inputs more productively – from raw materials to energy to labor – thus offsetting the costs of improving environmental impact and ending the stalemate. Ultimately, this enhanced resource productivity makes companies more competitive, not less" (Porter, 1995, p. 120). With regard to worker health and viewing workers as resources that generate the billable hours that ultimately determine the profitability of a company, enhancing the productivity of workers can make companies more competitive. Investments in health practices can then be seen as analogous to investments in innovation that will make a company more competitive.

7.4.1.1 Static costs. Porter (1995) states that "policy makers, business leaders, and environmentalists have focused on the static cost impacts of environmental regulations and have ignored the more important offsetting productivity benefits from innovation" (p. 121). Porter further states that the result has been that "too often" the actions "unnecessarily drive up costs and slow down progress on environmental issues" (p. 121). The "static mindset," according to Porter, "has thus created a self-fulfilling prophecy leading to ever more costly environmental regulation" (p. 121). When "regulators tend to set regulations in ways that deter innovation…companies, in turn, oppose and delay regulations instead of innovating to address them" (Porter, 1995, p. 121). In regard to worker health, the workers' compensation system, similar to the debate between competitiveness and the environment, because of its incorrect framing, "has spawned an industry of litigators and consultants that drains resources away from real solutions" (Porter, 1995, p. 122).

7.4.1.1.1 Real hidden costs. Environmental pollution, according to Porter (1995), is a form of economic waste. Waste can take the form of scrap, harmful substances, or energy forms discharged into the environment. Pollution signals that "resources have been used incompletely, inefficiently, or ineffectively" (Porter, 1995, p. 122). The hidden costs are then the additional activities that companies have to perform to take of the waste, but "add no value to customers." These hidden costs within the construction industry appear in eight classic forms of waste previously presented: waiting, overproduction, rework, motion, processing, inventory, intellect, and transportation (Galloway, 2014). According to Viscusi and Evans (1990), being injured/ill clearly reduces the level of usefulness of a worker. So the "question of interest" focuses on how the marginal utility of income is affected by an injury/illness, given that it is known that the marginal utility of a given level of income is "greater when healthy than when injured" or ill (Viscusi & Evans, 1990, p. 371). Hence, if healthy workers produce waste that can be translated into productivity losses, then an unhealthy worker, based on the above idea of Viscusi and Evans (1990), will be less "useful" and, hence, generate a lower income for the company when he/she is ill. If one compounds the lower income generated with wastes (productivity losses) that are normally associated with performing the work, but that are potentially greater when the worker is ill, then the hidden (invisible) costs can begin to be seen or visible.

7.4.2 Shifting Mindsets

Regulators and industry are presently in an adversarial climate. This "power struggle," according to Porter (1995), drives up costs and makes the trade-off between meeting environmental standards and innovation steeper. The cost of meeting environmental standards in the present climate is mainly within the regulatory struggle and not for improving the environment (Porter, 1995). Static thinking by regulators and their present all-or-nothing mindset with regard to regulation compliance and structure, as well as the static thinking by industry that views regulations as barriers to profitability as opposed to opportunities for innovation or improving resource productivity, prevent both from achieving their interest (Porter, 1995).

7.4.2.1 Actual costs versus estimated costs. Porter (1995) presents several industry examples of how regulations, such as those in 1991 requiring substantial reductions in benzene emissions, resulted in lower-than-expected costs. Addressing the regulatory requirement resulted in the total removal of the benzene hazard and a savings of $3.3 million dollars a year. In addition to yearly savings, companies often do not account for savings as a result of the learning curve. For as industry becomes more knowledgeable regarding how to address environmental or health issues, then the cost of compliance can decline—as did the costs for controlling sulfur dioxide emissions, which in 1995 were half of the costs of 1990 when a regulation was set in effect (Porter, 1995).

7.4.3 Present Regulatory Challenges

Present regulations, according to Porter (1995), have many areas that discourage innovation. First, by prescribing specific technologies, innovation to develop new solutions is discouraged. Second, present regulations are too lax to promote innovation.

Allowing companies to incrementally achieve strict requirements encourages innovation because there will be no other option but to achieve the requirement. Third, present regulations do not regulate close to the end user. Regulating as close to the end user is practical, encourages upstream solutions, and "allows more flexibility for innovation in the end product and in all the production and distribution stages" (Porter, 1995, p. 124). Fourth, regulations presently "force companies to implement expensive solutions hastily" rather than allow companies to develop "amply, but well-defined phase-in periods tied to industry capital investment cycles that allow the development of innovative resource-saving technologies" (Porter, 1995, p. 124). Fifth, presently there is a need for increased market incentives such as "pollution charges and deposit-refund schemes that draw attention to resource inefficiencies" (p. 124). Drawing attention to resource inefficiencies can encourage innovation and the creative use of technologies. Sixth, narrowly conceived regulations impede the development of new technology. "Harmonizing or converging regulations in associated fields" encourages innovation through consistent regulations. Seventh, present U.S. regulations are not always in synchronization with regulations of other countries. According to Porter (1995) maximizing early mover advantages gives U.S. companies a competitive advantage on the global stage, but it is a balancing act because regulations ahead or behind that of other nations may lead to innovating in the wrong direction. Eighth, standards that change at a more rapid pace than companies can adapt discourages innovation. Set "standards and phase-in periods accepted early enough" allow companies to "lock in and tackle root-cause solutions" rather than worry about changing government philosophies (Porter, 1995, p. 124). Ninth, presently regulators may not understand the technology and economics that drive an industry's competitiveness. According to Porter (1995), "better information exchange will help avoid costly gaming in which ill-informed companies use an array of lawyers and consultants to try to stall the poorly designed regulations of ill-informed regulators" (p. 124). Lastly, tenth, the time and resources presently required for the regulatory process are costly for companies. "Potential and actual litigation creates uncertainty and consumes resources…. Mandatory arbitration procedures or rigid arbitration steps before litigation would lower costs and encourage innovation" (Porter, 1995, p. 124).

7.4.4 New Regulatory Vision

Porter (1995) argues that there is a false assumption that companies will be competitive without a regulatory push. The false assumption about the competitive reality is "that all profitable opportunities for innovation have already been discovered, that managers have perfect information about them, and that organizational incentives are aligned with innovating" (Porter, 1995, p. 127). Regulations that promote innovations that "redesign products, processes, and methods of operation" can provide a new frame of reference for regulations (p. 127). Porter (1995) presents six reasons for why a new regulatory vision is needed. These reasons are as follows:

1) To create pressure motivating companies to innovate. Outside pressure plays an important role in "overcoming organizational inertia and fostering creative thinking."
2) To improve environmental quality in cases where innovation and improvements "do not completely offset the cost of compliance" or "in which it takes time for learning effects to reduce overall cost of innovative solutions."

3) "To alert and educate companies about likely resource inefficiencies and potential areas for technological improvement (although government cannot know better than companies to address them)."

4) "To raise the likelihood that product innovations and process innovations in general will be environmentally friendly."

5) "To create demand for environmental improvement until companies and customers are able to perceive and measure the resource inefficiencies of pollution better."

6) "To level the playing field during the transition period to innovation-based environmental solutions, ensuring that one company cannot gain position by avoiding environmental investments. Regulation provides a buffer for innovative companies until new technologies are proven and the effects of learning can reduce technological costs." (p. 128)

7.4.5 Measuring Accelerates Progress

Porter (1995) states that managers can "accelerate their companies' progress toward a more competitive environment" by first measuring both direct and indirect environmental impacts (p. 131). According to Porter, ignorance prevents companies from innovating. An example Porter (1995) cites is that of an audit of an organic chemical company. The company was exploring waste reduction opportunities in its 40 waste streams. The careful audit uncovered 497 different waste streams, which was wrong by a factor of ten. Porter (1995) states that "the act of measurement alone leads to enormous opportunities to improve productivity" (p. 132).

7.4.5.1 Reaping the greatest benefits. Adopting a resource-productivity framework will allow a company to reap the greatest benefits. First, direct resource inefficiencies will be found at the company level, and therefore, at the plant, one should check for discharged or in the dumpsters. Indirect resource inefficiencies will be found at the levels of the customer, suppliers, and channels. Check for resource inefficiencies in the use of the product, the discarded packaging, and in resources left in the used-up product (Porter, 1995). Second, "Learn to recognize the opportunity cost of underutilized resources" (p. 132). What is the true cost of underutilized resources? What are second-order impacts the waste has on other resources? What is the opportunity cost of the wasted resources or productivity forgone? Regarding worker health, a less-than-optimal health state will result in a less than optimally productive worker (Viscusi & Evans, 1990). Evaluating health practices as discrete projects or stand-alone investments does not provide management the best information and evaluation methods for improving resource (worker) productivity (Porter, 1995). Third, by creating a "bias in favor of innovation-based and productivity enhancing solutions" that allow companies to "trace their own and their customer's discharges, scrap, emissions, and disposal activities back into company activities to gain insight about beneficial product design, packaging, raw material, or process changes", companies can potentially enhance utilization and resource recovery (Porter, 1995, p. 132). With regard to worker health, developing measuring standards relating worker health to project wastes can be a first step for companies to quantify resource costs presently invisible, and potentially greater than perceived.

7.4.6 A New Paradigm

Porter (1995) writes that it is time for "the reality of modern competition to inform our thinking about the relationship between competiveness and the environment" (p. 133). Traditionally, access to the lowest cost inputs, such as capital, labor, energy, and raw materials, provided companies and countries an advantage (Porter, 1995). Today's globalized economy is "making the notion of comparative advantage obsolete" because low cost inputs are available anywhere, and "new rapidly emerging technologies" are offsetting "disadvantages in the cost of inputs" (Porter, 1995, p. 133). It is not enough to simply have resources but, to be competitive, resources must be used productively. Regardless of whether the resource is natural, physical, human, and/or capital, global competition is demanding that companies innovate to raise resource productivity (Porter, 1995). According to Porter (1995), countries/companies that "stick with resource-wasting methods and forgo environmental standards because they are *"too expensive"*" will remain uncompetitive, relegating themselves to poverty (p. 133).

So when faced with regulations, if companies can adopt a mindset of innovation to meet new requirements, then potentially this new mindset can lead to higher productivity for all companies (Porter, 1995).

7.4.7 Worker Health and Regulations

Presently, statistics of the actual numbers of workers impacted by the four long-standing health concerns of welding fumes, crystalline silica, noise, and musculoskeletal disorders are inaccurate to unavailable. The first step companies can take to address these long-standing health concerns is to measure the impact of these health hazards on the worker and then measure the impact of health hazards on the productivity of the worker. However, because organizational inertia or resistance to change, though it may be perceived or excused as an external force, in actuality is an internal decision and may benefit from the push of a mandated regulatory requirement to break through.

7.4.7.1 The fourfold and increased conscious awareness. The fourfold has the path of balance and imbalance. The path of imbalance—south to north—represents the constant balancing act done when walking a path. When we walk, we do not look at our feet. Our feet remain, for the most part, “invisible” as we walk along. However, through our vision, we take in data about our environment that helps us make decisions as to what path we will walk. A study by Berencsia, Ishiharab, and Imanakaa (2005) shows that postural sway amplitudes are larger for the central vision conditions than for the peripheral vision conditions. Hence, reasoning the central south-north axis of the human being is an “imbalanced path.”

The path of balance—east to west—represents the horizon. Looking to the horizon allows sailors to gauge the relative movement of their ship and get their bearings. The horizon provides a reference to the larger external world that would not be possible without it. With regard to the human being, peripheral vision rather than central vision contributes to maintaining a stable standing posture (Berencsia et al., K., 2005). The results of a study by Berencsia et al. (2005) show that peripheral vision has a stabilizing effect in the direction of a stimulus observation (i.e., the head/gaze direction), irrespective of trunk orientation. The two paths cross at the level of the heart or *coeur* (French) or core.

So what do the paths of balance and imbalance have to do with the long-standing health concerns of construction trade workers? Building on the idea that resistance to change is an internal and not external force, then the data known and unknown regarding the long-standing health issues of welding fumes, crystalline silica, noise, and musculoskeletal disorders represent the constant balancing act of incomplete information that is constantly shifting. For, as more knowledge is gained for one aspect, this new knowledge sheds light on areas previously unknown that influence health practices and climate within the construction industry. Like the limitations of our peripheral vision or our blind spots, full and complete knowledge regarding the health issues may never be obtained. However, as our central and peripheral vision work together to stabilize us, we need to use the data we have regarding the long-standing health concerns of construction trade workers to continually strive to find a balance between the costs of innovation and the cost of human life. Ultimately, what is in our core, where the paths of balance and imbalance cross, is what will drive the level of attention given the long-standing health issues. Thus, like resistance, the fourfold is not something external. Rather the fourfold is also something internal to all of us. We unconsciously continually replace old data and integrate new data at every moment of our lives. By bringing this continual internal process to a conscious awareness, the importance and urgency of addressing these concerns is elevated. It is elevated to a level where, when we see “others,” we realize we are seeing ourselves, and thus, when we allow others to be exposed to cumulative health hazards, we are ultimately exposing ourselves—for we are all bound by the overarching fourfold that is the planet or existence in which we live and share.

CHAPTER 8: INTELLECTUAL MERIT

To date, much research has been generated to investigate and document the safety of construction workers, while health issues remain largely uninvestigated. This research via an interdisciplinary approach, at the intersection between engineering, health, and social sciences, cross-pollinates new knowledge among these fields. By qualifying and quantifying the impacts associated with the underlying hesitation of the construction industry to directly address the long-standing health concerns of its workforce, the intellectual merit of this groundbreaking research is the development of a comprehensive list of practices, barriers, and catalysts for the implementation of health measures at construction sites. From this list, what emerges is that the areas where the greatest opportunity to influence worker health are the areas where traditionally occupational health and safety experts are not involved. The mixed methods approach of this research, in addition to identifying and quantifying practices, barriers, and catalysts to the implementation of health measures on construction sites, also presents a conceptual model/practical tool for the construction industry developed from the direct experiences of workers and occupational health and safety experts. The conceptual model provides construction stakeholders the opportunity to tap into their creativity to develop solutions to pressing health concerns that are not possible via a linear and limiting checklist.

Further intellectual merit of this research is the direct contribution to the NORA's strategic Goal 8.0: "Increase understanding of factors that comprise both positive and negative construction safety and health cultures; and, expand the availability and use of effective interventions at the policy, organizational, and individual level to maintain safe work practices 100% of the time in the construction industry" (p. 64). Complementarily, this study directly contributes to NORA's intermediate Goal .8.1 (and several of its specific research goals) in improving the understanding of the factors with a positive and a negative impact on health culture and in providing practices to maintain and improve the health working condition of workers. It contributed to the NORA goals by clarifying and increasing the understanding of the context of the health hazards and presenting context-based descriptions for the developed practice codes. This context would facilitate the understanding of the preventative practice for occupational health and safety professionals who may not commonly work directly with all presented hazards.

CHAPTER 9: BROADER IMPACT

Through its broader impacts, this research promises to influence industries beyond construction, such as agriculture, forestry, fishing, healthcare, manufacturing, mining, warehousing, and utilities, all of which have long-term worker health concerns. Moreover, with the application of ancestral knowledge or indigenous wisdom to frame and develop a conceptual model of the construction industry, this research is an example of how being open to knowledge beyond traditional disciplines can provide seeds of wisdom that if planted and sown within the careful parameters of scientific methodologies can create opportunities for solutions not possible without that stretching of the imagination.

At every stage, this study requires the integration of research, education, and industry in order to lay the foundation for a new paradigm. Therefore, the outcomes of this research can be leveraged with private entities and public agencies alike, so that companies can achieve the NORA health goals established for the construction industry. These broader impacts have the potential to eventually result in healthier employees, better products, and lower out-of-pocket health care expenses. Ultimately, this research can not only possibly help the construction industry's economic goals, but can also possibly help the nation maintain its position as a global economic leader through its part in helping to create a healthier workforce.

CHAPTER 10: CONCLUSIONS AND RECOMMENDATIONS

Fourfold structuration is a millennia old framework for organizing known and unknown data. It has been represented in art to the categorization of process control states. Thus, using fourfold structuration as a way to frame the existing challenges to improving the present state of health practices and climate within construction facilitates making more tangible the seemingly abstract relationship of health to productivity and profits for all levels of the construction industry. Moreover, by building upon process control concepts for managing the impacts varying environmental and project conditions have on health, fourfold structuration is again facilitating the organization of seemingly abstract data and providing a starting point for creating parameters for understanding how worker health status impacts productivity. Similar to how there are different types of control charts that relate various aspects of a process, various types of charts can be developed that relate varying components of health status to productivity and, hence, profitability impacts.

This research has shown that because profits are the main interest of the construction industry, profits can be considered analogous to a millwheel powered by the behaviors, ethics, and leadership within the industry. From the perspective that behaviors, ethics, and leadership are all reflections of inner human facets, it behooves the construction industry and its culture to clearly understand how its productivity and profitability are impacted by cumulative health damage incurred by workers throughout the project delivery process. When the impacts at all levels are understood, then the industry can best determine how to implement preventative safety measures and compensation plans to both save companies money in the short-term and maximize profits in the long-term. Based on the results of this research, implementation has a great opportunity to impact worker health if begun at the design and planning project stages.

Implementing the findings of this research—that the greatest impacts to health practices and climate at construction sites can potentially be at the design and planning stages of a project—can create a new professional paradigm for the construction industry. Education and knowledge with regard to health may become more important to the industry in the same way safety within the construction industry has risen to a level of greater awareness.

The findings of this research show that traditional practices, such as regulatory enforcement and job hazard analysis, are infrequently utilized and that they have a low ability to enable the implementation of health practices. A limiting factor of regulatory enforcement is possibly the sheepishness in their ability to protect workers from retaliation and discrimination when employees voice concerns over health and safety (U.S. Department of Labor, 2010). Additionally, outdated and otherwise limited occupational exposure standards for materials and environments, in conjunction with a slow and resource-intensive regulatory process, make issuing new and severely needed regulations very difficult and time-consuming.

Ironically, worker health is not always prioritized, though it is linked to productivity (i.e., profitability). A company's profitability is determined by the number of worker billable hours. The healthier a worker, the more productive he/she can be. Moreover, the idea that it is either safety or profits already sets the expectation that both cannot be done. A major limiting factor is that the industry has structured itself in a manner that sets up health and profits as an either/or outcome and has entrenched traditional views that limit new and creative opportunities for setting up an "and" outcome with regard to health and profits. A new expectation that sets both safety and profits as the desired intention needs to be established, because where attention is focused determines what will manifest. However, as presented in this research, the intrinsic motivation of an individual/company can be a greater motivator than increased profits, for what lies at the core is what is reflected.

Though traditions, such as organizations like trade unions, provide opportunities to address the challenges faced by the construction industry, within these organizations and others like open shops, the industry needs to get out of its own way. It needs to stop doing the same things and expect different results. The intuition developed from the knowledge and experience of tradition can help bring to light areas of worker health concerns. However, unless the information is used—what is done with the information—knowledge and experience will not have the opportunity to become wisdom, which is knowledge and experience in action. The gap in safety and especially health protocols will continue to exist, with the available knowledge and experience serving no one. Moreover, the gap will continue to cost the industry profits and perpetuate the idea that addressing health concerns is too costly. When in reality, when looked at closely, the costs are most likely for the continual reinvention of solutions for something someone has already solved rather than for costs that address worker health concerns.

The health concerns that have manifested are not something that is happening to the construction industry or to the worker. Rather, the adverse health issues and long-standing health concerns are manifestations resulting from the mindsets of all levels of the industry. This research brings to light that ultimately, it is not short-term profitability concerns that prevent the implementation of health practices, but rather it is the need for increasing the understanding within the construction industry of how worker health is directly tied to productivity and profitability in overall business processes. These processes are influenced by mindsets that come in the form of barriers, and/or catalysts, depending upon the individual or company.

The findings of this research evolved through the integrating of indigenous/ ancestral knowledge, qualitative and quantitative research methods, process control concepts, and productivity improvement concepts and have the potential for endless possibilities for improving the health of construction trade workers everywhere. The hope is that this integrative research has demonstrated that even within a strict scientific methodology there are infinite opportunities for creative solutions. Moreover, the hope is that this research is the fruit that feeds the next researcher who courageously chooses to journey around the medicine wheel.

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APPENDIX A

SUMMARY, KEY PROVISIONS, AND OSHA OCCUPATIONAL EXPOSURE TO RESPIRABLE CRYSTALLINE SILICA FACT SHEET FINAL RULE OVERVIEW

The following is the summary from the 3/25/2016 Federal Register:

Rule by the Occupational Safety and Health Administration for Occupational Exposure to Respirable Crystalline Silica:

The Occupational Safety and Health Administration (OSHA) is amending its existing standards for occupational exposure to respirable crystalline silica. OSHA has determined that employees exposed to respirable crystalline silica at the previous permissible exposure limits face a significant risk of material impairment to their health. The evidence in the record for this rulemaking indicates that workers exposed to respirable crystalline silica are at increased risk of developing silicosis and other non-malignant respiratory diseases, lung cancer, and kidney disease. This final rule establishes a new permissible exposure limit of 50 micrograms of respirable crystalline silica per cubic meter of air (50 μg/m3) as an 8-hour time-weighted average in all industries covered by the rule. It also includes other provisions to protect employees, such as requirements for exposure assessment, methods for controlling exposure, respiratory protection, medical surveillance, hazard communication, and recordkeeping.

OSHA is issuing two separate standards—one for general industry and maritime, and the other for construction—in order to tailor requirements to the circumstances found in these sectors.

Key Provisions

- Reduces the permissible exposure limit (PEL) for respirable crystalline silica to 50 micrograms per cubic meter of air, averaged over an 8-hour shift.
- Requires employers to: use engineering controls (such as water or ventilation) to limit worker exposure to the PEL; provide respirators when engineering controls cannot adequately limit exposure; limit worker access to high exposure areas; develop a written exposure control plan, offer medical exams to highly exposed workers, and train workers on silica risks and how to limit exposures.
- Provides medical exams to monitor highly exposed workers and gives them information about their lung health.
- Provides flexibility to help employers — especially small businesses — protect workers from silica exposure.

Compliance Schedule

Both standards contained in the final rule take effect on June 23, 2016, after which industries have one to five years to comply with most requirements, based on the following schedule:

Construction - June 23, 2017, one year after the effective date.

General Industry and Maritime - June 23, 2018, two years after the effective date.

Hydraulic Fracturing - June 23, 2018, two years after the effective date for all provisions except Engineering Controls, which have a compliance date of June 23, 2021.

OSHA® FactSheet

Workers' Exposure to Respirable Crystalline Silica: Final Rule Overview

More than 2 million workers gain protections from deadly dust

Background

Workplace illness takes the lives of thousands of workers each year. Those workers and their families rely on the U.S. Department of Labor's Occupational Safety and Health Administration to set and enforce standards that reduce the risk to those workers of contracting illnesses or suffering injuries on the job, so that no worker is forced to sacrifice their life or health for their livelihood. Respirable crystalline silica is particularly hazardous for the nation's workers.

Workers who inhale very small crystalline silica particles are at increased risk of developing serious — and often deadly — silica-related diseases. These tiny particles (known as "respirable" particles) can penetrate deep into workers' lungs and cause silicosis, an incurable and sometimes fatal lung disease. Crystalline silica exposure also puts workers at risk for developing lung cancer, other potentially debilitating respiratory diseases such as chronic obstructive pulmonary disease, and kidney disease. Approximately 2.3 million people in the U.S. are exposed to silica at work.

To better protect workers from dangerous crystalline silica, OSHA has finalized two new silica standards: one for general industry and maritime, and the other for construction. These rules are based on extensive review of peer-reviewed scientific evidence, current industry consensus standards, an extensive public outreach effort, and nearly a year of public comment, including several weeks of public hearings. They provide commonsense, affordable and flexible strategies for employers to protect workers in their workplaces from the serious risks posed by silica exposure.

OSHA estimates these standards will save the lives of more than 600 workers each year and prevent more than 900 cases of silicosis each year once the full effects of the rule are realized.

What is crystalline silica?

Crystalline silica is a common mineral that is found in materials that we see every day in roads, buildings, and sidewalks. It is a common component of sand, stone, rock, concrete, brick, block, and mortar.

- Exposures to crystalline silica dust occur in common workplace operations involving cutting, sawing, drilling, and crushing of concrete, brick, block, rock, and stone products (such as construction tasks), and operations using sand products (such as in glass manufacturing, foundries, sand blasting, and hydraulic fracturing).

Why do we need new silica standards?

- We have known about the dangers of silica for decades. More than 80 years ago, U.S. Secretary of Labor Frances Perkins first brought experts and stakeholders together to determine the best ways to protect workers from silica.
- OSHA's current permissible exposure limits for silica are more than 40 years old. They are based on research from the 1960s and earlier that do not reflect more recent scientific evidence.
- Strong evidence shows that the current exposure limits do not adequately protect worker health. For example, since the current exposure limits were adopted, respirable crystalline silica exposure has been found to cause lung cancer and kidney disease at the levels currently permitted.
- Many employers are already implementing the necessary measures to protect their workers from silica exposure. The technology for most employers to meet the new standards is widely available and affordable.

How will the rule protect workers?

- The rule significantly reduces the amount of silica dust that workers can be exposed to on the job. That means that employers will have

to implement controls and work practices that reduce workers' exposure to silica dust. For most activities, that means that employers will have to ensure that silica dust is wetted down or vacuumed up before workers can breathe it in.
- Employers are required under the rule to limit access to high exposure areas, provide training, provide respiratory protection when controls are not enough to limit exposure, provide written exposure control plans, and measure exposures in some cases. Employers are also required to offer medical examinations to highly exposed workers. Workers who find out they have an illness, such as lung disease, can use that information to make employment or lifestyle decisions to protect their health.

How will OSHA help employers comply with the rule to protect their workers?

- The rule provides flexibility to help employers — especially small businesses — protect workers from silica exposure, with staggered compliance dates to ensure sufficient time to meet the requirements. Employers have from one to five years to get the right protections in place.
- The rule includes special flexibility for the construction industry. For the most common tasks in construction, OSHA has spelled out exactly how to best protect workers. If employers follow those specifications, they can be sure that they are providing their workers with the required level of protection. If they have better ideas about how to provide protection, they can do that too — as long as they make sure that their methods effectively reduce their workers' exposure to silica dust.

What industries are affected?

Affected industries include:

- Construction
- Glass manufacturing
- Pottery products
- Structural clay products
- Concrete products
- Foundries
- Dental laboratories
- Paintings and coatings
- Jewelry production
- Refractory products
- Ready-mix concrete
- Cut stone and stone products
- Abrasive blasting in maritime, construction, and general industry
- Refractory furnace installation and repair
- Railroad transportation
- Oil and gas operations

Additional information

Additional information on OSHA's silica rule can be found at www.osha.gov/silica.

OSHA can provide extensive help through a variety of programs, including technical assistance about effective safety and health programs, workplace consultations, and training and education.

OSHA's On-site Consultation Program offers free and confidential occupational safety and health services to small and medium-sized businesses in all states and several territories across the country, with priority given to high-hazard worksites. On-site consultation services are separate from enforcement and do not result in penalties or citations. Consultants from state agencies or universities work with employers to identify workplace hazards, provide advice on compliance with OSHA standards, and assist in establishing and improving safety and health management systems. To locate the OSHA On-site Consultation Program nearest you, call 1-800-321-OSHA (6742) or visit www.osha.gov/dcsp/smallbusiness.

For more information on this and other health-related issues impacting workers, to report an emergency, fatality, inpatient hospitalization, or to file a confidential complaint, contact your nearest OSHA office, visit www.osha.gov, or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For assistance, contact us. We can help. It's confidential.

OSHA® Occupational Safety and Health Administration

www.osha.gov (800) 321-OSHA (6742)

U.S. Department of Labor

DSG FS-3683 03/2016

APPENDIX B

TOTAL OF ALL FIRMS SIZES

Number of Firms, Number of Establishments, Employment, and Annual Payroll by Enterprise Employment Size for the United States, All Industries: 2013

release date: 2/9/2016

SOURCE: 2013 County Business Patterns. For information on confidentiality protection, sampling error, and nonsampling error, see http://www.census.gov/econ/susb/methodology.html.

For definitions, see http://www.census.gov/econ/susb/definitions.html.

NAICS CODE	NAICS DESCRIPTION	ENTERPRISE EMPLOYMENT SIZE	NUMBER OF FIRMS	NUMBER OF ESTABLISHMENTS	EMPLOYMENT	EMPLOYMENT RANGE FLAG	EMPLOYMENT NOISE FLAG	ANNUAL PAYROLL ($1,000)	ANNUAL PAYROLL NOISE FLAG
23	Construction	01: Total	646,433	658,483	5,470,181		G	293,999,490	G
236	Construction of Buildings	01: Total	194,036	196,559	1,120,235		G	61,762,265	G
2361	Residential Building Construction	01: Total	154,357	155,497	557,965		G	25,592,658	G
23611	Residential Building Construction	01: Total	154,357	155,497	557,965		G	25,592,658	G
236115	New Single-Family Housing Construction (except For-Sale Builders)	01: Total	48,017	48,145	158,732		G	6,907,614	G
236116	New Multifamily Housing Construction (except For-Sale Builders)	01: Total	2,675	2,707	27,000		G	1,879,807	G
236117	New Housing For-Sale Builders	01: Total	13,141	13,686	88,721		G	6,002,127	G
236118	Residential Remodelers	01: Total	90,570	90,959	283,512		G	10,803,110	G
2362	Nonresidential Building Construction	01: Total	39,749	41,062	562,270		G	36,169,607	G
23621	Industrial Building Construction	01: Total	2,994	3,180	77,623		G	4,789,251	G
236210	Industrial Building Construction	01: Total	2,994	3,180	77,623		G	4,789,251	G
23622	Commercial and Institutional Building Construction	01: Total	36,797	37,882	484,647		G	31,380,356	G
236220	Commercial and Institutional Building Construction	01: Total	36,797	37,882	484,647		G	31,380,356	G
237	Heavy and Civil Engineering Construction	01: Total	36,500	39,065	876,990		G	57,607,173	G
2371	Utility System Construction	01: Total	17,649	19,155	518,293		G	33,112,106	G
23711	Water and Sewer Line and Related Structures Construction	01: Total	10,919	11,159	148,640		G	8,613,302	G
237110	Water and Sewer Line and Related Structures Construction	01: Total	10,919	11,159	148,640		G	8,613,302	G
23712	Oil and Gas Pipeline and Related Structures Construction	01: Total	1,842	2,093	163,057		G	11,824,107	G
237120	Oil and Gas Pipeline and Related Structures Construction	01: Total	1,842	2,093	163,057		G	11,824,107	G
23713	Power and Communication Line and Related Structures Construction	01: Total	4,946	5,903	206,596		G	12,674,697	G
237130	Power and Communication Line and Related Structures Construction	01: Total	4,946	5,903	206,596		G	12,674,697	G
2372	Land Subdivision	01: Total	5,482	5,551	23,387		G	1,397,655	G
23721	Land Subdivision	01: Total	5,482	5,551	23,387		G	1,397,655	G
237210	Land Subdivision	01: Total	5,482	5,551	23,387		G	1,397,655	G
2373	Highway, Street, and Bridge Construction	01: Total	9,331	10,121	250,457		G	17,511,577	G
23731	Highway, Street, and Bridge Construction	01: Total	9,331	10,121	250,457		G	17,511,577	G
237310	Highway, Street, and Bridge Construction	01: Total	9,331	10,121	250,457		G	17,511,577	G
2379	Other Heavy and Civil Engineering Construction	01: Total	4,135	4,238	84,853		G	5,585,835	G
23799	Other Heavy and Civil Engineering Construction	01: Total	4,135	4,238	84,853		G	5,585,835	G
237990	Other Heavy and Civil Engineering Construction	01: Total	4,135	4,238	84,853		G	5,585,835	G
238	Specialty Trade Contractors	01: Total	416,389	422,859	3,472,956		G	174,630,052	G
2381	Foundation, Structure, and Building Exterior Contractors	01: Total	84,604	85,312	676,419		G	30,650,001	G
23811	Poured Concrete Foundation and Structure Contractors	01: Total	18,613	18,745	173,843		G	8,220,916	G
238110	Poured Concrete Foundation and Structure Contractors	01: Total	18,613	18,745	173,843		G	8,220,916	G
23812	Structural Steel and Precast Concrete Contractors	01: Total	3,237	3,282	59,715		G	3,224,311	G
238120	Structural Steel and Precast Concrete Contractors	01: Total	3,237	3,282	59,715		G	3,224,311	G
23813	Framing Contractors	01: Total	10,115	10,135	61,852		G	2,209,311	G
238130	Framing Contractors	01: Total	10,115	10,135	61,852		G	2,209,311	G
23814	Masonry Contractors	01: Total	17,832	17,928	119,042		G	5,033,837	G
238140	Masonry Contractors	01: Total	17,832	17,928	119,042		G	5,033,837	G
23815	Glass and Glazing Contractors	01: Total	5,328	5,409	45,532		G	2,255,229	G
238150	Glass and Glazing Contractors	01: Total	5,328	5,409	45,532		G	2,255,229	G
23816	Roofing Contractors	01: Total	17,129	17,355	145,487		G	6,421,056	G
238160	Roofing Contractors	01: Total	17,129	17,355	145,487		G	6,421,056	G
23817	Siding Contractors	01: Total	7,241	7,277	28,477		G	1,098,601	G
238170	Siding Contractors	01: Total	7,241	7,277	28,477		G	1,098,601	G
23819	Other Foundation, Structure, and Building Exterior Contractors	01: Total	5,149	5,181	42,471		G	2,186,740	G
238190	Other Foundation, Structure, and Building Exterior Contractors	01: Total	5,149	5,181	42,471		G	2,186,740	G
2382	Building Equipment Contractors	01: Total	166,953	170,887	1,680,178		G	92,472,846	G
23821	Electrical Contractors and Other Wiring Installation Contractors	01: Total	69,012	70,471	709,731		G	39,427,876	G
238210	Electrical Contractors and Other Wiring Installation Contractors	01: Total	69,012	70,471	709,731		G	39,427,876	G
23822	Plumbing, Heating, and Air-Conditioning Contractors	01: Total	92,111	93,508	840,511		G	44,908,299	G
238220	Plumbing, Heating, and Air-Conditioning Contractors	01: Total	92,111	93,508	840,511		G	44,908,299	G
23829	Other Building Equipment Contractors	01: Total	5,923	6,908	129,936		G	8,136,671	G
238290	Other Building Equipment Contractors	01: Total	5,923	6,908	129,936		G	8,136,671	G
2383	Building Finishing Contractors	01: Total	102,025	103,005	634,118		G	26,587,540	G
23831	Drywall and Insulation Contractors	01: Total	16,529	17,053	193,199		G	8,679,555	G
238310	Drywall and Insulation Contractors	01: Total	16,529	17,053	193,199		G	8,679,555	G
23832	Painting and Wall Covering Contractors	01: Total	31,240	31,296	166,035		G	6,527,853	G
238320	Painting and Wall Covering Contractors	01: Total	31,240	31,296	166,035		G	6,527,853	G
23833	Flooring Contractors	01: Total	13,555	13,708	61,796		G	2,561,956	G
238330	Flooring Contractors	01: Total	13,555	13,708	61,796		G	2,561,956	G
23834	Tile and Terrazzo Contractors	01: Total	8,643	8,660	44,400		G	1,786,137	G
238340	Tile and Terrazzo Contractors	01: Total	8,643	8,660	44,400		G	1,786,137	G
23835	Finish Carpentry Contractors	01: Total	25,732	25,851	110,773		G	4,520,527	G
238350	Finish Carpentry Contractors	01: Total	25,732	25,851	110,773		G	4,520,527	G
23839	Other Building Finishing Contractors	01: Total	6,348	6,437	57,915		G	2,511,512	G
238390	Other Building Finishing Contractors	01: Total	6,348	6,437	57,915		G	2,511,512	G
2389	Other Specialty Trade Contractors	01: Total	62,978	63,655	482,241		G	24,919,665	G
23891	Site Preparation Contractors	01: Total	33,541	33,867	285,513		G	15,201,971	G
238910	Site Preparation Contractors	01: Total	33,541	33,867	285,513		G	15,201,971	G
23899	All Other Specialty Trade Contractors	01: Total	29,451	29,788	196,728		G	9,717,694	G
238990	All Other Specialty Trade Contractors	01: Total	29,451	29,788	196,728		G	9,717,694	G
			3,235,731	**3,292,415**				**1,469,997,450**	

APPENDIX C

TOTAL OF FIRMS WITH 500+ EMPLOYEES

Number of Firms, Number of Establishments, Employment, and Annual Payroll by Enterprise Employment Size for the United States, All Industries: 2013 — release date: 2/9/2016

SOURCE: 2013 County Business Patterns. For information on confidentiality protection, sampling error, and nonsampling error, see http://www.census.gov/econ/susb/methodology.html.

For definitions, see http://www.census.gov/econ/susb/definitions.html.

NAICS CODE	NAICS DESCRIPTION	ENTERPRISE EMPLOYMENT SIZE	NUMBER OF FIRMS	NUMBER OF ESTABLISHMENTS	EMPLOYMENT	EMPLOYMENT RANGE FLAG	EMPLOYMENT NOISE FLAG	ANNUAL PAYROLL ($1,000)	ANNUAL PAYROLL NOISE FLAG
23	Construction	09: 500+	954	8,235	943,792		G	63,951,959	G
236	Construction of Buildings	09: 500+	275	1,832	160,491		G	12,557,386	G
2361	Residential Building Construction	09: 500+	96	807	39,919		G	3,345,712	G
23611	Residential Building Construction	09: 500+	96	807	39,919		G	3,345,712	G
236115	New Single-Family Housing Construction (except For-Sale Builders)	09: 500+	33	68	4,863		H	439,760	H
236116	New Multifamily Housing Construction (except For-Sale Builders)	09: 500+	20	28	2,292		G	198,583	G
236117	New Housing For-Sale Builders	09: 500+	39	446	22,053		H	2,152,929	H
236118	Residential Remodelers	09: 500+	18	265	0	J	S	554,440	H
2362	Nonresidential Building Construction	09: 500+	210	1,025	120,572		G	9,211,674	G
23621	Industrial Building Construction	09: 500+	61	198	38,506		G	2,438,279	G
236210	Industrial Building Construction	09: 500+	61	198	38,506		G	2,438,279	G
23622	Commercial and Institutional Building Construction	09: 500+	173	827	82,066		G	6,773,395	G
236220	Commercial and Institutional Building Construction	09: 500+	173	827	82,066		G	6,773,395	G
237	Heavy and Civil Engineering Construction	09: 500+	338	2,219	356,437		G	24,059,126	G
2371	Utility System Construction	09: 500+	205	1,386	241,908		G	16,099,106	G
23711	Water and Sewer Line and Related Structures Construction	09: 500+	58	225	23,578		G	1,513,338	G
237110	Water and Sewer Line and Related Structures Construction	09: 500+	58	225	23,578		G	1,513,338	G
23712	Oil and Gas Pipeline and Related Structures Construction	09: 500+	95	276	97,635		H	6,999,895	G
237120	Oil and Gas Pipeline and Related Structures Construction	09: 500+	95	276	97,635		H	6,999,895	G
23713	Power and Communication Line and Related Structures Construction	09: 500+	98	885	120,695		G	7,585,873	G
237130	Power and Communication Line and Related Structures Construction	09: 500+	98	885	120,695		G	7,585,873	G
2372	Land Subdivision	09: 500+	27	37	932		H	82,395	H
23721	Land Subdivision	09: 500+	27	37	932		H	82,395	H
237210	Land Subdivision	09: 500+	27	37	932		H	82,395	H
2373	Highway, Street, and Bridge Construction	09: 500+	115	680	71,452		G	4,903,849	G
23731	Highway, Street, and Bridge Construction	09: 500+	115	680	71,452		G	4,903,849	G
237310	Highway, Street, and Bridge Construction	09: 500+	115	680	71,452		G	4,903,849	G
2379	Other Heavy and Civil Engineering Construction	09: 500+	55	116	42,145		G	2,973,776	G
23799	Other Heavy and Civil Engineering Construction	09: 500+	55	116	42,145		G	2,973,776	G
237990	Other Heavy and Civil Engineering Construction	09: 500+	55	116	42,145		G	2,973,776	G
238	Specialty Trade Contractors	09: 500+	540	4,184	426,864		G	27,335,447	G
2381	Foundation, Structure, and Building Exterior Contractors	09: 500+	110	345	48,129		G	2,653,099	G
23811	Poured Concrete Foundation and Structure Contractors	09: 500+	36	106	20,063		G	1,082,852	G
238110	Poured Concrete Foundation and Structure Contractors	09: 500+	36	106	20,063		G	1,082,852	G
23812	Structural Steel and Precast Concrete Contractors	09: 500+	25	45	6,310		H	449,877	H
238120	Structural Steel and Precast Concrete Contractors	09: 500+	25	45	6,310		H	449,877	H
23813	Framing Contractors	09: 500+	11	17	3,731		G	117,386	G
238130	Framing Contractors	09: 500+	11	17	3,731		G	117,386	G
23814	Masonry Contractors	09: 500+	19	63	4,142		G	201,161	G
238140	Masonry Contractors	09: 500+	19	63	4,142		G	201,161	G
23815	Glass and Glazing Contractors	09: 500+	5	14	1,282		H	95,142	H
238150	Glass and Glazing Contractors	09: 500+	5	14	1,282		H	95,142	H
23816	Roofing Contractors	09: 500+	10	68	0	I	D	0	D
238160	Roofing Contractors	09: 500+	10	68	0	I	D	0	D
23817	Siding Contractors	09: 500+	5	7	196		G	8,275	G
238170	Siding Contractors	09: 500+	5	7	196		G	8,275	G
23819	Other Foundation, Structure, and Building Exterior Contractors	09: 500+	13	25	3,479		G	273,430	G
238190	Other Foundation, Structure, and Building Exterior Contractors	09: 500+	13	25	3,479		G	273,430	G
2382	Building Equipment Contractors	09: 500+	328	2,815	276,593		G	19,441,640	G
23821	Electrical Contractors and Other Wiring Installation Contractors	09: 500+	178	997	125,869		G	8,815,155	G
238210	Electrical Contractors and Other Wiring Installation Contractors	09: 500+	178	997	125,869		G	8,815,155	G
23822	Plumbing, Heating, and Air-Conditioning Contractors	09: 500+	142	946	98,693		G	6,930,614	G
238220	Plumbing, Heating, and Air-Conditioning Contractors	09: 500+	142	946	98,693		G	6,930,614	G
23829	Other Building Equipment Contractors	09: 500+	56	872	52,031		H	3,695,871	H
238290	Other Building Equipment Contractors	09: 500+	56	872	52,031		H	3,695,871	H
2383	Building Finishing Contractors	09: 500+	74	576	52,246		H	2,388,467	H
23831	Drywall and Insulation Contractors	09: 500+	35	446	30,165		H	1,480,875	H
238310	Drywall and Insulation Contractors	09: 500+	35	446	30,165		H	1,480,875	H
23832	Painting and Wall Covering Contractors	09: 500+	9	12	15,120		H	561,288	H
238320	Painting and Wall Covering Contractors	09: 500+	9	12	15,120		H	561,288	H
23833	Flooring Contractors	09: 500+	4	39	962		H	58,533	H
238330	Flooring Contractors	09: 500+	4	39	962		H	58,533	H
23834	Tile and Terrazzo Contractors	09: 500+	2	2	0	C	D	0	D
238340	Tile and Terrazzo Contractors	09: 500+	2	2	0	C	D	0	D
23835	Finish Carpentry Contractors	09: 500+	18	47	2,720		G	149,418	G
238350	Finish Carpentry Contractors	09: 500+	18	47	2,720		G	149,418	G
23839	Other Building Finishing Contractors	09: 500+	14	30	3,148		G	133,876	H
238390	Other Building Finishing Contractors	09: 500+	14	30	3,148		G	133,876	H
2389	Other Specialty Trade Contractors	09: 500+	101	448	49,896		G	2,852,241	G
23891	Site Preparation Contractors	09: 500+	67	253	21,434		G	1,329,452	G
238910	Site Preparation Contractors	09: 500+	67	253	21,434		G	1,329,452	G
23899	All Other Specialty Trade Contractors	09: 500+	40	195	28,462		G	1,522,789	G
238990	All Other Specialty Trade Contractors	09: 500+	40	195	28,462		G	1,522,789	G
			6,376	**41,175**	**4,690,135**			**318,900,889**	

APPENDIX D

TOTAL OF FIRMS WITH < 10 (I.E., 0-9) EMPLOYEES release date: 2/9/2016

NAICS CODE	NAICS DESCRIPTION	ENTERPRISE EMPLOYMENT SIZE	NUMBER OF FIRMS	NUMBER OF ESTABLISH MENTS	EMPLOYMENT	EMPLOYMENT NOISE FLAG	ANNUAL PAYROLL ($1,000)
23	Construction	02: 0-4	441,872	441,897	687,437	G	27,830,723
23	Construction	03: 5-9	99,633	99,675	651,742	G	26,514,656
236	Construction of Buildings	02: 0-4	146,979	146,989	213,586	G	8,483,052
236	Construction of Buildings	03: 5-9	25,234	25,240	163,019	G	6,674,786
2361	Residential Building Construction	02: 0-4	126,603	126,608	178,651	H	6,616,328
2361	Residential Building Construction	03: 5-9	17,472	17,477	111,255	G	4,149,458
236115	New Single-Family Housing Construction (except For-Sale Builders)	02: 0-4	38,988	38,992	57,245	H	2,257,692
236115	New Single-Family Housing Construction (except For-Sale Builders)	03: 5-9	6,105	6,106	38,855	G	1,475,389
236116	New Multifamily Housing Construction (except For-Sale Builders)	02: 0-4	1,640	1,640	2,562	G	120,408
236116	New Multifamily Housing Construction (except For-Sale Builders)	03: 5-9	399	399	2,621	G	124,150
236117	New Housing For-Sale Builders	02: 0-4	9,797	9,797	15,714	H	685,616
236117	New Housing For-Sale Builders	03: 5-9	1,837	1,840	11,891	G	533,442
236118	Residential Remodelers	02: 0-4	76,178	76,179	103,130	H	3,552,612
236118	Residential Remodelers	03: 5-9	9,132	9,132	57,888	G	2,016,477
2362	Nonresidential Building Construction	02: 0-4	20,377	20,381	34,935	G	1,866,724
2362	Nonresidential Building Construction	03: 5-9	7,762	7,763	51,764	G	2,525,328
23621	Industrial Building Construction	02: 0-4	1,478	1,478	2,448	G	125,651
23621	Industrial Building Construction	03: 5-9	584	584	3,846	G	175,008
236210	Industrial Building Construction	02: 0-4	1,478	1,478	2,448	G	125,651
236210	Industrial Building Construction	03: 5-9	584	584	3,846	G	175,008

23 62 2	Commercial and Institutional Building Construction	02: 0-4	18,899	18,903	32,487	G	1,741,073
23 62 2	Commercial and Institutional Building Construction	03: 5-9	7,178	7,179	47,918	G	2,350,320
23 62 20	Commercial and Institutional Building Construction	02: 0-4	18,899	18,903	32,487	G	1,741,073
23 62 20	Commercial and Institutional Building Construction	03: 5-9	7,178	7,179	47,918	G	2,350,320
23 7	Heavy and Civil Engineering Construction	02: 0-4	19,007	19,011	31,328	G	2,006,705
23 7	Heavy and Civil Engineering Construction	03: 5-9	6,173	6,182	40,996	G	2,196,426
23 71	Utility System Construction	02: 0-4	8,361	8,363	14,926	G	836,617
23 71	Utility System Construction	03: 5-9	3,284	3,287	21,873	G	1,050,125
23 71 1	Water and Sewer Line and Related Structures Construction	02: 0-4	5,711	5,712	10,449	G	505,655
23 71 1	Water and Sewer Line and Related Structures Construction	03: 5-9	2,114	2,115	13,987	G	656,386
23 71 10	Water and Sewer Line and Related Structures Construction	02: 0-4	5,711	5,712	10,449	G	505,655
23 71 10	Water and Sewer Line and Related Structures Construction	03: 5-9	2,114	2,115	13,987	G	656,386
23 71 2	Oil and Gas Pipeline and Related Structures Construction	02: 0-4	563	563	892	G	88,473
23 71 2	Oil and Gas Pipeline and Related Structures Construction	03: 5-9	255	256	1,749	G	102,173
23 71 20	Oil and Gas Pipeline and Related Structures Construction	02: 0-4	563	563	892	G	88,473
23 71 20	Oil and Gas Pipeline and Related Structures Construction	03: 5-9	255	256	1,749	G	102,173
23 71 3	Power and Communication Line and Related Structures Construction	02: 0-4	2,087	2,088	3,585	H	242,489
23 71 3	Power and Communication Line and Related Structures Construction	03: 5-9	916	916	6,137	G	291,566
23 71 30	Power and Communication Line and Related Structures Construction	02: 0-4	2,087	2,088	3,585	H	242,489
23 71 30	Power and Communication Line and Related Structures	03: 5-9	916	916	6,137	G	291,566

	Construction						
23 72	Land Subdivision	02: 0-4	4,350	4,352	6,629	H	338,136
23 72	Land Subdivision	03: 5-9	613	613	3,873	G	197,930
23 73	Highway, Street, and Bridge Construction	02: 0-4	3,959	3,959	6,087	G	608,098
23 73	Highway, Street, and Bridge Construction	03: 5-9	1,565	1,571	10,605	G	723,566
23 73 1	Highway, Street, and Bridge Construction	02: 0-4	3,959	3,959	6,087	G	608,098
23 73 1	Highway, Street, and Bridge Construction	03: 5-9	1,565	1,571	10,605	G	723,566
23 73 10	Highway, Street, and Bridge Construction	02: 0-4	3,959	3,959	6,087	G	608,098
23 73 10	Highway, Street, and Bridge Construction	03: 5-9	1,565	1,571	10,605	G	723,566
23 79	Other Heavy and Civil Engineering Construction	02: 0-4	2,337	2,337	3,686	G	223,854
23 79	Other Heavy and Civil Engineering Construction	03: 5-9	711	711	4,645	G	224,805
23 79 9	Other Heavy and Civil Engineering Construction	02: 0-4	2,337	2,337	3,686	G	223,854
23 79 9	Other Heavy and Civil Engineering Construction	03: 5-9	711	711	4,645	G	224,805
23 79 90	Other Heavy and Civil Engineering Construction	02: 0-4	2,337	2,337	3,686	G	223,854
23 79 90	Other Heavy and Civil Engineering Construction	03: 5-9	711	711	4,645	G	224,805
23 8	Specialty Trade Contractors	02: 0-4	275,887	275,897	442,523	G	17,340,966
23 8	Specialty Trade Contractors	03: 5-9	68,232	68,253	447,727	G	17,643,444
23 81	Foundation, Structure, and Building Exterior Contractors	02: 0-4	55,670	55,671	84,440	G	3,547,715
23 81	Foundation, Structure, and Building Exterior Contractors	03: 5-9	13,809	13,813	90,282	G	3,246,847
23 81 1	Poured Concrete Foundation and Structure Contractors	02: 0-4	11,544	11,544	17,045	G	890,365
23 81 1	Poured Concrete Foundation and Structure Contractors	03: 5-9	3,316	3,316	21,757	G	804,411
23 81 10	Poured Concrete Foundation and Structure Contractors	02: 0-4	11,544	11,544	17,045	G	890,365
23 81 10	Poured Concrete Foundation and Structure Contractors	03: 5-9	3,316	3,316	21,757	G	804,411
23 81 2	Structural Steel and Precast Concrete Contractors	02: 0-4	1,296	1,296	2,113	G	131,378
23 81 2	Structural Steel and Precast Concrete Contractors	03: 5-9	622	622	4,145	G	182,475

23 81 20	Structural Steel and Precast Concrete Contractors	02: 0-4	1,296	1,296	2,113	G	131,378
23 81 20	Structural Steel and Precast Concrete Contractors	03: 5-9	622	622	4,145	G	182,475
23 81 3	Framing Contractors	02: 0-4	7,462	7,462	11,664	G	418,676
23 81 3	Framing Contractors	03: 5-9	1,541	1,541	10,002	G	316,911
23 81 30	Framing Contractors	02: 0-4	7,462	7,462	11,664	G	418,676
23 81 30	Framing Contractors	03: 5-9	1,541	1,541	10,002	G	316,911
23 81 4	Masonry Contractors	02: 0-4	12,585	12,585	18,097	G	737,241
23 81 4	Masonry Contractors	03: 5-9	2,570	2,572	16,761	G	580,641
23 81 40	Masonry Contractors	02: 0-4	12,585	12,585	18,097	G	737,241
23 81 40	Masonry Contractors	03: 5-9	2,570	2,572	16,761	G	580,641
23 81 5	Glass and Glazing Contractors	02: 0-4	2,990	2,990	5,044	G	198,347
23 81 5	Glass and Glazing Contractors	03: 5-9	1,114	1,114	7,289	G	288,746
23 81 6	Roofing Contractors	02: 0-4	10,707	10,708	16,369	G	673,906
23 81 6	Roofing Contractors	03: 5-9	2,892	2,892	18,976	G	672,098
23 81 60	Roofing Contractors	02: 0-4	10,707	10,708	16,369	G	673,906
23 81 60	Roofing Contractors	03: 5-9	2,892	2,892	18,976	G	672,098
23 81 7	Siding Contractors	02: 0-4	5,759	5,759	8,721	H	289,220
23 81 7	Siding Contractors	03: 5-9	867	868	5,591	G	187,804
23 81 70	Siding Contractors	02: 0-4	5,759	5,759	8,721	H	289,220
23 81 70	Siding Contractors	03: 5-9	867	868	5,591	G	187,804
23 81 9	Other Foundation, Structure, and Building Exterior Contractors	02: 0-4	3,327	3,327	5,387	H	208,582
23 81 9	Other Foundation, Structure, and Building Exterior Contractors	03: 5-9	888	888	5,761	G	213,761
23 81 90	Other Foundation, Structure, and Building Exterior Contractors	02: 0-4	3,327	3,327	5,387	H	208,582
23 81 90	Other Foundation, Structure, and Building Exterior Contractors	03: 5-9	888	888	5,761	G	213,761

23 82	Building Equipment Contractors	02: 0-4	103,724	103,725	181,646	G	6,958,984
23 82	Building Equipment Contractors	03: 5-9	30,182	30,186	198,857	G	8,359,122
23 82 1	Electrical Contractors and Other Wiring Installation Contractors	02: 0-4	43,789	43,790	75,705	G	2,915,982
23 82 1	Electrical Contractors and Other Wiring Installation Contractors	03: 5-9	12,075	12,075	79,362	G	3,374,862
23 82 10	Electrical Contractors and Other Wiring Installation Contractors	02: 0-4	43,789	43,790	75,705	G	2,915,982
23 82 10	Electrical Contractors and Other Wiring Installation Contractors	03: 5-9	12,075	12,075	79,362	G	3,374,862
23 82 2	Plumbing, Heating, and Air-Conditioning Contractors	02: 0-4	57,018	57,018	100,768	G	3,805,130
23 82 2	Plumbing, Heating, and Air-Conditioning Contractors	03: 5-9	16,964	16,966	111,721	G	4,608,963
23 82 20	Plumbing, Heating, and Air-Conditioning Contractors	02: 0-4	57,018	57,018	100,768	G	3,805,130
23 82 20	Plumbing, Heating, and Air-Conditioning Contractors	03: 5-9	16,964	16,966	111,721	G	4,608,963
23 82 9	Other Building Equipment Contractors	02: 0-4	2,917	2,917	5,173	H	237,872
23 82 9	Other Building Equipment Contractors	03: 5-9	1,143	1,145	7,774	G	375,297
23 82 90	Other Building Equipment Contractors	02: 0-4	2,917	2,917	5,173	H	237,872
23 82 90	Other Building Equipment Contractors	03: 5-9	1,143	1,145	7,774	G	375,297
23 83	Building Finishing Contractors	02: 0-4	74,379	74,385	113,893	H	3,820,920
23 83	Building Finishing Contractors	03: 5-9	14,244	14,249	93,054	G	3,277,138
23 83 1	Drywall and Insulation Contractors	02: 0-4	10,302	10,304	16,768	H	603,550
23 83 1	Drywall and Insulation Contractors	03: 5-9	2,625	2,627	17,315	G	618,356
23 83 10	Drywall and Insulation Contractors	02: 0-4	10,302	10,304	16,768	H	603,550
23 83 10	Drywall and Insulation Contractors	03: 5-9	2,625	2,627	17,315	G	618,356
23 83 2	Painting and Wall Covering Contractors	02: 0-4	23,633	23,633	35,099	H	1,187,513
23 83 2	Painting and Wall Covering Contractors	03: 5-9	4,188	4,188	27,293	G	902,027

23 83 2	Painting and Wall Covering Contractors	04: 10-19	1,994	1,997	26,304	G	1,009,760
23 83 20	Painting and Wall Covering Contractors	02: 0-4	23,633	23,633	35,099	H	1,187,513
23 83 20	Painting and Wall Covering Contractors	03: 5-9	4,188	4,188	27,293	G	902,027
23 83 3	Flooring Contractors	02: 0-4	10,508	10,509	16,365	H	503,141
23 83 3	Flooring Contractors	03: 5-9	1,682	1,683	10,890	G	379,434
23 83 30	Flooring Contractors	02: 0-4	10,508	10,509	16,365	H	503,141
23 83 30	Flooring Contractors	03: 5-9	1,682	1,683	10,890	G	379,434
23 83 4	Tile and Terrazzo Contractors	02: 0-4	6,351	6,351	9,406	H	300,014
23 83 4	Tile and Terrazzo Contractors	03: 5-9	1,173	1,173	7,744	G	267,088
23 83 40	Tile and Terrazzo Contractors	02: 0-4	6,351	6,351	9,406	H	300,014
23 83 40	Tile and Terrazzo Contractors	03: 5-9	1,173	1,173	7,744	G	267,088
23 83 5	Finish Carpentry Contractors	02: 0-4	19,767	19,767	29,886	H	975,219
23 83 5	Finish Carpentry Contractors	03: 5-9	3,447	3,449	22,401	G	830,029
23 83 50	Finish Carpentry Contractors	02: 0-4	19,767	19,767	29,886	H	975,219
23 83 50	Finish Carpentry Contractors	03: 5-9	3,447	3,449	22,401	G	830,029
23 83 9	Other Building Finishing Contractors	02: 0-4	3,818	3,821	6,369	G	251,483
23 83 9	Other Building Finishing Contractors	03: 5-9	1,129	1,129	7,411	G	280,204
23 83 90	Other Building Finishing Contractors	02: 0-4	3,818	3,821	6,369	G	251,483
23 83 90	Other Building Finishing Contractors	03: 5-9	1,129	1,129	7,411	G	280,204
23 89	Other Specialty Trade Contractors	02: 0-4	42,115	42,116	62,544	G	3,013,347
23 89	Other Specialty Trade Contractors	03: 5-9	9,999	10,005	65,534	G	2,760,337
23 89 1	Site Preparation Contractors	02: 0-4	21,658	21,658	34,224	G	1,521,411
23 89 1	Site Preparation Contractors	03: 5-9	5,486	5,489	36,103	G	1,567,270
23 89 10	Site Preparation Contractors	02: 0-4	21,658	21,658	34,224	G	1,521,411
23 89 10	Site Preparation Contractors	03: 5-9	5,486	5,489	36,103	G	1,567,270
23 89 9	All Other Specialty Trade Contractors	02: 0-4	20,457	20,458	28,320	G	1,491,936

23 89 9	All Other Specialty Trade Contractors	03: 5-9	4,513	4,516	29,431	G	1,193,067
23 89 90	All Other Specialty Trade Contractors	02: 0-4	20,457	20,458	28,320	G	1,491,936
23 89 90	All Other Specialty Trade Contractors	03: 5-9	4,513	4,516	29,431	G	1,193,067
			2,551,459	**2,551,738**	**6,398,956**		**260,411,644**

SOURCE: 2013 County Business Patterns. For information on confidentiality protection, sampling error, and nonsampling error, see http://www.census.gov/econ/susb/methodology.html.
For definitions, see http://www.census.gov/econ/susb/definitions.html.

APPENDIX E

AN OVERVIEW OF EACH TYPE OF POTENTIAL EMPLOYER/EMPLOYEE BUSINESS RELATIONSHIP

<u>An Overview of Each Type of Potential Employer/Employee Business Relationship:</u>

1) <u>Independent Contractors</u>. The general rule is that an individual is an independent contractor if the person for whom the services are performed has the right to control or direct *only* the result of the work and *not* the means and methods of accomplishing the result. Independent trades such as doctors, veterinarians, and auctioneers who offer their services to the public are generally not employees. However, it depends on the circumstance. The four criteria for independent contractor status include:

a. Separate set of books and records

b. Risk of a loss and opportunity for a profit

c. Principal place of business separate from those receiving the services

d. Availability to provide self-employed services to the general public.[52]

2) <u>Common-Law Employees</u>. Under an employer-employee relationship anyone who performs services is generally an employee, regardless the label. What matters is the substance of the relationship, not the label. That the employer has the *right to control* the details of *how* the services are performed is what governs the worker's status, not whether the individual is employed full time or part time. Generally, pay income, social security, and Medicare taxes on wages paid to common-law employees are withheld unless certain tax exemptions apply. Furthermore, for employment tax purposes, no distinction is made between classes of employees, e.g.,

superintendents, managers, and other supervisory personnel. Therefore, under common-law rules, anyone who performs services is generally an employee if the person for whom the services are performed has:

a. The right to control *what* will be done, and

b. *How* it will be done; even when the employee has freedom of action.

Therefore, workers are generally employees if the following 20 rules summarized by the IRS can be applied:

1) Must comply with employer's instructions about the work.
2) Receive training from or at the direction of the employer.
3) Provide services that are integrated into the business.
4) Provide services that must be rendered personally.
5) Hire, supervise, and pay assistants for the employer.
6) Have a continuing working relationship with the employer.
7) Must follow set work hours
8) Work full-time for an employer.
9) Must do their work on the employer's premises.
10) Must do their work in a sequence set by the employer.
11) Must submit regular reports to the employer.
12) Receive payments of regular amounts at set intervals.
13) Receive payments for business and/or travelling expenses.
14) Rely on the employer to furnish tools and material.
15) Lack a major investment in facilities used to perform the service.

16) Cannot make a profit or suffer a loss from the services.

17) Work for one employer at a time.

18) Do not offer their services to the general public.

19) Can be fired by the employer.

20) May quit work anytime without incurring liability.

3) Statutory Employees. If workers are independent contractors under the common law rules, such workers may still be treated as employees by statute for certain employment tax purposes, i.e., "statutory employees". This happens if any one of the following four categories and three conditions described next under Social security and Medicare taxes are met:

a. A driver who distributes beverages (other than milk) or meat, vegetable, fruit, or bakery products; or who picks up and delivers laundry or dry cleaning, and if the driver is an employer's agent or is paid on commission.

b. A full-time life insurance sales agent whose principal business activity is selling life insurance or annuity contracts, or both, primarily for one life insurance company.

c. An individual who works at home on materials or goods that supplied by the employer and that must be returned to the employer or to an appointed person, and if specifications for the work to be done are also provided.

d. A full-time traveling or city salesperson who works on behalf of the employer and turns in orders to the employer from wholesalers, retailers, contractors, or operators of hotels, restaurants, or other similar establishments. The goods sold must be merchandise for resale or supplies for use in the buyer's business operation. The work performed for the employer must be the salesperson's principal business activity. Social security and Medicare taxes from the wages of statutory employees must be withheld if all three of the following conditions apply.

i. The service contract states or implies that substantially all the services are to be performed personally by them.

ii. The statutory employee doesn't have a substantial investment in the equipment and property used to perform the services (other than an investment in facilities for transportation, such as a car or truck).

iii. The services are performed on a continuing basis for the same payer. Federal unemployment (FUTA) tax. For FUTA tax (the unemployment tax paid under the Federal Unemployment Tax Act), the term “employee” means the same as it does for social security and Medicare taxes, except that it doesn't include statutory employees defined in categories 2 and 3, above. Any individual who is a statutory employee described under category 1 or 4, earlier, is also an employee for FUTA tax purposes and subject to FUTA tax.

4) Statutory Nonemployees. There are three categories of statutory nonemployees: direct sellers, licensed real estate agents, and certain companion sitters. Direct sellers and licensed real estate agents are treated as self-employed for all federal tax purposes, including income and employment taxes if:

a. Substantially all payments for services as direct sellers or real estate agents are directly related to sales or other output, rather than to the number of hours worked; and

b. Services are performed under a written contract providing that they won't be treated as employees for federal tax purposes. Direct sellers. Direct sellers include persons falling within any of the following three groups.

   i. Persons engaged in selling (or soliciting the sale of) consumer products in the home or place of business other than in a permanent retail establishment.

   ii. Persons engaged in selling (or soliciting the sale of) consumer products to any buyer on a buy-sell basis, a deposit-commission basis, or any similar basis pre-scribed by regulations, for resale in the home or at a place of business other than in a permanent retail establishment.

   iii. Persons engaged in the trade or business of delivering or distributing newspapers or shopping news (including any services directly related to such delivery or distribution).

APPENDIX F

NORA (2008) STRATEGIC GOALS 8 AND 12

NORA (2008) Strategic Goals 8 and 12

STRATEGIC GOAL 8.0: Increase understanding of factors that comprise both positive and negative construction safety and health cultures; and, expand the availability and use of effective interventions at the policy, organizational, and individual level to maintain safe work practices 100% of the time in the construction industry.

TOPIC: CONSTRUCTION SAFETY AND HEALTH CULTURE

Type of construction work (e.g. residential construction vs. highway construction)

- Management involvement and commitment in safety
- Design for safety
- Leadership
- Foreman and supervisor involvement in safety
- Employee involvement in safety
- Employee characteristics such as union, non-union, or family member
- Trade characteristics or sub-cultures
- Employer characteristics such as prime contractor or subcontractor or size
- Extent and type of safety training provided
- Educational levels

- Ethnic and cultural values of a diverse multinational workforce
- Regional practices
- Owner involvement – both positive and negative
- Safety and health management programs and system components such as use of incentives, discipline, goal setting, accident investigation approaches, communication methods, sharing of findings, etc.

Research Goal 8.1.2: Evaluate how safety and health cultures influence key construction industry subgroups such as:

- New workers
- Young/Older workers
- Apprentices
- Female workers
- Immigrant workers
- Other workers at disproportionate risk of injuries and illnesses

Research Goal 8.1.3: Conduct interviews of best practice construction employers and safety and health professionals to evaluate current practices in regards to construction safety culture and climate and what works for them and why. Collect information that could be used to develop a general baseline regarding the current use of climate surveys and other practices in construction.

Research Goal 8.1.4: Forge new partnerships with construction unions, small and large employers, trade associations, and others to evaluate factors and subgroups identified in RG 8.1.1 and 8.1.2. Attempt to build good relations with employers having a poor safety record to better understand the role of culture in relationship to why these problems exist.

Research Goal 8.1.5: Conduct research on indicators associated with strong safety culture, such as management commitment, policies and procedures, leadership, communication, employee involvement, etc. Examine issues that can help provide diagnostic tools for improving construction safety culture.

Research Goal 8.1.6: Investigate the monetary relationship (e.g. business case) between positive and negative construction health and safety cultures.

Research to Practice Goal 8.1.7: Create a repository of existing and new research on factors and indicators influencing positive and negative safety cultures in construction.

Research to Practice Goal 8.1.8: Disseminate results of this research to the construction industry, workshops, and other communication media to stakeholders, labor unions, and industry associations to raise awareness of construction safety culture issues across the industry.

Intermediate Goal 8.2: Develop and expand the use of validated measurement methods for evaluating safety culture and safety climate in the construction industry.

Performance Measure: Within 7 years, using information gathered on factors contributing to positive or negative construction cultures; develop, validate, and inventory direct and indirect measures of construction culture and encourage their use throughout the industry.

There is a need to develop additional effective construction-relevant methods and toolkits to assess safety culture. Resulting research results can be transformed into products for use by construction stakeholders to validly and reliably measure safety culture.

Research Goal 8.2.1: Survey and inventory the existing literature to determine the available methods that measure safety culture and climate. Evaluate the existing measurement methods to determine the key conceptual elements of the existing measures, identifying similarities between methods, conceptual gaps in the existing measures, and usability of the methods within the expected contexts of use (large and small construction companies, contractors, subcontractors).

Research Goal 8.2.2: Develop a baseline metric against which progress can be measured through longitudinal research.

Research Goal 8.2.3: Develop a multi-method set of cross-validated measures of construction safety and health culture and climate, including simple "toolkit" methods contractors can use in the field to determine the impact of their company culture on safety and health.

Research Goal 8.2.4: Validate measurement methods that consistently identify the positive and negative aspects of construction safety and health culture.

Research Goal 8.2.5: Use partnerships established in RG 8.1.4 to validate and utilize existing and newly developed construction culture measurement methods.

Research Goal 8.2.6: Use validated measurement methods to perform research on the effects of positive and negative safety culture on safety and health outcomes in construction settings.

Research to Practice Goal 8.2.7: Create a repository of existing and newly developed measurement methods for positive and negative safety cultures in construction.

Research to Practice Goal 8.2.8: Disseminate construction culture measurement methods through various workshops and other channels to construction industry associations, labor unions, and government entities.

Intermediate Goal 8.3: Partner with construction stakeholders to develop and disseminate effective intervention measures for improving safety and health culture in the construction industry.

Performance Measure: By 2016, in coordination with IG 8.1 and 8.2, develop, implement, and disseminate three interventions designed to improve construction culture.

There is a need for interventions that can be used to reliably improve construction culture. This will position culture to be more effectively managed to improve safety and health outcomes.

Research Goal 8.3.1: Identify and evaluate interventions for improving construction safety and health cultures. Use partnerships established in RG 8.1.4 to pilot and validate the interventions.

Research Goal 8.3.2: Determine best available avenues to transfer and diffuse effective health and safety culture interventions in the construction industry.

Research Goal 8.3.3: Identify and validate an attainable goal for improvement of construction safety and health culture from the baseline established in IG8.2, RG 8.2.3 - e.g. 20% improvement.

Research to Practice Goal 8.3.4: Develop and implement a strategy to distribute and diffuse information products (across a range of media and channels) about how to measure and improve construction safety culture to construction industry stakeholders.

Strategic Goal 12.0: Reduce injury and illness among groups of construction craft workers through improved understanding of why groups of workers experience disproportionate risks in construction work and expanding the availability and use of effective interventions.

TOPIC: DISPARITIES IN HEALTH AND SAFETY IN CONSTRUCTION

Intermediate Goal 12.1: Improve surveillance of work-related injuries, illnesses, hazards and related costs among workers at disproportionate risk of injury in construction in order to set intervention priorities, guide future research, and evaluate progress in reaching prevention goals.

Performance Measure: Within 2 years, review, inventory, and recommend improvements or upgrades to existing datasets to increase the knowledge base of injury, illness, and exposure of worker populations that are known to be a greater risk. Within five years, create and pilot at least three innovative approaches designed to improve our understanding of risks and injury experiences of at-risk workers.

Research Goal 12.1.1: Review current occupational illnesses and injury data surveillance datasets and standard reports (e.g. CFOI, SOII, IMIS) to identify and recommend modifications to improve surveillance of at-risk construction craft workers and identify gaps to be addressed through new surveillance initiatives.

Research Goal 12.1.2: Explore and implement use of other existing state and national surveillance systems (e.g. BRFSS, NHANES/MEPS, others) and databases to address gaps in information about occupational injuries, illnesses and risks factor among at-risk workers in construction. This should include exploration of construction-targeted government surveys similar to the National Agricultural Workers Survey.

Research Goal 12.1.3: Strengthen capacity of states and community-based organizations to track work-related injuries and illnesses among construction craft workers who are at disproportionate risk, using innovative approaches to data collection such as through community clinics and other organizations serving at-risk worker populations employed in construction.

Research Goal 12.1.4: Support efforts to improve collection of improved race, country of origin, gender, age, and detailed ethnicity information in health and employment data sets.

Research Goal 12.1.5: Expand surveillance research to explore systematic underreporting of at-risk construction craft workers in existing occupational health surveillance systems.

Intermediate Goal 12.2: Improve our understanding of conditions and factors that contribute to disproportionate risk and the mechanisms through which vulnerability places workers at increased risk for work-related injury (or illness) in the construction trades, and their longitudinal effects.

Performance Measure: By 2014, identify and evaluate factors that contribute to disparities in worker health and safety; inventory these findings for future research and intervention development; and develop and implement interventions designed to improve working conditions and reduce injuries and illness among high-risk groups.

<u>Research/Research to Practice Goal 12.2.1:</u> Explore, via meetings with key intermediate groups associated with vulnerable worker groups (e.g. National Day Laborers Organizing Network, BCTD Women in the Trades Committee), their perspectives on vulnerable worker needs and opportunities, and the roles of these groups in research, partnering and dissemination of intervention information.

<u>Research Goal 12.2.2:</u> Evaluate formal and informal policies and workplace norms and conditions that may systematically increase disparities in health in the construction trades. This should include workplace norms and policies along with construction industry practices such as informal sector employment and cost-shifting practices.

<u>Research Goal 12.2.3:</u> Increase research on understudied work environments where high-risk groups are concentrated, with a focus on understanding worker exposures. Examples include day laborers and residential construction.

<u>Research Goal 12.2.4:</u> Improve understanding of how individual worker characteristics may contribute to worker injury and illness. This should include exploration of social, cultural, and age-related differences and safety attitudes including factors that may contribute to precarious employment (informal work arrangements, immigration status, economic conditions, and alternative employment).

Research Goal 12.2.5: Identify current interventions and practices used to address construction health disparities. Evaluate how existing construction mechanisms such as the use of competent persons, 10- and 30-hour safety training, apprenticeship skill training, and contractor prequalification programs can be modified to more effectively address worker risks.

Research Goal 12.2.6: Develop and evaluate new types of construction-tailored interventions to address disproportionate risks. These might include creative mechanisms involving community-based organizations, peer-to-peer networks, family-based measures, or similar efforts as well as policy initiatives.

Intermediate Goal 12.3: Develop and disseminate materials on risk and effective interventions to raise awareness and increase the utilization of these methods by construction stakeholders and to influence policy-makers. Based on existing information, Hispanic workers should be an important target group, but efforts should not neglect other groups, including non-Hispanic immigrants and inexperienced workers.

Performance Measure: By 2016, develop and disseminate five intervention materials/methods found to be effective from implementation according to IG 2.

Research Goal 12.3.1: Explore the delivery and evaluation of new types of creative mechanisms for reaching immigrant construction craft workers that target contractors, workers, community groups, advocacy groups, local unions, schools, etc. Pilot and evaluate the effectiveness of promising dissemination methods.

Research to Practice Goal 12.3.2: Increase dissemination of safety, workers' rights, and resource information to immigrant/at-risk workers. Evaluate barriers to understanding of such materials. Employ various types of communication channels/methods to reach these hard-to-reach workers.

Research to Practice Goal 12.3.3: Establish partnerships with construction organizations and groups who represent at-risk workers to develop and disseminate materials. Communicate findings and results of research to these partner organizations to aid in disseminating study results and promote policy changes when necessary.

Research to Practice Goal 12.3.4: Forge new mechanisms for outreach to small employers and companies including family-owned businesses with at-risk worker populations to evaluate intervention effectiveness and disseminate important safety and health information. Evaluate effectiveness of direct-to-worker communication vs. employer-based communication for getting results with vulnerable populations.

APPENDIX G

KEY AREAS OSHA HAS REQUESTED ASSISTANCE FROM STAKEHOLDERS AND OTHER AGENCIES IN ADDRESSING

A. Stronger Enforcement: many employers are willing to permit workplace hazards because it is not in their financial interest to abate serious hazards, particularly in the short term. Workplace safety, in traditional economic terms, is an example of a market failure. The economic and social costs of workplace injuries are too often borne by the injured worker, their family and taxpayer supported social programs, rather than the employer.

B. Ensure Workers Have a Voice: Workers must be knowledgeable of their rights under the law and feel secure in actively exercising their rights without fear of retaliation. And knowledgeable, secure, empowered workers are OSHA's best eyes and ears.

C. Refocus and Strengthen Compliance Assistance Programs: OSHA has important tools beyond enforcement and penalties to encourage employers to abate hazards. Examples are the on-site consultation program, and compliance assistance tools, including fact sheets and guidance documents to help employers and workers understand and abate hazards. OSHA is encouraging the development and dissemination of tools, information and best practices that enable at-risk workers to understand the workplace hazards they face, and how to use their rights to protect themselves, as well as enable employers to provide safe workplaces.

D. Change Workplace Culture: Employers Must "Find and Fix" Workplace Hazards:

Ensuring that American workplaces are safe will require a paradigm shift, with employers going beyond simply attempting to meet OSHA standards, to implementing risk-based workplace injury and illness prevention programs. This represents a fundamental change in workplace culture, with its success resting on the close collaboration between employers and workers.

E. Develop Innovative Approaches to Addressing New (and Old) Hazards:

Improve Intra-Agency Collaboration: OSHA's present process for issuing new or revised regulations or workplace Permissible Exposure Limits (PELs) takes many years and require sizable resource commitments. Increased collaboration with other worker protection agencies, like Mine Safety and Health Administration (MSHA), and other federal, state and local public health agencies, including the National Institute for Occupational Safety and Health (NIOSH), the National Institute for Environmental Health Sciences and the Environmental Protection Agency will continue to evolve to enhance safeguarding public health.

F. Improve and Modernize Workplace Injury and Illness Tracking: Strengthen Focus on Accurate Recordkeeping: Reports and patterns of current workplace injuries and illnesses are a particularly important tool in preventing future injuries and illnesses. OSHA must complete its transition to electronic data collection to take advantage of the many benefits of electronic injury tracking. Unfortunately, many employers, particularly in high-hazard industries have implemented programs, inadvertently or by design, that discourage injury reporting. OSHA has begun engaging stakeholders to help distinguish between programs that encourage safe work and those that discourage injured workers from reporting injuries.

G. Strengthen OSHA's Use of Science: OSHA, as a public health agency, must be firmly grounded in strong science. Strengthening ties to the scientific and public health communities, and working more closely with NIOSH, will help develop better ways to more quickly incorporate scientific advances into regulatory and compliance assistance activities, and serve as a conduit of information from the scientific community to workers and employers.

H. Strengthen State OSHA Plans: OSHA's enforcement work is significantly done by state plans that cover private and public sector workers in twenty-two states and territories, and public sector employees only in five more. OSHA must continue to ensuring these plans are, as required by law, at least as effective as the federal enforcement program. OSHA must help state plans grow in strength and effectiveness, and embrace new initiatives and approaches.

I. Conduct Work with Transparency, Openness, Integrity and Humility: OSHA's actions must be transparent and the decision-making process open. OSHA has much to learn from its stakeholders, and a concerted effort is being made to reach out to members and representatives of vulnerable populations whose voices are not normally heard.

OSHA has been working on an Open Government action plan that addresses a myriad of issues including innovative stakeholder engagement and improved public access to important data sets. Posted on the web, results of 585,000 exposure measurement samples gathered in 67,000 inspections, joins the data set of the workplace fatality reports, and the previously posted establishment-specific injury and illness rates collected in the OSHA Data Initiative.

APPENDIX H

LETTER OF CONSENT

To Whom It May Concern:

I am writing this letter on behalf of (YOUR ORGANIZATION) to offer support for and planned participation in the CPWR Small Study proposal that is being submitted by Dr. Grau. His proposal is aimed at assessing how to engage construction organizations in the proactive assessment and prevention of long-standing cumulative health hazards. As the (YOUR PROFESSIONAL TITLE/POSITION), I strongly support this proposal both in concept and execution.

I personally commit to serving in expert panel for the proposed research project. I will participate as an expert member in Delphi study and contribute with my experience, knowledge, and interest for the topic under investigation. I welcome the opportunity to personally collaborate with Dr. Grau and the other experts in the panel on this project.

I look forward to contribute enhancing the health and wellbeing of the construction workforce through my participation in this study. Please do not hesitate to contact me should you require additional information.

Sincerely,

NAME

PROFESSIONAL TITLE

Cell: PHONE (BEST CONTACT)

APPENDIX I

NORA DERIVED SEMI-STRUCTURED INTERVIEW GUIDE QUESTIONS

FOR CRAFT AND OSH EXPERTS

NORA Derived Semi-Structured Interview Guide Questions for Craft and OSH Experts

The National Occupational Research Agenda (NORA) to bridge the gap between research and practice communities, has several research and research to practice goals. The following questions focus on the four cumulative health hazards as identified by NORA: Crystalline Silica, Welding Fumes, Hearing Loss, Musculo-skeletal Disorders.

Bio information

Education, number of years of experience –detail positions, current position and affiliation, experience with each of the 4 cumulative health hazards below.

Preliminary Information

Are you aware or do you have experience with each the cumulative health hazards of noise and hearing loss, silica exposure, welding fumes, and musculoskeletal disorders?

QUESTIONS

Current Practices

13) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive the prevention of long-standing hazard of noise and hearing loss?

14) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive in the prevention of long-standing hazard of silica exposure?

15) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive in the prevention of long-standing hazard of welding fumes?

16) To the best of your knowledge, what practices are currently used by owners and/or contractors to effectively drive in the prevention of long-standing hazard of musculoskeletal disorders?

Factors and Interventions

17) What are the key negative individual /worker factors that prevent the proactive adoption of measures that would protect workers from the four cumulative health hazards?

18) What are the key interventions at individual /worker level that would lead to the proactive adoption of measures against the four cumulative health hazards?

NOTE: Previous 2 questions could be further investigated for worker subgroups, as suggested by NORA. New workers, Young/Older workers, Apprentices, Female workers, Immigrant workers, other workers at disproportionate risk of injuries and illnesses.

19) What are the key organizational factors that compromise the proactive adoption of measures against the four cumulative health hazards?

20) In your expert opinion, what are the key interventions at organizational level that would lead to the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?

21) In your expert opinion, what are the key policy and industry factors that compromise the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?

22) In your expert opinion, what are the key interventions at policy and industry level that could lead to the proactive assessment, consideration, and adoption of measures against the four cumulative health hazards?

23) What is the monetary relationship (e.g. business case) between positive and negative construction health and safety cultures in regards to the four cumulative hazards?

24) To the best of your knowledge, what data or sources can be available to quantitatively document a cost to benefit associated with the prevention of the four health hazards? Any ideas?

NOTE: Factors for questions 7-10 according to NORA, Safety and health management programs typically include four basic component groups: 1) management leadership and employee involvement; 2) worksite analysis; 3) hazard prevention and control; and 4) safety and health training [Garner, 2004]. Also, NORA details:

- Inherent construction attributes such as productivity pressure ("time is money") and low bid practices
- Industry-wide construction safety practices
- Project level influences and attributes, e.g., project size and complexity, project length and employee turnover
- Type of construction work (e.g. residential construction vs. highway construction)
- Management involvement and commitment in safety
- Design for safety
- Leadership
- Foreman and supervisor involvement in safety
- Employee involvement in safety
- Employee characteristics such as union, non-union, or family member
- Trade characteristics or sub-cultures
- Employer characteristics such as prime contractor or subcontractor or size
- Extent and type of safety training provided
- Educational levels

- Ethnic and cultural values of a diverse multinational workforce
- Regional practices
    - Owner involvement – both positive and negative
    - Safety and health management programs and system components such as use of incentives, discipline, goal setting, accident investigation

APPENDIX J

CODING TABLES

Table 1. Data pulled from Raw Interview Data through the Development of Axial Codes.

Transcript Excerpt	**Open Codes**	**Axial Codes**
293. 1099 Classification of workers considered an illegal practice.	1099 worker classification considered illegal	1099 Classification Unfair Labor Practice
294. 1099 classification considered an unfair labor practice against employees.	1099 classification considered an unfair labor practice	1099 Classification Unfair Labor Practice
292. National labor relations board considers 1099 employees an unfair labor practice.	1099 construction employees considered unfair labor practice.	1099 Considered Unfair Labor Practice
273. 1099 classification places responsibility of wage documentation on workers.	1100 classification places responsibility of wage documentation on workers.	1099 Wage Documentation Responsibility
105. 2nd hand exposures to health hazards can reduce productive life of workers.	2nd hand health hazards reduce worker productive life	2nd Hand Hazards Reduce Productivity
360. Can incentivize communication of project hazards by acknowledging good health and safety practices.	Acknowledging good health and safety practices incentivizes communication	Acknowledging Practices Incentivizes Communication
388. Working with procurement and acquisition are important key for buying "usable" safety and health products.	Procurement and acquisition are important for buying usable safety and health products	Acquisition Important for Buying Usable Products
290. Promoting active and healthy lifestyles away from work is important.	Promoting active and healthy lifestyles is important	Active/Healthy Lifestyle Promotion

106. Reduction of workers to 2nd hand exposures to health hazards needs to be addressed.	2nd hand exposures of health hazards need to be addressed	Address 2nd Hand Exposures
217. Know equipment sub-contractors will actually use to be able to address the potential hazards.	Know equipment contractors will use so can address potential hazards	Address Contractor Equipment Hazards
207. Shifting worker mindsets to adhere to health and safety practices needed.	Shift in mindsets to adhere to practices	Adherence to Health and Safety Practices
190. Administrative and engineering controls are key for reducing worker exposures to health hazards.	Administrative and engineering controls are key for reducing hazard exposures	Administrative Controls Reduce Exposures
39. Age reduces immune defenses so as workers age they may have exponential adverse health effects to exposures.	Age reduces immune defenses	Age Reduces Immunity
266. Aging workforce = health and safety issue directly impacting construction productivity.	Aging workforce directly impacts construction productivity	Aging Directly Impacts Productivity
159. All employers are not responsible and provide workers with protective equipment.	All employers do not provide protective equipment	All Employers Do Not Provide Equipment
159. All employers are not responsible and provide workers with protective equipment.	All employers do not provide protective equipment	All Employers Not Responsible
216. Photos and other alternatives for communicating hazards to workers is useful.	Alternatives, e.g., photos, useful for communicating hazards	Alternative Hazard Communication

414. Technology to communicate photos/visuals of issues to team members faster and more clearly.	Use technology to communicate issues faster	Alternative Hazard Communication
130. Analyze health and safety problems from the standpoint of opportunities to increase productivity.	Health and safety problems are opportunities to increase productivity	Analyze Problems for Opportunties
64. Difficult to track quarterly or annual impacts of silica or noise to workers.	Quarterly and annual impacts of silica or noise difficult to track	Annual Silica Impacts
341. Leadership taking time to appreciate accomplishments of workers helps promote continued safety and health issue awareness.	Appreciation of accomplishments by leadership promotes safety and health awareness	Appreciation by Leadership
210. Physical barriers can be determined based on work circumstances, e.g. location.	Location determines appropriate physical barriers.	Appropriate Barriers Determined by Location
66. Appropriate regulations can help eliminate industry hazards.	Appropriate regulation help eliminate hazards	Appropriate Regulation Eliminates Hazards
160. Culture of workers is that workers are a nusance if they request personal protections.	Construction culture perceives workers as nusance if ask for protections	Asking for Protections Perceived as Nusance
105. Assessment for interventions to ensure new hazards are not overlooked is important.	Assessment for interventions to ensure new hazards not overlooked	Assess Interventions for New Hazards
53. Work assessments part of Preplanning to provide equipment for workers.	Preplanning worker assessments provide worker equipment	Assessments Provide Workers Equipment

111. Materials to protect pedestrians cost money.	Protection materials cost money	Available Capital Limits Practices
240. Capital availability is a limiting factor for smaller companies to implement known health and safety practices.	Capital availability limiting factor for implementing health and safety factors.	Available Capital Limits Practices
295. Workers now have an avenue to file against unfair labor practices through the National Labor Relations Board.	Avenue for workers to file against unfair labor practices	Avenue Against Unfair Labor Practices
198. Need avenues for health and safety OSHA partners to work with small and mid-size companies.	Need avenues for OSHA to partner with small and mid-sized companies	Aveues for OSHA Partnerships Needed
198. Need avenues for health and safety OSHA partners to work with small and mid-size companies.	Need avenues for OSHA to partner with small and mid-sized companies	Aveues for OSHA Partnerships Needed
253. Illegal practices for companies are used to avoid liability for worker's injured attempting to meet productivity demands.	Illegal practices used to avoid liability for injured workers	Avoid Injured Worker Liability
242. Open shop pays employees more to avoid putting the worker on the company insurance. Employee encouraged to state injuries were not job related.	Open shop pays employees more and encourages worker to state injuries not job related to avoid putting worker on company insurance.	Avoid Worker on Insurance

34. Small shop owners need education to increase their awareness to cumulative health hazards.	Small shop owners need awareness to cumulative health hazards	Awareness of Hazards by Small Shop Owners
163. Perspectives on responsible company actions needs to be baselined to extend beyond immediate financial values.	Responsible actions need to be baselined beyond immediate financial values	Baseline Beyond Financial Values
163. Perspectives on responsible company actions needs to be baselined to extend beyond immediate financial values.	Responsible actions need to be baselined beyond immediate financial values	Baseline Responsible Actions
102. Strategies for creating new behavior baselines need to be considered.	New baseline strategies needed	Baseline Strategies Needed
330. Benefits of job analysis are identifying opportunities for bettering: production, quality, material selection, scheduling, staffing.	Job analysis benefits include better production, quality, material selection, scheduling, and staffing	Benefits of Job Analysis
104. Job hazards assessment can determine best mitigations to prevent injuries.	Job hazards assessment can determine mitigations	Benefits of Job Analysis
223. Work with vendors to learn about new technology to understand benefit.	Learn from vendors about benefits of new technology	Benefits of Technology
329. Job analysis is finding out about the project.	Job analysis is finding out about the project.	Benefitsof Job Analysis

340. Human interaction and appreciation is the best incentive.	Best incentive is interaction and appreciation	Best Incentives
367. London Olympics construction example offers the good of the best practices.	London Olympics offers examples of best practices	Best Practice Examples
68. Best practices help reduce job hazards.	Best practices reduce job hazards	Best Practices Reduce Hazards
282. Better manufacturered tool design is helping to reduce musculoskeletal injuries in workers.	Better manufacturered tool design is helping to	Better Tool Design Reduces Injuries
337. World class construction companies give bonuses based on feedback beyond safety.	Bonuses given based on feedback beyond safety	Beyond Safety Bonuses
284. Better tool design does not replace the need to educate workers on proper biomechanics of his/her work.	Tool design does not replace biomechanics education	Biomechanic Education
337. World class construction companies give bonuses based on feedback beyond safety.	Bonuses given based on feedback beyond safety	Bonuses Based on Feedback
36. Really large company owners interest is mainly the bottom line at the expense of the health of its worker health and safety.	Owners interest is mainly the bottom line at the expense of the health of worker health and safety.	Bottom Line Owners Main Interest
36. Really large company owners interest is mainly the bottom line at the expense of the health of its worker health and safety.	Owners interest is mainly the bottom line at the expense of the health of worker health and safety.	Bottom Line Owners Main Interest

184. Government contracting officers constrained to maintain projects on budget and on schedule.	Government contracting officers constrained to budget and schedule	Budget Schedule Constraints
228. Need to incentivize businesses to collaborate with OSHA to ensure education is provided to workers.	Need business incentives to ensure OSHA education is provided to workers	Business Incentives for Educating Workers
275. Businesses misclassify project types to pocket differences in wage costs.	Businesses misclassify project types to pocket differences in wage costs.	Businesses Misclassify Project Types
56. Work with venture capitalists to invest in companies that adopt using safer materials or eliminate hazardous materials from processes.	Capital investments for companies that adopt safer materials and processes	Capital Investments for Companies
185. Everything above a specified deductible is shared by contractors in the captive.	Captive contractors share costs above a deductible	Captive Costs above Deductible Shared
184. Captive insurance is a company owned by multiple contractors.	Multiple contractors own a captive	Captive has Multiple Owners
236. Developing a captive insurance group is not feasible for smaller sub-contractor type companies.	Captive insurance not feasible for smaller sub-contractors	Captive Insurance Infeasible for Smaller companies
187. Captive insurance maybe an avenue to educate owners regarding cost of worker illnesses.	Captive insurance maybe an avenue for educating owners regarding cost of worker illnesses	Captive Insurance May Educate Owners

356. Captive owners need to be open to outside suggestions for improvement.	Captive owners need to be open to outside suggestions	Captive Owners Need to be Openminded
183. Capitive insurance company is owned by multiple companies that share the costs.	Captive insurance costs shared by multiple owners	Captive Owners Share Costs
355. Captive insurance does not advise owners.	Owners not advised by captive insurance	Captives Do Not Advise
237. Financial capital needed for captives.	Financial capital needed.	Captives Need Capital
143. Finishing High School needed to find an occupation.	Needed an occupation after high school	Career After High School
3. Masonry career offered opportunities college did not.	Masonry career offered opportunities college did not	Career Opportunities
276.a Everyday construction product consumer mindsets also need to be changed.	Consumer mindsets need changing.	Change
222. Change and awareness of health issues takes time.	Change and awareness takes time	Change and awareness takes time
10. False sense of personnel protection regarding health and safety needs to be changed.	False sense of health and safety protections needs to change	Change False Sense of Protection

272. Need to change mindset regarding how workers work.	Change mindset regarding how workers work	Change How Workers Work Mindset
81. Need to change mindset of company medical to work with safety to protect workers rather than cover up symptoms of the development of worker adverse health conditions.	Work with Safety to Protect Workers rather than Cover up Symptoms of Adverse Health Conditions	Change Mindset from Cover Up to Protection
147. Macho mindset and ability to take exposures to health hazards needs to be changed.	Macho mindset to acceptance of health hazards needs to change	Change Mindset of Hazard Acceptance
363. Change company mindset to be open to communication from workers.	Change mindset to be open to worker communication	Change Mindset to Open Communication
309. How do small and mid sized companies communicate change orders.	Communication of change orders	Change Order Communication
353. Perception of trades as low skill needs to change.	Perception of trades as low skill needs to change	Change Trade as Low Skill Perception
354. Young people's perception is that trades are low skilled needs to change.	Perception that trades are low skill needs to change	Change Trade as Low Skill Perception
149. Industry needs to change mindset regarding value of the worker.	Industry mindset of worker value needs to change	Change Worker Value Mindset
232. Project changes impact project schedules.	Changes impact schedules	Changes Impact Schedules

218. Check quality of equipment used by sub-contractors.	Check quality of subcontractor equipment	Check Sub-Contractor Equipment Quality
31. Choose best protection method that does not create other potential hazards for workers, eg. Slip and fall with wet methods.	Choose method that will not create other hazards for workers	Choose Practices Minimizing Hazards
75. Chronic pain/immediate pain provides person immediate feedback to a problem.	Chronic pain provides person immediate feedback	Chronic Pain Provides Immediate Feedback
207. Clear expectations of 2nd and 3rd tier sub-contractors is critical for reducing health hazards.	Clear expectations of 2nd and 3rd tier sub-contractors is critical for reducing health hazards.	Clear Expectations Reduce Health Hazards
228. Continual reinforcement of clear expectations from management are important for protecting worker health.	Continual Reinforcement of management expectations	Clear Management Expectations
233. Project changes require close cooperation with management to ensure health and safety practices remain consistent.	Project changes require close cooperation with management	Close Management Cooperation for Project Changes
378. Communication and collaboration among leaders to trades people needs improvement.	Communication and collaboration among leaders to trades people needs improvement	Collaboration Improvement Needed
349. College puts young people in debt versus saving for a pension.	College puts young people in debt versus providing a pension	College Debt Versus Career Pension
370. Color Coding	Color Coding	Color Coding

279. Hazard color coding helps workers work safer.	Color coding helps to work safer	Color Coding to Work Safer
280. Color coding represents potential musculoskeletal injuries.	Musculoskeletal injuries represented via color coding	Color Coding to Work Safer
281. Color coding reduces questions regarding hazards of the task.	Questions regarding hazards reduced via color coding	Color Coding to Work Safer
9. Opportunities combining college education and trade training did not exist.	Opportunities combining college education and trade training did not exist.	Combined Trade and College Education Non-Existent
215. Communicate dangers to workers using everyday language and examples.	Use every day language to communicate dangers	Communicate Dangers via Everyday Language
312. Change mindset regarding the communication of observed unsafe work practices.	Communication of observed unsafe work practices	Communicate Unsafe Practices
220. OSHA needs time to communicate message to industries.	OSHA needs time to communicate message to industries.	Communicating OSHA Messages Takes Time
369. Communication	Communication	Communication
221. Mindsets regarding communication among various management levels and contractor levels needs improvement.	Mindsets regarding communication among various management levels needs improvement	Communication Mindsets Need Improvement
424. Communication skills	Communication skills	Communication Skills

267. Community groups/grass roots helping workers.	Community groups helping workers	Community groups helping workers
268. Community groups vital resource for communicating worker health and safety information.	Community groups vital for communicating health and safety information	Community Groups Vital for Communicating Information
56. Work with venture capitalists to invest in companies that adopt using safer materials or eliminate hazardous materials from processes.	Capital investments for companies that adopt safer materials and processes	Companies adopting Safer Materials and Processes
79. Company doctors are interested in protecting the company's health at the expense of worker health.	Company doctors protect company at worker expense	Companies protected at Worker Expense
231. Need avenues for companies to collaborate with OSHA to provide appropriate trade health and safety information.	Need avenues for company cooperation with OSHA	Company Avenues for OSHA Cooperation
338. Varying company cultures regarding incentives.	Company cultures vary regarding incentives	Company Incentive Cultures Vary
235. Priority of companies is key for maintaining processes that are in place: such as production, quality, and safety and health.	Company priorities key for maintaining production, quality, and safety and health	Company Priorities Key
264. Processes in construction have been compliance based.	Construction processes are compliance based	Compliance Based Construction Processes

185. Neutral 3rd party contract monitors are obligated to uphold contracts and ensure compliance.	Contract monitors obligated to uphold and ensure compliance	Compliance via Contract Monitors
182. Third party contract monitors are hired by large companies to ensure contract provisions are adhered to.	Contract monitors hired by large companies to adhere to contract provisions	Compliance via Contract Monitors
258. Present OSHA training is compliance based.	OSHA training is compliance based	Complianced Based Training
108. Improved work conditions to incentivize workers to stay in the trade.	Improved work conditions can incentivize workers to stay in trade	Conditions Incentivize Workers to Stay
108. Improved work conditions to incentivize workers to stay in the trade.	Improved work conditions can incentivize workers to stay in trade	Conditions Incentivize Workers to Stay
169. High worker turnover results in higher insurance premiums for consciencous employers.	Conscienous employer pay higher insurance premiums for high worker turnover	Conscienous Employer Pays Higher Insurance
286. Consequences for fatalities are not a Deterrent because companies can negotiate fines to almost nothing.	Consequences are not a deterrent because negotiate fines to almost nothing	Consequences Not Deterrent
401. Reinforcement of behavioral expectations needs consistency among all management levels.	Consistency needed in reinforcement of behavioral expectations	Consistent Behavioral Expectations

400. Consistent communication e.g., safety surveys with staff and workers gives baseline knowledge/training needed by staff.	Consistent communication gives baseline training needed by staff	Consistent Communication Needed
320. Leadership has to enforce safety expectations consistently.	Leadership has to consistently enforce safety expectations	Consistent Leadership Safety Expectations
122. Exposure to construction material hazards extends to other fields such as art and stone workers.	Exposure to material health hazards not unique to construction	Construction Hazard Exposures Not Unique
346. Construction industry needs an image makeover.	Makeover needed for construction	Construction Image Makeover
188. Neutral 3rd party contract monitors are not widely used by high end jobs because 3rd party monitor increases risk to project owner.	Contract monitors increase risk to project owners	Contract Monitors Increase Owner Risks
186. OSHA cannot enforce health and safety contract requirements.	Health and safety contract requirements cannot be enforced by OSHA	Contract Requirements Not OSHA Enforceable
190. Contract violations such as implementation of health and safety provisions are common.	Contract violations of health and safety provisions common	Contract Violations Common
35. General contractor needs to be held accountable for health hazards it allows workers to be exposed to.	Contractor held accountable for worker exposures.	Contractor Accountability for Exposures

381. Contractor is not based off whether it's union or not.	Contractor is not based off whether it's union or not.	Contractor Chosen Not Labor Source Based
14. As an independent contractor was exposed to new building construction hazards.	Contractors exposed to construction hazards	Contractors exposed to construction hazards
17. General contractors are responsible for overall scheduling of trade interactions.	General Contractors Responsible for Overall Trade Scheduling	Contractors Responsible for Scheduling Trades
181. Health and safety requirements need to be incorporated into contract bids.	Incorporate health and safety into contract bids	Contracts Incorporate Health and Safety Bids
257. Employer avoidance of responsibility regarding worker health and safety is a contributing factor to the shortage of needed skilled workers.	Employer avoidance of responsibility regarding health and safety is a contributing factor to the shortage of skilled workers	Contributing Factor to Worker Shortage
155. Treatment of workers as disposable is contributing to worker shortages.	Treating workers as disposable contributes to worker shortages	Contributions to Workers Shortages
282. Convert lost wage accounts after certain periods for worker health and safety education programs.	Convert lost wage accounts to health and safety education programs.	Conversion of Lost Wage Accounts
172. Cost of maintaining and cost of buying equipment motivates cutting corners with health and safety practices.	Cost of equipment and maintenance motivates cutting health and safety corners	Corners Cut to Increase Profits

42. Ignorance regarding health and safety risks prioritize cutting corners to increase profits.	Cutting corners to increase profits prioritized	Corners Cut to Increase Profits
153. Workers exposed wearing minimal PPE to materials that corrode cars.	Workers exposed to corrosive materials with minimal PPE	Corrosive Material Workers Exposures
152. Dangerous materials are given names like "Green Dragon" - shows workers have awareness of dangers.	Naming of dangerous materials shows workers aware of dangers	Corrosive Material Workers Exposures
114. Economic cost/benefit analysis/assessment of costs of protection from hazards to cost of elimination of hazards. I.e., cost of protection versus cost of prevention.	Cost of prevention versus cost of protection	Cost
178. Industry has developed algorithms for costs of injuries and illnesses.	Algorims developed for costs.	Cost Algorims
241. Companies need to do economic assessments of expenditures to recognize existing financial opportunities for implementing health and safety practices.	Recognize existing financial opportunities for implementing Health and Safety.	Cost Benefit Analysis
134. Cost-benefit analysis of implementing health and safety protocols.	Cost benefit analysis	Cost Benefit Analysis

180. Develop various individual company case studies showing cost and potential savings is a way to demonstrate the severity of the problems regarding health and safety in the constructin industry.	Develop case studies showing severity and cost of health and safety issues.	Cost Benefit Analysis
222. Cost-benefit analysis of using less hazardous materials is a potential incentive for the use of less hazardous materials.	Cost-benefit analysis potential incentive for use of less hazardous materials	Cost Benefit of Using Less Hazarous Materials
177. Construction industry needs to look at cost of injury and illnesses to worker's holistically.	Look at cost of injuries and illnesses	Cost of Injuries and Illnesses
172. Cost of irresponsible employers paid by other employers in the insurance pool.	Cost of irresponsible employers paid by insurance pool.	Cost Paid by Insurance Pool
117. Track cost of indirect materials used for protecting against hazards versus what it would cost to eliminate hazards overall.	Track cost of protecting against hazards versus protecting against hazards.	Cost Tracking
175. Cost of health hazards and injuries distributed across industry in cost of insurance premiums.	Costs of injuries and illnesses distributed across industry	Costs Distributed Across Industry
176. Illnesses and injury cost shared by all companies that pay into insurance, e.g. Worker's Compensation Insurance.	Cost shared by all companies that pay into workers compensation insurance	Costs Distributed Across Industry

249. Money drives the bus.	Money drives the bus.	Costs Drive Decisions
57. Cost is the main driver of decisions.	Decisions driven by costs	Costs Drive Decisions
127. Money is a great motivator.	Money is a great motivator.	Costs drive Decisions
175. Cost of health hazards and injuries distributed across industry in cost of insurance premiums.	Costs of injuries and illnesses distributed across industry	Costs of Injuries and Illnesses
139. Creativity is the limiting factor to finding collaborative solutions.	Creativity is a limiting factor to collaborative solutions	Creativity Limits Collaborative Solutions
366. Constant criticism demotivates workers to communicate issues.	Constant criticisms demotivates workers	Criticism Demotivates Workers
16. Provide personal protection to other trades scheduled to be exposed to cross trade hazards.	Personal protections needed for cross trade hazards	Cross Trade Hazard Protections
32.Health and safety protections should be in place for the trade work being performed.	Protections for Trades being Performed	Cross Trade Hazard Protections
209. Physical barriers are an option for protecting workers from cross trade hazards.	Physical barriers protect from cross trade hazards	Cross Trade Hazards Protection
192. Separation of trades	Need separation of trades	Cross Trade Hazards Protections

27. From limited open shop organizations the message was "Employees are your enemies".	Open shop message was "Employees are your enemies".	Culture of Employee Mistrust
28. Open shop associations created culture of mistrust toward employees.	Open shop created culture of mistrust toward employees	Culture of Employee Mistrust
160. Culture of workers is that workers are a nuisance if they request personal protections.	Construction culture perceives workers as nuisance if ask for protections	Culture of Employee Mistrust
104. Cumbersome preventative health and safety measures can decrease worker productivity and deincentivize workers to health and safety protocols.	Cumbersome preventative health and safety measures decrease worker safety, productivity, and deincentivize safety protocols	Cumbersome Practices Deincentivize Safety
265. Texas communities with large immigrant populations experienced 1-2 deaths daily.	One to two deaths daily	Daily Deaths
12. Workers exposed 1,000 times per day to harmful noise levels.	Workers exposed daily to harmful noise levels	Daily Harmful Noise Exposures
14. Secondary workers exposed to high levels of noise impacts	Workers exposed to high levels of secondary noise	Daily Harmful Noise Exposures
20. Exposure to certain tools like jack hammer high pitch causes permanent hearing loss.	High pitch noises cause permanent hearing loss	Daily Harmful Noise Exposures
5. Dampening structures built to reduce noise levels	Dampening structures reduce noise levels	Dampening Reduces Noise Levels

389. Low bid mindsets result in purchasing dangerous products.	Dangerous products purchased with low bid mindsets	Dangerous Product Purchases
61. Tracking injury data helps illuminate job hazards that need to be addressed.	Tracking injury data illuminates job hazards	Data Tracking Illuminates Hazards
280. Davis-Bacon laws require certification of payroll for construction jobs.	Davis-Bacon require construction job payroll certification	Davis-Bacon Requires Payroll Certification
164. Define company gains beyond financial gains, e.g. reputational enhancement.	Define company gains beyond financial gains	Define Gains Beyond Financial
229. Superintendent and foreman are important for delivering consistent expectations messages to workers.	Superintendent and foreman are important for delivering consistent communication to Workers	Delivering Consistent Communication to Workers
201. Design tools that reduce the hazard effectively.	Design tools that reduce the hazard effectively.	Design Hazard Reduction Tools
49. Tool design needs to account for impact to user.	Tool design needs to account for impact to user	Design Tools Accounting for User Impacts
15. Dry cut diamond saw blade made clouds of dust, i.e., tool not designed with worker in mind.	Tools not designed with worker in mind	Design Tools for Worker
110. Rather than preparation for protecting pedestrians from hazards eliminate the hazards when designing the work to be done.	Eliminate hazards when designing the work rather than protecting from hazard	Design Work Eliminating Hazard

275. Change to construction practices is being influenced by vendor and manufacturing tool design improvements.	Vendor and manufacturing designs influencing changes to construction practices	Designs Influence Construction Practices
98. Development of Public Health Agency/Branch for OSHA or collaborate with the US Department of Health and Human Services to track industries with greater number of ill workers; and work to determine their financial liability.	Develop government and industry collaboration to track illnesses and financial responsibility of industries	Determine Financial Responsibility
63. Medical costs paid by the government could be tied to industry or occupation of benefit recipient.	Medical costs tied to industry.	Determine Financial Responsibility
162. Suggestion needed for how to determine the cost/benefit of eliminating health hazards.	Need suggestion for determining cost benefit of eliminating hazards	Determining Hazard Elimination Cost Benefit
98. Development of Public Health Agency/Branch for OSHA or collaborate with the US Department of Health and Human Services to track industries with greater number of ill workers; and work to determine their financial liability.	Develop government and industry collaboration to track illnesses and financial responsibility of industries	Develop Government and Industry Collaboration
84.a To develop protocols to protect workers from developing later stage adverse health outcomes.	Develop protocols protecting workers from adverse later stage health outcomes	Develop Protocols Protecting Worker Health

142. Industry focus groups with workers to develop collaborative solutions with workers and experts.	Industry needs to work with trades people and experts to develop solutions	Develop Solutions with Trades People and Experts
171. Process for tracking exposures to worker injuries from previous employers needs to be developed.	Need to develop process for tracking worker injuries and exposures	Develop Tracking for Injuries and Exposures
302. Construction industry struggling to develop skills assessment of workers.	Industry struggling to develop worker skills assessment	Develop Worker Skills Assessment
99. Lag time for the onset of cumulative health hazards a challenge for determining the industry/employer responsible for exposing the worker to health hazards.	Lagtime creates challenge for determining employer responsible for health hazard exposures	Difficult Determining Responsible Employer
421. Difficult for one person to catch all safety issues.	Difficult for one person to catch all safety issues.	Difficulty Catching All Issues
247. There is a disconnect between employee health and safety training and understanding what that training means to that employees individual health.	Disconnect between employee health and safety training and individual health.	Disconnect Between Training and Health
397. Diverse workforce creates challenges regarding what is perceived as a hazard.	Diverse workforce creates challenges regarding what is perceived as a hazard.	Diverse Hazard Perceptions Challenging

415. Women and diversity in construction bring different perspectives to solutions to issues.	Women and diversity in construction bring different Perspectives	Diversity Brings Different Perspectives
430. Diversity makes construction strong in America.	Diversity makes construction strong	Diversity makes construction stronger
121. Diversity in the industry can provide more ideas for solutions.	Diversity can provide more ideas/solutions	Diversity Provides More Ideas
398. Diverse workforce provides opportunities for creative solutions to health and safety challenges.	Diverse workforce provides opportunities for creative solutions	Diversity Provides Opportunities
425. Diversity	Diversity needed	Diversity Provides Opportunities
422. Different perspectives allows the capture of more ideas that may otherwise have been missed.	Different perspectives allows capture of other ideas	Diverstiy Provides More Ideas
79. Company doctors are interested in protecting the company's health at the expense of worker health.	Company doctors protect company at worker expense	Doctors Protect Companies
226. Potential economic loss in investing in equipment that may not work as promised.	Economic losses when equipment does not work as promised	Economic Losses of Non-functional Equipment
246. Educate people about safety and health who can effect or make change.	Educate people who have the ability to make or authorize change	Educate Authority
135. Education of the people who have the ability to make change or authorize change is important.	Educate people who have the ability to make change or authorize change	Educate Authority

248. Owners need to be educated about how safety and health ties into productivity.	Owner Need Education About Ties into Productivity	Educate Owners About Productivity
187. Captive insurance maybe an avenue to educate owners regarding cost of worker illnesses.	Captive insurance maybe an avenue for educating owners regarding cost of worker illnesses	Educate Owners on Illness Costs
159. Public perceptions regarding exposure to cumulative health hazards needs to be evaluated via truthful education to the issue.	Public perception of health hazards needs truthful education	Educate Public of Hazards
150. Educate workers as to the value of their trade.	Educate workers as to the value of their trade	Educate Trades to their Value
69. Public Service announcements can be used to educate about hazards such as silica.	Educate about silica via public service announcements	Educate via Public Service Announcements
30. Educate public regarding silica dangers.	Education about dangers.	Education
399. Educating staff/workers regarding expectations creates common baseline for health and safety practices.	Education creates common baseline for practices	Education Creates Baseline Practices
205. Workers need to take personal accountability for their well being when training/education and appropriate PPEs are provided.	Personal accountability of workers enhanced when training/education and PPE provided	Education Enhances Personal Accountability
7. Worker education needed regarding basic worker protections	Education needed regarding basic worker protections	Education for Basic Worker Protections

36. Silica dangers are not new. Education is needed regarding dangers.	Education needed regarding silica dangers	Education for Basic Worker Protections
76. Lack of worker education regarding job hazards is a large problem.	Lack of education to job hazards is a large problem	Education for Basic Worker Protections
256. Employee education regarding applicable health and safety protections needed.	Education needed for applicable health and safety protections	Education for Health and Safety Preventions
Education of workers to job hazards is important.	Education to job hazards important	Education for Health and Safety Preventions
76. Lack of worker education regarding job hazards is a large problem.	Lack of education to job hazards is a large problem	Education for Health and Safety Preventions
288. Education regarding injury prevention is needed in physically demanding industries like construction.	Physically demanding industries need injury prevention education	Education for Health and Safety Preventions
289. Education regarding stress of static postures is needed as well.	Education regarding static posture stress needed	Education for Health and Safety Preventions
227. Companies required to provide basic health and safety education.	Companies required to provide basic education	Education for Health and Safety Preventions
45. Lack of knowledge regarding health and safety protections.	Knowledge regarding health and safety protections	Education for Health and Safety Preventions
255. Academic institutions need to train engineers regarding safety and health issues.	Train engineers regarding safety and health issues	Education for Health and Safety Preventions

37. Education regarding "benign" looking hazards is needed in industry.	Education needed regarding benign looking hazards	Education for Health and Safety Preventions
125. Unknown unknowns can be minimized via education.	Education can minimize the unknown unknowns	Education Minimizes Unknown Unknowns
202. Ignorance of health hazards by workers points to the need for education of potential workforce and continuing education.	Ignorance of health hazards points to need for education and continuing education	Education Needed for Health and Safety Preventions
86. Education regarding adverse health issues from cumulative health hazard exposure is needed.	Education regarding adverse health issues from cumulative	Education Needed for Health and Safety Preventions
13. Education needed for workers and employers regarding cumulative harmful health effects.	Education needed regarding cumulative harmful health effects	Education Needed for Health Hazards
110. Improved training for new trades people needed to minimize dangers.	Trades people need training to minimze dangers	Education Needed for Injury Prevention
247. Educate supervisors and sub-contractors regarding health and safety hazards.	Supervisors and sub-contractors need education	Education of Supervisors and Sub-Contractors
123. Education provides workers opportunities to better define career paths.	Education provides better defined career paths	Education Offers defined Career Paths
254. Worker education needed regarding their health and safety protections.	Education needed regarding health and safety protections	Education regarding Health and Safety Protections
204. Education regarding available options to reduce use of materials with toxins.	Options to reduce toxins available via education	Education Regarding Reduction of Toxins

97. Education to root-causes of musculskeletal injuries needed for workers and managers.	Workers and Managers need education to root causes of musculoskeletal injuries	Education to Root Causes of Injuries
84. Education of workers to beginning signs of adverse health outcomes is needed.	Workers need education to signs of adverse health outcomes	Education to Signs of Adverse Health
7. Did not understand the value of a college education.	Value of college education not understood.	Education Value Not Understood
224. Ego limits people to be open to change.	Ego limits openness to change	Ego Limits Change
140. Openmindedness needed for the development of possible solutions to eliminating or reducing worker exposure to cumulative health hazards.	Openmindedness needed for developing solutions or eliminating exposures to health hazards	Eliminating Hazard Exposures
429. Immigrants and women in construction should be embraced not pushed away.	Immigrants and women in construction should be embraced	Embrace Immigrants and Women in Construction
163. Employees injured on the job are encouraged to say they were injured at home.	Employees injured on the job are encouraged to say they were injured at home.	Employee Job Injuries
30. Training new employees is resource intensive.	New employee training is resource intensive	Employee Training Resource Intensive
29. Message needs to shift to "Employees as Assets".	Shift mindset to employees as assets	Employees as Assets Mindset

163. Employees injured on the job are encouraged to say they were injured at home.	Employees injured on the job are encouraged to say they were injured at home.	Employees Encouraged to say Injured at Home
164. Employers avoid responsibility of worker health and safety consequences by encouraging workers to state they were injured at home.	Employers avoid responsibility by encouraging workers to say they were injured at home	Employees Encouraged to say Injured at Home
242. Open shop pays employees more to avoid putting the worker on the company insurance. Employee encouraged to state injuries were not job related.	Open shop pays employees more and encourages worker to state injuries not job related to avoid putting worker on company insurance.	Employees Encouraged to say Injured at Home
22. Employees are every bit as important as the equipent for a company.	Employees as important as equipment for a company	Employees Important like Equipment
257. Employer avoidance of responsibility regarding worker health and safety is a contributing factor to the shortage of needed skilled workers.	Employer avoidance of responsibility regarding health and safety is a contributing factor to the shortage of skilled workers	Employer Avoidance of Health and Safety Responsibilities
379. Sub-contractors can pick and choose the general contractors they want to work for based on safety ratings and pay and quality.	Sub-contractors can use safety ratings, pay, and quality to choose employer/general contractor	Employer Chosen via Safety Rating
266. Community Social contracts with local employers have increased worker on the job heath and safety practices.	Community contracts with employers have increased safety and health practices	Employer Community Contracts Increase Safety

213. Employer is ignorant to adverse health outcomes that result from the exposure of workers to health hazards.	Employer ignorant to adverse health outcomes resulting from exposures	Employer Education of Adverse Health Outcomes
187. Captive insurance maybe an avenue to educate owners regarding cost of worker illnesses.	Educate owners on costs of worker illnesses via captive insurance	Employer Education of Illness Costs
291. Protection from liability is the employers main concern for its experts.	Protection from liability is the employers main concern	Employer Liability Protection
129. Intrinsic motivation of employers needed to reduce or eliminate worker exposure to health hazards.	Employer motivation needed to reduce/eliminate worker health hazard exposures	Employer Motivation Reduces Exposures
164. Employers avoid responsibility of worker health and safety consequences by encouraging workers to state they were injured at home.	Employers avoid responsibility by encouraging workers to say they were injured at home	Employers Avoid Responsibility
145. Young people were taken advantage of by business owners and exposed young workers to health hazards.	Employers take advantage of young people and expose them to hazards	Employers Expose Youth to Hazards
162. Employers tell employees insurance costs a lot.	Employers tell employees insurance costs a lot.	Employers Told Insurance Expensive

190. Administrative and engineering controls are key for reducing worker exposures to health hazards.	Administrative and engineering controls are key for reducing hazard exposures	Engineering Controls Reduce Exposures
194. Engineering Technology	Engineering Technology	Engineering Technology
318. Mindset regarding importance of safety needs to become engrained in construction culture.	Need to engrain mindset of the importance of health and safety	Engrain Importance of Heath and Safety
377. Low bid mentality is engrained in workers and mangement organizations as a whole.	Low bid mentality engrained into workers and organization	Engrained Low Bid Mentality
148. University's did studies on union workers for hearing loss; but was this information transferred into the industry.	Ensure transfer of university studies to industry	Ensure Knowledge Transfer to Industry
239. There is a need to ensure qualifications are verifiable.	Need to ensure qualifications are verifiable	Ensure Qualifications Verifiable
244. Need for verification of worker classification to ensure honest wage practices.	Verification of worker classification needed to ensure honest wage practices.	Ensuring Honest Wage Practices
260. Safety is a new consideration added to entrenched mindsets.	Entrench safety as a new mindset	Entrench New Safety Mindset
225. Worker needs to feel comfortable using the new equipment.	Equipment needs to feel comfortable to the worker	Equipment Needs to Feel Comfortable

224. Contractors do not like to get rid of equipment simply because something seems better. Need equipment replacement plan to reduce potential hazards.	Equipment replacement plan needed to reduce potential hazards	Equipment Replacement Plan
58. Ergonomic processes are used to minimize or eliminate biomechanical impacts to body.	Ergonomic processes can minimize or eliminate impacts to body	Ergonomic Processes Impact Body
278. Other countries are leading changes in ergonomic design.	Other countries lead in ergonomic changes	Ergonomics of Other Countries
117. Continual rotational trade processes need to be examined for potential improvements.	Trade processes need to be examined for potential improvements	Examine Trade Processes for Improvements
118. Practical experience of Occupational Health and Safety experts to health hazards personally experienced is minimal.	Minimal personal & practical experience of Occupational health and safety experts to hazards	Experience of OSH Experts
290. Occupational health and safety consultants assist companies to reduce opportunities for liability resulting from worker injury or illness; protection from liability.	Occupational health and safety experts assist in reducing liability from worker injury or illness	Experts Assist in Injury/Illness Liability Reduction
133. Cost of exposing worker's is presently not apparent to owners.	Cost of worker exposure not apparent to owners	Exposure Cost is not Apparent
44. Exposure to hazards can complicate existing health issues.	Hazard exposures complicate existing health issues	Exposures Complicate Existing Health Issues

285. Changing mindsets regarding preventable ergonomics will facilitate its wider acceptance.	Changing mindsets will facilitate wider acceptance of ergonomics	Facilitating Wider Ergonomics Acceptance
77. Intermittent exposures to health hazards allow young men to heal giving them a false sense of health.	Intermittent exposures allow healing giving a false sense of health	False Sense of Health
96. False sense of invincibility for workers who continually perform unsafe practices w/out injury.	Performing unsafe practices without injury gives false sense of invincibility	False Sense of Invincibility
9. Intermittent use of loud tool gives workers a false sense of protection.	Intermittent use of loud tool gives workers a false sense of protection.	False Sense of Safety
8. Lag-time before on-set of impact to personal health gives false sense of "safety".	Lagtime before impact to health gives false sense of safety	False Sense of Safety
238. Prevalance of falsifying worker qualifications.	Prevalance of falsifying worker qualifications	Falsifying Worker Qualifications Prevalent
2. Family Influence.	Family Influence	Family Influence
347. Family influence telling kids not to go into trades like in the past.	Family influences kids not to go into trades	Family Influence Against Trades
4. Followed father's footsteps.	Father's footsteps	Father's footsteps
268. Fatigued Workforce = health and safety issue directly impacting construction productivity.	Fatigued workforce directly impacts construction productivity	Fatigue Directly Impacting Productivity

46. Open shops out number union shops by about 6 to 1.	Open shops outnumber union shops 6 to 2	Fewer Union Shops
13. Working environment was filthy. Respirators/PPE were needed.	Worker subjected to filthy environments	Filthy Worker Environments
136. Financial donations to politicians influence elections and laws passed.	Laws passed by politicians influenced by financial donations	Financial Donations Influence Laws Passed
392. Job Preplanning team requires members who can focus first on the work then the cost.	Preplanning requires focusing on the work before the cost	Focus on Work Before Cost
226. Foreman needs to enforce behaviors of apprentices and expectations regarding health and safety behaviors on jobsites.	Foreman needs to enforce behaviors and expectations on jobsites	Foreman Enforces Expected Jobsite Behaviors
231. Foreman important to ensure sub-contractors are adhering to management expectations.	Foreman important to ensure sub-contractors adhere to management expectations	Foreman ensures subcontractors Adhere to Expectations
229. Superintendent and foreman are important for delivering consistent expectations messages to workers.	Superintendent and foreman are important for delivering consistent communication	Foreman Important for Delivering Consistent Communication
231. Foreman important to ensure sub-contractors are adhering to management expectations.	Foreman ensures sub-contractors to adhere to management expectations	Foreman Important for Management Expectations
230. Foreman need to reinforce PPE requirements.	Foreman needs to reinforce PPE requirements	Foreman Reinforces PPE Requirements

178. Functional design of health and safety equipment to work with in the construction environment can help promote greater acceptance of health and safety practices.	Functional design of equipment can promote greater acceptance of health and safety practices	Functional Design of Equipment Promotes Practices
180. Functional health and safety equipment can help protect experienced workers who may have lessened dexterity as a result of age.	Functional health and safety equipment can help protect experienced workers with less dexterity	Functional Equipment Protects Aging Workers
227. Quality, production, ease of use, end user likeablity, are important for new equipment selection.	Quality, production, ease of use, end user likeablity, are important for new equipment selection.	Functionality Important for Equipment Selection
282. Convert lost wage accounts after certain periods for worker health and safety education programs.	Convert lost wage accounts to health and safety education programs.	Funding for Education Programs
114. Construction industry did not plan for future trade worker needs.	No planning for future trade workers needed.	Future Planning Needed
6. Gave up opportunity to finish college to become a bricklayer.	Gave up college to become bricklayer	Gave Up College
70. Education and awareness regarding cumulative health hazards for general public.	Education and awareness for general public	General Public Awareness of Health Hazards
72. Education needed for general public regarding cumulative health hazards.	General public education needed regarding cumulative health hazards	General Public Education of Health Hazards

238. Small companies work with local insurance companies and use general Worker's Compensation Insurance.	Small companies use general Worker's Compensation Insurance	General Worker's Compensation Used
101. Older experienced workers work with illness because think getting sick is normal for a construction worker.	Older workers think getting sick is normal	Getting Sick Perceived Normal
102. Mindset that getting sick or injured as a construction worker is acceptable and the normal course of things.	Construction worker mindset is that getting sick or injured is normal	Getting Sick Perceived Normal
99. Pain accepted as a "normal" part of the job.	Pain accepted as normal	Getting Sick Perceived Normal
146. An individual regardless of social or economic status should not accept exposure to a health hazard as a normal practice of employment.	Individual should not accept exposure to health hazard as a normal employment practice	Getting Sick Perceived Normal
93. Government agency collaboration could help to track onset of illnesses and financially responsible parties for adverse health outcomes developed by workers.	Government collaboration to track parties resposnible for onset of illnesses	Government Collaboration for Tracking Parties
187. Government contracts have third party payroll certifiers.	Government contracts have third party payroll certifiers	Government Contract Payroll Certifiers
184. Government contracting officers	Government contracting officers constrained to budget and schedule	Government Contracting Officer Constraints

constrained to maintain projects on budget and on schedule.		
274. Government can be asset in protecting workers from abusive wage practices.	Government can be asset in protecting workers from abusive wage practices.	Government Worker Protections from Abusive Practices
237. Need avenues for collaboration between businesses, employees, and government agencies.	Collaboration needed between businesses, employees, and government agencies	Government/Industry Stakeholder Collaboration Needed
120. Potential trades people have other options for employment today.	Other employment options for trades people today	Greater Employment Options Today
220. Sub-contractor exposures to health hazards needs greater focus.	Health hazard exposures need greater focus	Greater Focus on Hazard Exposures
24. Hazards Communication needs to happen at initial worker training prior to exposure to hazards.	Hazard communication at initial worker training	Hazard Communication at Initial Training
18. No communication channels throughout open-shop organizations to provide information about dangers of construction hazards.	Organizations perceived as construction-managers	Hazard Communication Channels Lacking
236. Requirement of appropriate health and safety communication regarding job hazards needed for employees.	Appropriate health and safety communication needs to be a requirement	Hazard Communication Channels Lacking
127. Hazards Communication needed for companies.	Companies need hazards communication	Hazard Communication Channels Lacking

39. There is need for channels to communicate health and safety information to industry.	Channels to communicate health and safety information to industry needed	Hazard Communication Channels Lacking
219. Communication with sub-contractors regarding equipment hazards can reduce worker exposures.	Communication regarding equipment hazards can reduce worker exposures	Hazard Communication Reduces Exposures
384. Its still a worker exposed to hazards regardless of union or open shop.	Workers exposed to health hazards regardless of labor source	Hazard Exposure Regardless of Labor Source
146. An individual regardless of social or economic status should not accept exposure to a health hazard as a normal practice of employment.	Individual should not accept exposure to health hazard as a normal employment practice	Hazard Exposure Unacceptable Employment Practice
151. Construction sites exposed workers, and visitors to dangerous health hazards.	Construction sites expose people to health hazards	Hazard Exposures On Construction Sites
34. Large equipment is sometimes designed to reduce hazards needed for smaller tools.	Hazard reduction design of smaller tools needed for larger equipment	Hazard Reduction Designs for Larger Equipment
45. Second hand smoking illnesses are analogous to dangers of cross trade hazard exposures.	Cross trade hazard dangers are analogous to second hand smoke	Hazards Analogous to 2nd Hand Smoke
391. Creates potentially more expensive hazards.	Hazards are expensive	Hazards are Expensive
214. Education regarding health hazards is often overlooked in construction.	Construction overlooked hazards education	Hazards Education Overlooked

169. Worker exposure to health hazards consistent regardless of company size.	Health hazard exposures consistent regardless of company size	Hazards Exposures Consistent Regardless of Company Size
75. Ignorance by worker of job hazards impacts the workers' personal health.	Ignorance of job hazards impacts worker's personal health	Hazards Impact Worker Health
123. Recognition of hazards using certain materials not confined to construction.	Material hazards not confined to construction	Hazards Not Confined to Construction
343. Change mindsets of people to think of health and safety at home as well as work.	People need to think of health and safety at home and work	Health and Safety at Home and Work
40. Use manufactures as potential channels for communicating health and safety knowledge to industries.	Communicating health and Safety Knowledge to Industries	Health and Safety Communication to Industries
241. Companies need to do economic assessments of expenditures to recognize existing financial opportunities for implementing health and safety practices.	Recognize existing financial opportunities for implementing Health and Safety.	Health and Safety Implementation
134. Cost-benefit analysis of implementing health and safety protocols.	Implementing health and safety protocols	Health and Safety Implementation
409. Look at what other countries doing with regard to safety.	Look at other countries regarding safety	Health and Safety in Other Countries
404. Learn best health and safety practices from other industries, e.g. Mars Corporation.	Learn health and safety practices from other industries	Health and Safety In Other Countries

229. Make certification or health and safety licenses a requirement for businesses.	Make health and safety licenses a business requirement	Health and Safety Licence Business Requirement
50. Health and safety equipment are considered overhead costs rather than capital investments.	Health and safety equipment not considered capital investment	Health and Safety Not a Capital Investment
71. Resource strapped organizations often do not prioritize health and safety protocols.	Health and safety protocols not prioritized	Health and Safety Not Prioritized
234. Health and Safety plans are not compulsory for construction businesses.	Health and Safety plans are not compulsory	Health and Safety Plans Not Compulsory
235. Health and safety plans are not required to be shared with employees.	Sharing health and safety plans not required	Health and Safety Plans Not Required
230. Employee health and safety training is not required of employers.	Employee health and safety planning not required	Health and Safety Plans Not Required
249. Actual health and safety practices not major barriers to worker protections.	Health and Safety practices not barriers	Health and Safety Practice Barriers
234. Enforcement, communication, and education from mid-management to field level leadership is essential for maintaining integrity of health and safety programs.	Enforcement, communication, and education essentila for integrity of health and safety programs	Health and Safety Program Integrity
51. The need to purchase health and safety equipment raises the price of job bids/contracts.	Price of job contracts raised with need to purchase health and safety equipment	Health and Safety Raises Contract Prices

136. Unethical to knowingly expose people to a health hazards.	Knowingly exposing people unethical	Health Hazard Exposures Unethical
140. Utilize public service announcements and other "everyday" media to inform general public about hazards.	Inform general public about hazards via public service announcements	Health Hazard Information via Public Service Announcements
138. Previous campaigns about health hazards such as smoking and second hand smoke have become public knowledge via public service education.	Smoking hazards have become public knowledge via public service education	Health Hazard Information via Public Service Announcements
8. Lag-time before on-set of impact to personal health gives false sense of "safety".	Lagtime before impact to health gives false sense of safety	Health Impact Lagtime
64. Difficult to track quarterly or annual impacts of silica or noise to workers.	Quarterly and annual impacts of silica or noise difficult to track	Health Impacts Difficult to Track
80. Health hazards cannot presently be traced to a root-cause for industries.	Health hazards cannot presently be traced to root cause	Health Impacts Difficult to Track
74. Lag time to onset of illnesses makes the severity of cumulative health issues difficult to drive home to people.	Lagtime of illnesses makes severity of issues difficult to drive home	Health Impacts Difficult to Track
63. Cumulative health effects not apparent to track like musculoskeletal injuries.	Cumulative health effects not apparent to track	Health Impacts Difficult to Track
40. Compounded health issues decrease worker	Compounded health issues decrease worker health exponentially.	Health Issues Exponentially Decrease Worker Health

health exponentially.		
107. Healthier environments are more productive.	Healthier environments are more productive	Healthier Environments are Productive
72. Owner mindset has to be focused on healthy employees as assets.	Focus on employees as assets	Healthy Employee as Asset Mindset
21. No flexibility in requiring workers to use hearing protection when exposed to hearing dangers.	Workers should be required to wear hearing protection when exposed to hearing dangers	Hearing Protection Required for Hearing Dangers
149. Hearing protection is used only when operating machinery; however, jobsites are noisy in general.	Hearing protection required when operating noisy machinery	Hearing Protection Required for Noisey Machinery
56. Assembly of pre-fabricated materials places high physical demands on workers.	Prefabrication assembly places high physical demands on workers	High Physical Demands on Workers
106. High worker turnover is a barrier to consistent application of hazard preventions.	High worker turnover is a barrier to consistent application of preventions.	High Worker Turnover Barrier to Preventions
87. Workers often demand higher wages when companies implement additional safety practices.	Workers demand higher wages when companies implement safety practices	High Worker Wage Demands
169. High worker turnover results in higher insurance premiums for consciencous employers.	Conscienous employer pay higher insurance premiums for high worker turnover	Higher Premium for High Worker Turnover

212. Workers ignorant to the connection between exposures to health hazards and the onset of adverse health consequences.	Ignorance between connection of hazard exposures and adverse health consequences	Ignorance of Connection between Hazard Exposure and Health Consequences
213. Employer is ignorant to adverse health outcomes that result from the exposure of workers to health hazards.	Employer ignorant to adverse health outcomes resulting from exposures	Ignorance of Construction Hazards
214. People think "dust" is harmless. Ignorant to construction site material dangers.	Ignorance regarding construction site material dangers	Ignorance of Construction Hazards
152a. Yet may be uninformed as to how to protect themselves appropriately.	Workers uninformed as to how to protect themselves	Ignorance of Construction Hazards
38. Small to medium sized companies are often ignorant to health and safety hazards.	Small to medium sized companies ignorant to hazards	Ignorance of Construction Hazards
44. Lack of awareness of dangers.	Lack of awareness of dangers	Ignorance of Construction Hazards
83. Little specks of blood as opposed to a large goop of blood; cause less to no concern to young workers ignorant to signs and symptoms of developing adverse health issues.	Young workers ignorant to signs and symptoms of developing health issues	Ignorance to Developing Health Issues
78. Impacts of intermittent exposures to health hazards do not leave immediate evident of severity of	Intermittent exposures do not leave evidence of the severity of developing health consequences	Ignorance to Developing Health Issues

adverse health consequences that are developing.		
248. Worker ignorance regarding illegal wage and employment practices.	Ignorance regarding illegal wage and employment practices	Ignorancee of Illegal Wage and Employment Practices
16. As a young worker ignorant of construction hazards.	Young worker ignorant of construction hazards	Ignorant of Construction Hazards
24. As a young worker ignorant of health and safety protections.	Young worker ignorant of health and safety protections	Ignorant of Health and Safety Protections
279. Immigrant workers are more ignorant of wage labor protections.	Immigrants ignorant of wage labor protections	Ignorant to Illegal Wage and Employment Practices
245. Actual practices of protecting workers hampered by political and illegal business practices.	Illegal business practices hamper protecting workers	Illegal Practices Hamper Worker Protections
165. Employers do illegal practices to avoid paying higher insurance premiums.	Employers do illegal practices to avoid paying higher insurance premiums.	Illegal Practices to Avoid Higher Premiums
165. Employers do illegal practices to avoid paying higher insurance premiums.	Employers do illegal practices to avoid paying higher insurance premiums.	Illegal Practices to Avoid Higher Premiums
253. Illegal practices for companies are used to avoid liability for worker's injured attempting to meet productivity demands.	Illegal practices used to avoid liability for injured workers	Illegal Practices to Avoid Liability
176. Irresponsible companies practice illegal	Illegal wage actions practiced to lower bid prices	Illegal Wage Actions Lower Bid Prices

wage actions to lower bid prices.		
243. Illegal wage practices are pervasive even on government contract jobs.	Illegal wage practices are pervasive even on government contract jobs.	Illegal Wage Practices on Government Jobs
88. Develop illness compensation funds for retired workers with silicosis similar to Black Lung Trust fund.	Develop illness compensation funds.	Illness Compensation Funds
208. Lagtime of onset of illnesses creates false sense of "safety and health" among workers.	Lagtime of illnesses creates false sense of "safety and health" among workers.	Illness Lagtime Creates False Sense of Health and Safety
253. Illusion that companies put safety first.	Illusion of safety	Illusion of Safety
10. Bricklayer trade provided career and immediate paid work that college did not.	Bricklayer trade provided immediate paid work that college did not	Immediate Trade Pay Versus College Debt
260. Immigrant workers ignorant to health and safety responsibilities of employers.	Immigrant workers ignorant to health and safety responsibilities of employers.	Immigrant Workers Ignorant to Employer Responsibilities
260. Immigrant workers ignorant to health and safety responsibilities of employers.	Immigrant workers ignorant to health and safety responsibilities of employers.	Immigrant Workers Ignorant to Health and Safety
418. America and the world have been built by immigrants.	Immigrants have built America and the world	Immigrants Built America
417. Immigration into construction is not a new phenomenon.	Immigration is not new for construction	Immigration in Construction Not New

376. Get shit done mindset impacts productivity, planning, etc.	Impatient mindsets impact productivity, planning	Impacts of Impatient Mindsets
375. Enemy of safety is get shit done.	Enemy of safety is impatient mindsets	Impatience is Safety Enemy
167. Equipment is not often maintained properly and can potentially harm workers.	Improperly maintained equipment can cause harm	Improperly Maintained Equipment Harms
215. Improvement needed in construction industry regarding education for all levels of industry to health and safety hazards.	Improvement needed regarding education of health and safety hazards	Improve Health and Safety Hazard Education
46.a Therefore, need to educate larger portion of industry to health and safety risks.	Larger portion of industry needs health and safety education	Improve Health and Safety Hazard Education
70. Greater ignorance regarding health and safety concerns is within the 99% of the construction industry comprised of companies with less than 500 employees and not the companies with 500+ employees.	Greater ignorance of health and safety concerns is in 99% of the industry	Improve Health and Safety Hazard Education
33. Small to mid-sized companies need resource and awareness education regarding health and safety issues that can impact worker well-being.	Education needed regardng health and safety issues	Improve Health and Safety Hazard Education

168. Working conditions can be improved even though they are better than in 3rd world countries.	Working conditions can be improved	Improve Working Conditions
205. 2nd and 3rd tier sub-contractor communication needs improvement.	2nd and 3rd tier sub-contractor communication needs improvement.	Improved 2nd/3rd Tier Subcontractor Communication
221. Mindsets regarding communication among various management levels and contractor levels needs improvement.	Mindsets regarding communication among various management levels needs improvement	Improved Communication Among Management Levels
221. Channels for communicating health and safety practices needs to be improved.	Improved channels for communicating health and safety practices	Improved Health and Safety Communication Channels
254. Smaller companies waste more on quality and production than would spend on safety.	More spent on quality and production than safety	Improving Efficiency Frees Resources
261. Need incentives or process changes to shift old mindsets disregarding safety.	Incentives and Process Changes Needed shifting mindsets disregarding safety	Incentives and Process Changes Needed
333. Incentives often do not have desired effect.	Incentives do not have desired effect	Incentives Lack Desired Effect
336. Incentives viewed in compliance (OSHA) as promoting the cover up of safety and health issues.	Compliance views incentives as cover up for issues	Incentives Viewed as Cover Up
118. Industry needs to reassess how it pays labor to incentivize laborers to remain in industry.	Industry needs reassessment of labor pay needed to incentivize labor retention	Incentivize Labor Retention
94. Develop incentives for businesses to prioritize	Incentivize businesses to prioritize worker health and safety within business	Incentivize Prioritizing Health and Safety

worker health and safety within their business plans.	plans.	
33. Equipment design needs to incorporate hazard reduction.	Hazard reduction incorporated into equipment design	Incorporate Hazard Reduction into Equipment Design
411. Incorporate technology into productivity, communication and job safety.	Incorporate technology into productivity, communication and job safety.	Incorporate Technology
131. Develop industry accountability to OSHA.	Industry accountability	Industry Accountability
60. Work in collaboration with insurance companies to address high injury and illness occurrences.	Address high injury and illnesses in collaboration with insurance companies	Industry and Insurance Collaboration Addressing Illness and Injuries
269. Construction industry needs to be open to new ideas addressing health and safety issues.	Construction industry needs to be open to new ideas	Industry Needs New Ideas
181a. Regulations do not increase costs, industry negligence increases costs.	Regulations do not increase costs, industry negligence increases costs.	Industry Negligence Increases Costs
90. Industry responsible for workers impacted by and exposed to health hazards.	Industry responsible for worker health hazard impacts	Industry Responsible for Worker Impacts
77. Incentives for industry to police itself are lacking.	Lacking incentives for industry to police itself	Industry Self-Policing Incentives Lacking
126. Opportunities for collaboration within the industry between workers and OHS experts needed to	Industry, OSH experts, and worker collaboration needed	Industry Stakeholder Collaboration Needed

address health issues.		
158. Industry can potentially use media to mislead general public regarding severity of health hazards.	Industry using media to mislead general public regarding health hazards.	Industry Using Media to Mislead
109. Inexperienced workers are the most dangerous.	Inexperienced workers are the most dangerous.	Inexperienced Workers are Dangerous
143. Media can be used to have health information become a "common" knowledge.	Health information can become "common knowledge" via media.	Inform About Heath via Media
250. Improved information delivery to employees of health and safety practices	Improved information delivery	Information Delivery
124. Information regarding material health hazard is more prevalent in other professions than in the construction industry.	Information regarding health hazards more prevalent in other professions	Information Prevalent in Other Professions
241. Employers avoid responsibility for injured workers.	Responsibility for injured workers avoided	Injured Worker Responsibility Avoided
292. Connection between musculoskeletal injuries and prescription drug abuse has larger societal impacts.	Connection between musculoskeletal injuries and prescription drug	Injuries Connected to Drug Abuse
252. Remind people that if they are injured their quality of life will be negatively impacted.	Injuries negatively impact quality of life	Injuries Impact Life Quality

179. Demonstrating to industry that indirect total costs of illnesses and injuries is a good motivation for industry to seriously address worker concerns.	Cost of injuries and illness is a good motivator for addressing worker concerns	Injury and Illness Costs Motivate Addressing Concerns
251. Need to develop company protocols for correctly documenting worker injuries and illnesses.	Company protocols needed for documenting injuries and illnesses	Injury and Illness Documentation Protocols
271. Data exists regarding injuries, but industry does not apply it.	Industry does not apply existing injury data	Injury Data Not Applied
100. Education needed regarding smarter work practices that reduce injury.	Education regarding work practices that reduce injury	Injury Reduction Practices Education
181. Reduction of injuries saves industry money	Reduction of injuries saves money	Injury Reduction Saves Money
60. Cooperation between insurance industry to communicate health and safety awareness to construction industry.	Insurance company can communicate health and safety awareness to construction industry	Insurance Communicates Health and Safety Industry Awareness
61.a Potential insurance rate decreases for responsible companies.	Insurance rates decrease for responsible companies	Insurance Decreased for Responsible Companies
65. Industry acceptance of responsibility for worker health can help reduce insurance premiums.	Reduction of insurance premiums via industry acceptance of responsibility for worker health	Insurance Decreased for Responsible Companies
172. Cost of irresponsible employers paid by other employers in the insurance	Cost of irresponsible employers paid by insurance pool.	Insurance Pool Costs

pool.		
166. Relationships between workers compensation rating and insurance premiums.	Insurance premiums are related to workers compensation ratings.	Insurance Premiums Related to Rating
243. Safety and health has to be integrated into the business plan.	Integrate health and safety into business plans	Integrate Health and Safety into Business Plans
257. Safety and health education needs to be promoted in engineering training programs.	Promote health and safety training in engineering programs	Integrate Health and Safety into Engineering Training
259. Safety and health considerations need to be integrated into all aspects of engineering training programs.	Safety and health need to be integrated into all aspects of engineering training programs	Integrate Health and Safety into Engineering Training
202. Train young construction professionals regarding material dangers.	Train young professionals regarding material dangers	Integrate Health and Safety into Engineering Training
394. Health and safety and risk training needed for young professionals.	Young professionals need health and safety training	Integrate Health and Safety into Engineering Training
94. Develop incentives for businesses to prioritize worker health and safety within their business plans.	Incentivize businesses to prioritize worker health and safety within business plans.	Integrate Health and Safety into Engineering Training
265. Safety needs to be incorporated as part of the process.	Process needs to incorporate safety	Integrate Safety into Business Plans
286. Safety needs to be integrated into the business plans.	Integration of safety needed into business plans	Integrate Safety into Business Plans

311. Managers need to interact with folks on the field before making decisions.	Before making decision managers need to interact with folks on field	Interact with Folks Before Making Decisions
77. Intermittent exposures to health hazards allow young men to heal giving them a false sense of health.	Intermittent exposures allow healing giving a false sense of health	Intermittent Exposures Allow Healing
9. Intermittent use of loud tool gives workers a false sense of protection.	Intermittent use of loud tool gives workers a false sense of protection.	Intermittent Use of Loud Tools
78. Impacts of intermittent exposures to health hazards do not leave immediate evident of severity of adverse health consequences that are developing.	Intermittent exposures do not leave evidence of the severity of developing health consequences	Intermittment Exposures Leave No Evidence
103. Intervention needs to be assessed for new hazards.	Interventions needed for new hazard Assessments	Interventions Needed for New Hazards
357. Incentivizing folks to change depends on what intrinsically motivates them.	Intrinsic motivation incentivizes folks	Intrinsic Motivation Incentivizes
56. Work with venture capitalists to invest in companies that adopt using safer materials or eliminate hazardous materials from processes.	Work with venture capitalists to invest in companies that adopt using safer materials	Invest in Companies Using Safer Materials
111. Invest in equipment that removes the hazard rather than protect for the hazard if possible.	Invest in equipment that removes rather than protects from the hazard	Invest in Equipment that Removes Hazard

111. Invest in equipment that removes the hazard rather than protect for the hazard if possible.	Invest in equipment that removes the hazard rather than protects from the hazard	Invest in Equipment that Removes Hazard
55a. Investors can use this analysis to rate a companies investment in worker health and safety prior to investing their capital in that company.	Investors can rate a companies investment in worker health and safety prior to investing in that company	Investers Rate Company Health and Safety Investments
239. Starting a captive with smaller companies is challenging because need investment captial.	Need investment captial to start a captive	Investment Captial Needed For Captive
55a. Investors can use this analysis to rate a companies investment in worker health and safety prior to investing their capital in that company.	Investors can rate a companies investment in worker health and safety prior to investing in that company	Investments Based on Health and Safety Rating
225. Young men and experienced workers may have the mindset of being invincible.	Young men and experienced workers may have invincible mindset	Invincible Worker Mindset
170. Irresponsible employers impact insurance premium costs for all employers.	Insurance premiums impacted by irresponsible employers	Irresponsible Employers Impact Premiums
88. Worker's Compensation Insurance is not associated with an employer who may have been the cause of the incident.	Workers compensation insurance not associated with employer responsible for incident.	Irresponsible Employers not Associated with Incident

88. Worker's Compensation Insurance is not associated with an employer who may have been the cause of the incident.	Workers compensation insurance not associated with employer responsible for incident.	Irresponsible Employers not Associated with Incident
89. Last employer worker was employed for pays the Worker's Compensation Insurance claims.	Workers compensation claim paid for by last employer	Irresponsible Employers not Associated with Incident
90. Employer may have limited avenues to prove his/her company did not expose the worker to a health hazard.	Limited avenues for employers to prove did not expose workers to hazards.	Irresponsible Employers not Associated with Incident
75. Ignorance by worker of job hazards impacts the workers' personal health.	Ignorance of job hazards impacts worker's personal health	Job Hazard Education Lacking
57. Preplanning of job work designed to accommodate physical abilities of worker biomechanics.	Worker biomechanics accommodated via job preplanning	Job Preplanning Accommodates Biomechanics
188. Preplanning and trade scheduling/job sequencing can minimize worker exposure.	Preplanning, trade scheduling, and job sequencing can minimize worker exposure	Job Sequencing
193. Job Sequencing	Job Sequencing	Job Sequencing
208. Job sequencing to miminize exposure of cross-trade hazards.	Job sequencing can minimize cross trade hazards	Job Sequencing Minimizes Hazards
11. Junior partner of union company.	Junior Partner	Junior Partner
173. Businesses can keep records of worker injuries.	Keep records of worker injuries	Keep Worker Injury Records

190. Administrative and engineering controls are key for reducing worker exposures to health hazards.	Administrative and engineering controls are key for reducing hazard exposures	Keys to Reducing Hazard Exposures
91. Have opportunities within construction to retrain workers so knowledge is transferred within the industry from labor to those supervising the work.	Knowledge transfer within industry needed from supervisors to laborers	Knowledge Transfer within Industry
427. Passing on experience of older workers to new generations is vital.	Vital to pass on experience	Knowledge Transfer within Industry
386. Use of Union labor changes bid prices and other processes on jobs.	Use of Union labor changes bid prices	Labor Source Changes Bid Prices
387. Union or open shop influence the type of relationship between trades and non-trades.	Union or open shop influence relationships between trades and non-trades	Labor Source Influences Trades/Non-Trades Relationships
298. Skill set of workers varies between open shop and unions.	Open shop and union worker skills vary	Labor Source Skills Vary
111. Lack of education of new trades person puts them at greater danger.	Lack of education endangers new trades people	Lack of Education Endangers Trade People
202. Ignorance of health hazards by workers points to the need for education of potential workforce and continuing education.	Ignorance of health hazards points to need for education and continuing education	Lack of Education to Health Hazards
98. Barrier is lack of identification of a hazard.	Barrier is lack of identification of a hazard.	Lack of Hazard Identification

191. Large corporations follow rules because have greatest potential for litigation.	Larger corporations have greatest potential for litigation	Large Corporations Greatest Litigation Potential
195. Large portion of construction industry is without real enforcement for health and safety regulations.	Large portion of construction without health and safety regulation enforcement	Large Portion of Construction without Enforcement
170. Workers do work for large US Manufacturers.	Workers Work for US Manufacturers.	Large US Manufacturer Workers
342. Leadership needs to make safety and health awareness important.	Leadership needs to make safety and health awareness important.	Leadership Awareness
321. Leadership need to practice what it preaches regarding safety issues.	Leadership needs to practice safety	Leadership Safety Practices
223. Work with vendors to learn about new technology to understand benefit.	Work with vendors to learn about new technology	Learn About New Technology Via Vendors
283. Reduction of OSHA fines via legal avenues cheaper for owners than to address health and safety violations.	OSHA fines reduced via legal action cheaper than addressing violations	Legal Action Reduces Fines
284. Businesses negotiate with OSHA to reduce fines.	Negotiation with OSHA can reduce fines	Legal Action Reduces Fines
286. Consequences for fatalities are not a Deterrent because companies can negotiate fines to almost nothing.	Consequences are not a deterrent because negotiate fines to almost nothing	Legal Action Reduces Fines
67. Ethical and moral business choices can be	Appropriate legislation can motivate ethical and business choices	Legislation Motivates Business Choices

motivated by appropriate legislation.		
380. Sub-contractors are charging less safety conscious contractors more money.	Less safety conscious contractors are charged more money	Less Safety Conscious Contractors Charged More
359. Near miss - discuss lessons learned so can remove future potential near miss hazards.	Discuss lessons learned to remove future hazards	Lessons Learned Discussions
37. Avenues for open shops to acquire health and safety information is limited.	Limited avenues for open shops to acquire health and safety information	Limited Avenues for Open Shop Information
26. Open shops ususally operate in a vacuum. No affliation with others for health and safety information.	Open shops operate in a vacuum and do not affliate with others	Limited Avenues for Open Shop Information
258. Construction industry needs to recognize skilled workers as a limited asset.	Industry needs to recognize workers as a limited asset	Long Term Planning for Worker Assets
259. Construction industry needs long-term planning with regard to workers as assets.	Longterm planning needed regarding workers as assets	Longterm Planning Workers Assets
323. Low bid society creates, thin, lean and mean society.	Low bid society creates, thin, lean and mean society.	Low Bid Creates Mean Socity

174. Irresponsible companies will low bid. Low bids often cut corners on health and safety provisions. E.g. Contracts should specifically outline health and saftey costs to show bids are realistic and fair.	Low bids cut corners on health and safety provisions	Low Bids Cut Health and Safety Provisions
391a. Using the lowest quality materials	Lowest quality materials used.	Low Quality Materials Used
134. Production costs increase from lower worker productivity has not reached a critical level for owners to recognize it's financial impacts.	Increased costs from lower worker productivity has not reached a critical level so financial impacts are realized	Lower Productivity Costs Not Reached Critical Level
134. Production costs increase from lower worker productivity has not reached a critical level for owners to recognize it's financial impacts.	Increased costs from lower worker productivity has not reached a critical level so financial impacts are realized	Lower Productivity Financial Impacts Not Realized
94. Macho attitude is a barrier to the application of education regarding health and safety practices.	Macho attitude is a barrier to application of education regarding safety practices	Macho Attitude is a Barrier
94. Macho attitude is a barrier to the application of education regarding health and safety practices.	Macho attitude is a barrier to application of education regarding safety practices	Macho Attitude is a Barrier
93. Macho attitudes physically endanger workers.	Macho attitudes endanger workers	Macho Attitudes Endanger
147. Macho mindset and ability to take exposures to	Macho mindset to acceptance of health hazards needs to change	Macho Attitudes Endanger

health hazards needs to be changed.		
92. Macho disposition about being a construction worker contributes to musculoskeletal injuries.	Macho attitudes contribute to musculoskeletal injuries	Macho Attitudes Endanger
95. Recognition of macho attitude influence on how workers should be trained is important.	Macho attitudes influences how workers are trained	Macho Attitudes Influence Training
23. Similarly to maintaining the "health" equipment via maintenance; Employee health should be considered as important. (Health of equipment = health of employee)	Employee health should be maintained as equipment is maintained.	Maintain Employee Health
235. Priority of companies is key for maintaining processes that are in place: such as production, quality, and safety and health.	Company priorities key for maintaining production, quality, and safety and health	Maintaining Health and Safety
235. Priority of companies is key for maintaining processes that are in place: such as production, quality, and safety and health.	Company priorities key for maintaining production, quality, and safety and health	Maintaining Productity
235. Priority of companies is key for maintaining processes that are in place: such as production, quality, and safety and health.	Company priorities key for maintaining production, quality, and safety and health	Maintaining Quality

73. Dangers of cumulative health hazards need to be made more concrete.	Health hazards dangers need to be made more concrete	Make Health Hazard Dangers More Concrete
42. Majority of deaths (99%) from silica are in male dominated industries like construction.	Majority of silica deaths are in male dominated industries	Male Silica Deaths Dominate Industries
228. Continual reinforcement of clear expectations from management are important for protecting worker health.	Continual Reinforcement of management expectations	Management Expectations Continually Reinforced
344. Management involvement and concern for worker well being is an incentive for recruiting and attracting workers.	Incentives for recruiting are management involvement and concern for worker well being	Management Incentives for Worker Recruitment
204. Mandatory training/education requirements for workers before they can work in the trade.	Mandatory training before workers can work	Mandatory Work Training
40. Use manufactures as potential channels for communicating health and safety knowledge to industries.	Use Manufacturers as potential channels for communicating to Industries	Manufacturers as Communication Channels
49. Manufacturers may deny their products are toxic for fear of litigation.	Manufacturers deny products are toxic fearing litigation	Manufacturers Deny Toxic Hazards
49. Manufacturers may deny their products are toxic for fear of litigation.	Manufacturers deny products are toxic fearing litigation	Manufacturers Fear Litigation

58. Manufacturers can be key for communicating to both open shop and union companies because regardless of labor type companies need to purchase certain materials and there are only a limited number of manufacturers of those materials.	Limited number of manufacturers can influence products	Manufacturers Influence Products
283. Manufacturers are influencing the general public by changing product designs.	Manufacturers influence public via product designs	Manufacturers Influence Public
58. Manufacturers can be key for communicating to both open shop and union companies because regardless of labor type companies need to purchase certain materials and there are only a limited number of manufacturers of those materials.	Manufacturers key for Communicating to Companies About Materials	Manufacturers Key for Communicating to Companies
54. Some manufacturers have removed hazards from their materials and they are still profitable.	Manufacturers who have removed hazards from materials are still profitable	Manufacturers Profitable After Removing Hazards
Manufacturers can set health and safety expectations for its contractors.	Manufacturers set Contractor Health and Safety Expectations	Manufacturers Set Contractor Expectations

58. Manufacturers can be key for communicating to both open shop and union companies because regardless of labor type companies need to purchase certain materials and there are only a limited number of manufacturers of those materials.	Manufacturers key for Communicating to Companies About Materials	Manufactures Key for Communicating About Materials
142. Media is an effective means to reach larger audiences with health hazard information.	Larger audiences can be reached media	Media Reaches Larger Audiences
81. Need to change mindset of company medical to work with safety to protect workers rather than cover up symptoms of the development of worker adverse health conditions.	Work with Safety to Protect Workers rather than Cover up Symptoms of Adverse Health Conditions	Medical and Safety Work Together
206. Mid and upper management is central to developing effective communications with sub-contractors.	Mid and upper management central to effective communications	Mid Level Managers Central to Communication
306. Use influence of mid-level managers to keep health and safety processes and communication in check and clear.	Mid level manager influence needed to keep communication in check and clear	Mid Level Managers Influence Communication
305. Mid-level managers can influence helping move things forward regarding risk management and risk	Mid level managers influence risk management and risk mitigation	Mid level Managers Influence Risk

mitigation.		
326. Mindset to work around safety or health issues rather than take issue seriously.	Mindset to work around safety or health issues rather than take issue seriously	Mindset of Working Around Safety and Health
113. Shift mindsets from protection to prevention.	Mindset shift from protection to prevention	Mindset Shift from Prevention to Protection
276.a Everyday construction product consumer mindsets also need to be changed.	Consumer mindsets need changing.	Mindsets
154. Companies did not have monitoring and hazard control programs.	No Monitoring and hazard control programs	Monitoring and Hazard Control Programs Absent
139. Safety is a moral choice beyond regulatory composition.	Safety is a moral choice beyond regulations	Moral Choices Beyond Legislation
199. Majority of construction jobs are tenant improvements and remodeling.	Tenant improvements and remodeling are the majority of construction jobs	Most Construction Not High End
189. Most construction jobs are not high end.	Most construction are not high end	Most Construction Not High End
410. Need to change mindset from safety as compliance to safety as good business practice.	Safety mindsets need to change from compliance to good business practice	Move from Compliance Mindset to Safety as Good Business Practices
365. Move mindsets from compliance to risk mitigation and risk hazard reduction.	Risk mindsets need to move from compliance to mitigation and hazard reduction	Move from Compliance Minset to Mitigation and Reduction

144. Multi-generational bricklayers.	Multi-generational bricklayers	Multi-generational bricklayers
151. Answers to problem are multilayered.	Answers are multilayered	Multilayer Answers
1. Family has been bricklayers for mulitple generations.	Bricklayers for Multiple Generations	Multiple Generation Bricklayers
161. Musculoskeletal injuries dominate cumulative health issues in construction.	Musculoskeletal injuries dominate cumulative health issues in construction.	Musculoskeletal Injuries Dominate Construction
34. Small shop owners need education to increase their awareness to cumulative health hazards.	Small shop owners need awareness to cumulative health hazards	Need Awareness of Cumulative Health Hazards
202. Ignorance of health hazards by workers points to the need for education of potential workforce and continuing education.	Ignorance of health hazards points to need for education and continuing education	Need Continuing Education for Health Hazards
124. Hazard education necessary at all levels of the organization.	Hazard education necessary at all levels	Need Hazard Education at All Levels
216a. Need for more impacting educational materials communicating dangers of health hazards.	Need for more impacting educational materials	Need Impacting Educational Materials
378. Communication and collaboration among leaders to trades people needs improvement.	Communication and collaboration among leaders to trades people needs improvement	Need Management to Field Communication
310. Staff meeting communications do not	Staff communnications do not make it to the field	Need Management to Field Communications

make it out onto the field all the time.		
307. Better processes needed for communicating expectations from top management to field level.	Better processes needed for communication from top management to field level	Need Management to Field Communications
277. Workers do not apply for reimbursement of stolen wages because ignorant to rights.	Worker ignorance of rights to apply for reimbursement of stolen wages	Need Worker Wage and Labor Education
32. Open shops message was that "Employees were enemies". So there was no concern for the employee as an asset.	No concern for the employee as asset.	Negative Industry Culture to Workers
331. Compliance as an incentive has not had positive results.	Compliance is not a positive incentive	Negative Results via Compliance
419. Think of how new and different approaches to a challenge can potentially create more holistic solutions.	New and different approches can create holistic solutions	New and Different Approaches Create Holistic Solutions
50. Introducing new tool design to general public takes time.	New tool design introduction takes time.	New Design Introduction takes Time
52. If health and safety issues are not addressed, a new generation of workers will be ill from exposures to occupational health hazards.	New generation of workers will be ill if health and safety issues not addressed.	New Generation of Ill Workers without Addressing Issues

198. New silica regulation increases the focus on health concerns resulting from silica exposures.	New silica regulation increases focus on health concerns from exposures	New Regulations Focused on Health Concerns
408. Bad habits start because there are no consequences for unsafe choices.	No consequences for unsafe choices	No consequences for unsafe choices
153. Industry experiences no financial consequences for treating people as disposable.	No financial consequences for treating people as disposable	No Consequences Treating People as Disposable
285. Businesses have no incentives to promote health and safety practices.	No incentives for business to promote health and safety	No Incentives for Health and Safety Promotion
81. Industry avoids financial consequences for cumulative health issues.	Financial consequences for cumulative health issues avoided	No Industry Consequences for Health Impacts
2. There is no legal OSHA standard requiring the use of hearing protection.	No legal OSHA standard for hearing protection	No Legal Hearing Protection Standard
19. OSHA recognizes noise as a hazard but there is no regulation.	No OSHA regulation for noise	No Legal Hearing Protection Standard
270. Wage theft of workers; workers have no legal protections.	Workers have no legal protections for wage theft.	No Legal Wage Theft Protection
146. Open shop did not offer career development/advancement opportunities to young workers.	Open shop did not offer career development	No Open Shop Career Development
296. Open shop may or may not have trade	Open shop may or may not have trade training.	No Open Shop Career Development

training.		
297. Union workers have training not available to open shop.	Union workers have training not available to open shop.	No Open Shop Career Development
20. As a young worker did not have any affliations with organizations where could go to gain knowledge regarding health and safety hazards.	No affliation with organization where could gain knowledge	No Open Shop Organizational Affiliations
299. Non-union requiring workers to have job skills training before getting hired.	Non-union requiring workers to have job	Non Union Worker Hiring Requirements
308. Not all projects have a project manager.	Not all projects have a project manager.	Not All Projects Have Manager
332. Small to mid-size project can be run by crew leader or most senior craftsperson not trained in project management.	Small to mid-size project can be run by crew leader or most senior craftsperson not trained in project management.	Not All Projects Have Manager
316. People don't get paid to sit around and think about risks.	People don't get paid to sit	Not Paid to Sit
291. Proper nutritional options impact worker fitness off duty.	Proper nutrition impacts workers off duty	Nutrition Impacts Workers
267. Obese Workforce = health and safety issue directly impacting construction productivity.	Obesity is directly impacting construction productivity	Obesity Directly Impacting Productivity

289. Occupational health and safety experts are not affiliated with OSHA.	Occupational health and safety experts not OSHA affiliated	OHS Experts Non-OSHA Affliliated
48. Design of selected tools should not eliminate one hazard and replace it with another.	Selected tool design should not replace one hazard with another	One Hazard Not Replaced by Another
421. Difficult for one person to catch all safety issues.	Difficult for one person to catch all safety issues.	One Person Catching Issues
300. Non-union collaborating with local schools to train workers.	Non-union collaborating with local schools to train workers.	Open Shop Collaboration with Local Schools
46. Open shops out number union shops by about 6 to 1.	Open shops outnumber union shops 6 to 1	Open Shop Numbers Greater
67. Open shops do not monitor payroll to ensure workers are classified correctly.	Open shops do not monitor payroll to ensure proper worker classification	Open Shop Payroll Not Monitored
242. Open shop pays employees more to avoid putting the worker on the company insurance. Employee encouraged to state injuries were not job related.	Open shop pays employees more and encourages worker to state injuries not job related to avoid putting worker on company insurance.	Open Shop Pays Higher Wages
76. Arizona mainly an open shop state.	Arizona is an open shop state	Open Shop State
363. Change company mindset to be open to communication from workers.	Change mindset to be open to worker communication	Open to Communication from Worker
140. Openmindedness needed for the development of possible	Openmindedness needed for developing solutions or eliminating exposures to health hazards	Openmindedness for Solutions to Exposures

solutions to eliminating or reducing worker exposure to cumulative health hazards.		
130. Analyze health and safety problems from the standpoint of opportunities to increase productivity.	Health and safety problems are opportunities to increase productivity	Opportunties to Increase Productivity
119. Occupational health and safety experts and craft workers need to work together; Industry collaboration needed.	Industry collaboration needed among OSH experts and craft workers	OSH Experts and Worker Collaboration Needed
218. OSHA funding limits its ability to enforce its regulations.	Funding limits OSHA ability to enforce regulations	OSHA Funding Limits Enforcement
219. Present generation of experienced workers is older than OSHA agency.	OSHA is a new agency	OSHA is a New Agency
217. OSHA is a newer agency at 40 years old. Not as famous as the IRS. Everyone knows about the IRS.	OSHA is a newer less famous agency	OSHA New Agency
197. Private health and safety experts partner with OSHA to ensure health and safety regulations are followed.	Private health and safety experts partner with OSHA to ensure regulations are followed	OSHA Partnerships Ensure Regulations Followed
173. Responsible companies contract bids are often considered high. Therefore, within contracts the costs of health and safety investments should be specifically outlined to show bids are realistic and fair.	Costs of health and safety should be outlined to show realistic and fair bids	Outline Bids Showing Health and Safety Costs

382. Owner of project determines the scope of the work regardless if labor is union or open shop.	Owner Determines Work Scope Regardless of Labor Source	Owner Determines Work Scope
201. Even with contract provisions, owner business practices and ethics determines worker health and safety protections.	Owner practices and ethics determine worker health and safety protections	Owner Determines Worker Protections
293. Project owner is ultimate word on ethics and practices executed on a project.	Project owner is ultimate word on executed ethics and practices	Owner Determines Worker Protections
69. Business owner's ethics and morals defines the overall culture of an organization.	Owner ethics and morals define organizational culture	Owner Ethics Defines Organizational Culture
137. Owner ethics determine the level of protections workers will have.	Owner ethics determines level of worker protections	Owner Ethics Determines Protections
138. Moral ethics of employers is central to protecting workers from health hazards.	Employer moral ethics central to protecting workers	Owner Ethics Determines Protections
201. Even with contract provisions, owner business practices and ethics determines worker health and safety protections.	Even with contract provisions owner practices and ethics determines worker protections	Owner Ethics Determines Worker Protections
294. Owner expectations sets the tone regarding health and safety practices.	Owner expectations sets tone	Owner Expectations Set Tone
128. Owners have to be personally invested in the well-being of its	Owners have to be personally invested in workforce well-being	Owner Invested in Worker Wellbeing

workforce.		
385. Owner is key to changing mindsets regarding workers safety.	Owner is key to changing worker safety mindset	Owner Key to Safety Mindset
128. Owners have to be personally invested in the well-being of its workforce.	Owners have to be personally invested in workforce well-being	Owner Personally Invested
35. Larger shop owners are disengaged regarding health and safety risks.	Large Shop Owners Disengaged Regarding Risks	Owners Disengaged Regarding Risk
186. Owners like to share ideas but do not like to share money.	Owners like idea sharing but not costs	Owners Like Sharing Ideas Not Costs
405. Potential personal health and safety impact to impacts to for example pilots makes them vested in ensuring risk to health and safety are minimized. I.e., vest risk for owners.	Personal impacts to health and safety can vest owners in minimizing risks	Owners Vested In Minimizing Risks
47. Manufacturers are potential partners for communicating awareness regarding health and safety risks.	Partners for communicating awareness regarding health and safety risks	Partners for Communicating Health and Safety Risks
122. Opportunities for less migratory work was less in the past.	Less opportunities for migratory work in the past	Past Migratory Worker Greater
8. Past trade training opportunities were limited by age.	Age limited past training opportunities	Past Opportunities Limited by Age

109. Preparation time for protecting pedestrians from exposures reduces worker productive time.	Preparation time to protect pedestrians reduces worker productive time	Pedestrian Protections Reduce Productivity
6. Workers protect pedestrians but do not protect themselves.	Pedestrians protected but not workers	Pedestrians Protected
141. Tap into young people in the industry without entrenched mindsets to develop solutions.	Tap into young people without entrenched mindsets	People without Entrenched Mindsets
345. Perceptions of increased physical harm and exposure to health hazards is a deterrent to attracting new workers to the trades.	Perceptions of increased physical harm is a deterrent to attracting new workers	Perceptions of Increased Harm Deter New Workers
53a. Increased numbers of adverse health outcomes for workers will deincentivized younger generations to join the trades. Further exhacerbating the shortage of skilled laborers.	Shortage of skilled labor exhacerbated by increased numbers of adverse health outcomes	Perceptions of Increased Harm Deter New Workers
405. Potential personal health and safety impact to impacts to for example pilots makes them vested in ensuring risk to health and safety are minimized. I.e., vest risk for owners.	Personal impacts to health and safety can vest owners in minimizing risks	Personal Impacts Vest Owners
243. Illegal wage practices are pervasive even on government contract jobs.	Illegal wage practices are pervasive even on government contract jobs.	Pervasive Illegal Wage Practices
209. Physical barriers are an option for protecting workers from cross trade	Physical barriers protect from cross trade hazards	Physical Barriers Protect

hazards.		
361. Use worker's everyday experiences to remove hazards and plan for maintenance.	Remove hazards and plan for maintenance using worker's experiences	Plan Maintenance Using Worker Experience
196. Political influences impact OSHA administration and government agency agendas.	Political influences impact OSHA	Political influences impact OSHA
135. Politics plays a huge role in what laws are enforced.	Politics plays a huge role in what laws are enforced.	Politics in Law Enforcement
301. Owners cannot afford a poor quality or poor production project.	Owners cannot afford poor quality production project	Poor Quality Project Unaffordable
1. Effective practices beyond PPE exist for workers.	Effective practices exist beyond PPE	Practices Beyond PPE
188. Preplanning and trade scheduling/job sequencing can minimize worker exposure.	Preplanning, trade scheduling, and job sequencing can minimize worker exposure	Practices Minimizing Worker Exposure
199. Preplanning and job sequencing and trade scheduling miminizes exposure of workers to other trades.	Preplanning, job sequencing, and trade scheduling minimizes worker exposures	Practices that Minimize Worker Exposures
27. Scheduling is important to minimize cross trade hazard exposures.	Minimize cross trade hazards via scheduling	Practices that Minimize Worker Exposures

15. Scheduling trades to avoid exposures to cross-trade hazards is important for protecting workers.	Trade scheduling important to avoid cross trade hazards	Practices that Minimize Worker Exposures
158. Precautions are in place, but based on whether company provides workers with protections.	Precautions based on provided worker protections	Precautions Based on Provided Protections
191. Prefabrication	Prefabrication	Prefabrication
56. Assembly of pre-fabricated materials places high physical demands on workers.	Prefabrication assembly places high physical demands on workers	Prefabrication Assembly
213. Prefabrication of certain job aspects can help to control exposure to health hazards.	Prefabrication can help control health hazard exposures	Prefabrication to Control Exposures
274. Prefabrication can reduce potential exposures to health hazards.	Prefabrication can reduce health hazard exposures	Prefabrication to Control Exposures
168. Worker's Compensation Insurance scores tied to insurance premiums.	Worker's Compensation Insurance scores tied to insurance premiums.	Premiums tied to Insurance Scores
47. Selection of tools that can minimize musculoskeletal impacts is part of preplanning.	Selection of tools is part of preplanning	Preplan Tool Selection
188. Preplanning and trade scheduling/job sequencing can minimize worker exposure.	Preplanning, trade scheduling, and job sequencing can minimize worker exposure	Preplanning

51a. Preplanning and tool selection has reduced musculoskeletal disorders greatly.	Preplanning and tool selection has reduced musculoskeletal disorders	Preplanning and Tool Selection Reduces MSDs
51. Preplanning and tool selection has reduced musculoskeletal disorders greatly.	Musculoskeletal disorders reduced by preplanning and tool selection	Preplanning and Tool Selection Reduces Musculoskeletal Disorders
46. Preplanning a job is an effective tool to avoid or minimize worker exposure to hazards.	Preplanning is an effective tool for minimizing worker exposures	Preplanning Effective Tool
46. Preplanning a job is an effective tool to avoid or minimize worker exposure to hazards.	Preplanning is an effective tool for minimizing worker exposures	Preplanning Minimizes Worker Exposures
52. Limitations of aging workforce can be mitigated via Preplanning and tool selection.	Preplanning and tools selection can mitigate limitations of aging workforce	Preplanning Mitigates Aging Worker Limitations
212. Preplanning for welding jobs can help to reduce exposure to health hazards.	Preplanning welding jobs reduces health hazard exposures	Preplanning Reduces Hazard Exposures
392. Job Preplanning team requires members who can focus first on the work then the cost.	Preplanning requires focusing on the work before the cost	Preplanning Requires Work Focus
55. Prescribed construction standards provided for foreman.	Foreman provided prescribed construction standards	Prescribed Construction Standards
407. Time savings is the main pressure to cut corners because time equals money.	Saving time, where time equals money is the main pressures to cut corners	Pressures to Cut Corners

103. Functional preventative health and safety measures can increase worker productivity.	Functional preventative health and safety measures can increase worker productivity	Preventative Measures Increase Productivity
287. Physically demanding jobs like construction need to adopt preventative practices as are present in other physically demanding professions like sports.	Physically demanding jobs need preventative practices	Preventative Practices for Demanding Jobs
195. Prevention through design.	Prevention through design	Prevention through design
141. Adopt communication means of health issues from other successful education campaigns like smoking and autism.	Use education campaigns for smoking and autism as models for construction health issues	Previous Public Service Campaigns as Models
262. Companies need to consider reputational risks a priority.	Reputational risks need to be prioritized	Prioritize Reputational Risks
251. Safety needs to remain a priority even when schedule and cost are being strained.	Even under strain safety needs to remain a priority	Prioritize Safety
335. Job Walks and education situations are examples of proactive processes.	Job walks and education are proactive processes	Proactive Processes
101. Implement controls for maintaining process changes.	Implement controls for maintaining process changes	Process Change Controls

252. Appropriate company health and safety processes influence implementation of worker health and safety practices.	Appropriate processes influence health and safety practices	Processes Influence Practices
390. Process to understand how procurement makes purchasing decisions is important for buying appropriate equipment.	Procurement process is important for appropriate equipment purchasing designs	Procurement Important for Equipment Purchases
388. Working with procurement and acquisition are important key for buying "usable" safety and health products.	Procurement and acquisition are important for buying usable safety and health products	Procurement Important for Purchasing Usable Products
283. Manufacturers are influencing the general public by changing product designs.	Product design changes influencing general public	Product Designs Influence Public
129. Productivity is a driver of industry behaviors.	Productivity is a driver of industry behaviors.	Productivity Drivers Industry Behaviors
42. Ignorance regarding health and safety risks prioritize cutting corners to increase profits.	Cutting corners to increase profits prioritized	Profit Increases Prioritized
41. Profits are priority over investing capital into health and safety processes and equipment.	Profits are a priority over health and safety investments	Profits Drive Engrained Behaviors
92. Profits are a main driver of engrained behaviors in construction.	Profits are a main driveer of engrained behaviors	Profits Drive Engrained Behaviors
358. Good Catch/Near miss programs acknowledge good safety	Programs acknowledging good safety practices	Programs Acknowledging Good Practices

practices of workers		
431. America and the world have progressed through construction.	America and the world have progressed through construction	Progress Through Construction
428. Safety is the responsibility of project leader and not just "safety department".	Safety is the responsibility of project leader not just "safety department"	Project Leader Responsible for Safety
382a. Owner of project determines the scope of the work regardless if labor is union or open shop.	Project owner determines scope regardless of labor source	Project Owner Determines Scope
383. Productivity is central on a project regardless of source of workforce.	Productivity is central on a project	Project Productivity Central
55. Promote the idea of Social Impact Analysis for companies.	Promote Social Impact Analysis for companies	Promote Company Social Impact Analysis
59. Work with communities of manufacturers to promote health and safety information.	Promote health and safety via working with communities of manufacturers	Promote Health and Safety via Manufacturers
256. Mindset that safety is everyone's job needs to be promoted.	Promote mindset that safety is everyone's job	Promote Safety Mindset
183. Even with health and safety provisions in the contract bids does not ensure health and safety provisions are adhered to and/or implemented.	Contract health and safety provisions do not ensure adherence	Provisions do not Ensure Adherence

283. Manufacturers are influencing the general public by changing product designs.	Manufacturers influence public via product designs	Public Influenced via Product Designs
158. Industry can potentially use media to mislead general public regarding severity of health hazards.	Industry using media to mislead general public regarding health hazards.	Public Mislead Regarding Hazard Severity
200. Purchase tools that have hazards controls built into its functionality.	Purchase tools with built in hazard controls	Purchase Hazard Control Tools
64. Difficult to track quarterly or annual impacts of silica or noise to workers.	Quarterly and annual impacts of silica or noise difficult to track	Quarterly Silica Impacts
118. Industry needs to reassess how it pays labor to incentivize laborers to remain in industry.	Industry needs reassessment of labor pay needed to incentivize labor retention	Reassess Wages to Attract Workers
119. Construction industry needs to reassess wages to remain competitive and attract new workers.	Wages need reassessment to remain competitive and attract new workers	Reassess Wages to Attract Workers
119. Construction industry needs to reassess wages to remain competitive and attract new workers.	Wages need reassessment to remain competitive and attract new workers	Reassess Wages to Attract Workers
339. Most appreciated "incentive" is simple recognition by boss or peers.	Simple recognition most appreciated incentive	Recognition is Appreciated
273. United States culture needs to recognize achievements and solutions developed by other nations: collaboration.	Need to recognize achievements and solutions of other nations	Recognize other Nations Achivements and Solutions

145. Workers need to esteem the value of their work.	Workers Need to Esteem Work Value.	Recognize Worker Value
148. Workers need to recognize the importance of their trades.	Workers need to recognize importance of their trade	Recognize Worker Value
108. Reduction of clean up time increases productive work time overall.	Reduction of clean up time increases overall work productivity	Reducing Cleanup Increases Productivity
181a. Regulations do not increase costs, industry negligence increases costs.	Regulations do not increase costs, industry neglience increases costs.	Regulations do Not Increase Costs
11. Pneumatic tools because of large amounts of noise are regulated for hearing protection.	Pneumatic tools regulated for hearing protection	Regulations for Pneumatic Tools
3. Hearing protection required in standards only for specific tools.	Only specific tools require hearing protection	Regulations for Pneumatic Tools
71. Regulations are main reason industry has concerned itself with silica.	Regulations are main reason industry has concerned itself with silica	Regulations Reason for Silica Concern
65. Regulatory agencies need incentives from industry/workers to establish requirements.	Regulatory agencies need incentives to establish requirements	Regulatory Incentives to Establish Requirements
364. Reinforce positive behaviors.	Reinforce positive behaviors.	Reinforce positive behaviors.
137. Previous health and safety hazards such as asbestos have been	Previous health hazards have been removed	Removal of Health Hazards

removed.		
359. Near miss - discuss lessons learned so can remove future potential near miss hazards.	Discuss lessons learned to remove future hazards	Removal of Health Hazards
80. Rather than work with safety and health to remove or reduce source adversely impacting worker health.	Work with safety and health to remove and reduce adverse health impact	Remove and Reduce Adverse Health Impact
361. Use worker's everyday experiences to remove hazards and plan for maintenance.	Remove hazards and plan for maintenance using worker's experiences	Remove Hazards and Plan for Maintenance
224. Contractors do not like to get rid of equipment simply because something seems better. Need equipment replacement plan to reduce potential hazards.	Equipment replacement plan needed to reduce potential hazards	Replacing Equipment Reduces Hazards
240. Health and Safety information should be required to be distributed to workers, just like retirement information is.	Distribution of health and safety information should be a requirement	Require Health and Safety Information Distribution
232. Make businesses be required to register their health and safety programs with the Department of Labor or OSHA.	Have a requirement to register health and safety programs with OSHA	Require Health and Safety Program Registration
368. Respect	Respect	Respect
61. Responsible companies have insurance.	Responsible companies have insurance	Responsible companies have insurance

175. There is a need for responsible contract bidding practices.	Responsible contract bidding needed	Responsible contract bidding needed
165. Worker's Compensation Insurance needs restructuring to better address health issues.	Restructuring of workers compensation needed	Restructure Worker's Compensation
389. Low bid mindsets result in purchasing dangerous products.	Dangerous products purchased with low bid mindsets	Results of Low Bid Mindset
144. Public perception of the construction worker needs to be revised.	Public perception of construction worker needs to be revised	Revise Construction Worker Public Perception
362. Opportunities to reward communicating potential health and safety issues before they become problems.	Communication rewarded regarding health and safety issues	Reward Health and Safety Communication
326. Mindset to work around safety or health issues rather than take issue seriously.	Mindset to work around safety or health issues rather than take issue seriously	Safety and Health Issues Not Taken Seriously
393. Construction industry compliance mindset needs to shift to incorporating safety in the business plan.	Shift industry mindset from compliance to incorporating safety into business plans	Safety as Good Business Mindset
428. Safety is the responsibility of project leader and not just "safety department".	Safety is the responsibility of project leader not just "safety department"	Safety Department Responsible for Safety
403. Health and safety needs to be incorporated from the planning, estimating until key	Incorporate safety from planning to turnover	Safety from Planning to Turnover

turnover to owners.		
256. Mindset that safety is everyone's job needs to be promoted.	Promote mindset that safety is everyone's job	Safety is Everyone's Job Mindset
245. Safety is presently reactive.	Safety is reactive	Safety is Reactivce
139. Safety is a moral choice beyond regulatory composition.	Safety is a moral choice beyond regulations	Safety Moral Choice
328. Make safety part of the everyday.	Safety should be part of the everyday	Safety Part of Everyday
371. Good Catch	Safety Program	Safety Program
373. Near miss	Safety Program	Safety Program
115. Calculate potential savings from cost of protection versus cost of prevention.	Savings from cost of protection versus cost of prevention.	Savings
241. Companies need to do economic assessments of expenditures to recognize existing financial opportunities for implementing health and safety practices.	Recognize existing financial opportunities for implementing Health and Safety.	Savings
182. Demonstrate feasibility of overall cost reductions via addressing worker health concerns.	Cost reductions feasible via addressing worker health concerns	Savings
196. Actual project work can determine job scheduling that will minimize worker exposure to health hazards of other	Scheduling of project work can minimize worker exposures to health hazards	Scheduling Minimizes Health Exposures

trades.		
19. Today, high schools are an opportunity to provide young people information regarding health and safety information.	Schools Provide Opportunities to inform regarding Health and Safety	Schools Provide Opportunities to Educate
315. Schools do not train safety and health into the programs.	Schools do not train safety and health	Schools Provide Opportunities to Educate
203. Education regarding health and safety practices can start in elementary school.	Start health and safety education in elementary school	Schools Provide Opportunities to Inform
107. Improved screening process for workers to predict retention.	Improved screening process to predict retention.	Screening to Improve Worker Retention
242. Safety realm/risk management needs to "sell" value of safety as profitable to companies.	Safety needs to be sold as profitable to companies	Sell Safety as Profitable
263. Create mindset of safety and health as profit increasing opportunities.	Create mindset of safety and health into profitable opportunities	Sell Safety as Profitable
120. Mindset shift needed of employees as enemies to employees as an asset.	Mindset of employees as enemies needs to shift	Shift Employees As Enemies Mindset
393. Construction industry compliance mindset needs to shift to incorporating safety in the business plan.	Shift industry mindset from compliance to incorporating safety into business plans	Shift from Compliance Mindset
322. Mindset regarding low bidding projects needs	Low bidding mindset needs to shift	Shift Low Bid Mindset

to shift.		
327. Traditional mindset of safety meeting in a trailer needs to shift.	Traditional meeting mindset needs to shift	Shift Meeting Mindsets
112. Shift mindsets from investing in protecting from the hazards to investing in reducing or eliminating the hazard.	Shift mindset from investing in protection to investing in reducing or eliminating hazard	Shift Mindset from Protection
334. Shifting safety mindset from reactive to proactive.	Shift safety from reactive to proactive	Shift Mindset to Proactive
112. Shift mindsets from investing in protecting from the hazards to investing in reducing or eliminating the hazard.	Shift mindset from investing in protection to investing in reducing or eliminating hazard	Shift Mindset to Reducing or Eliminating Hazard
261. Need incentives or process changes to shift old mindsets disregarding safety.	Incentives and Process Changes Needed shifting mindsets disregarding safety	Shift Mindsets Disregarding Safety
207. Shifting worker mindsets to adhere to health and safety practices needed.	Shift in worker mindsets to adhere to practices	Shift Worker Mindsets
116. Track cost of worker sick days to impact on productivity, i.e., company profits.	Cost of worker sick days impacts profits	Sick Days Impact Profits
43. Exposure and the lag-time to the onset of health issues deceives workers into thinking they are not being adversely impacted.	Exposure and the lag-time of health issues deceives workers into thinking they are not being adversely impacted.	Sickness Lagtime Deceives Workers

43. Exposure and the lag-time to the onset of health issues deceives workers into thinking they are not being adversely impacted.	Exposure and the lag-time of health issues deceives workers into thinking they are not being adversely impacted.	Sickness Lagtime Deceives Workers
62. Lag-time between exposures and onset of sickness creates difficulty in tracing origin of illnesses.	Lag-time of onset of sickness creates difficulty tracing origin	Sickness Lagtime Makes Tracking Difficult
99. Lag time for the onset of cumulative health hazards a challenge for determining the industry/employer responsible for exposing the worker to health hazards.	Lagtime creates challenge for determining employer responsible for health hazard exposures	Sickness Lagtime Makes Tracking Difficult
130. Silica exposure deaths were more acute previously.	Previous silica exposures were more acute	Silica Exposure Previoulsy More Acute
38. US. Death statistics have 100 workers dying per year from silica exposures.	Death statistics have 100 workers dying	Silica Exposure Worker Deaths
41. Impact from silica dust reduces body's immunity.	Silica dust impacts body's immunity	Silica Impacts Immunity
23. Silica is a hazard present in many construction materials.	Silica hazard is present in many construction materials	Silica in Many Construction Materials
131. Present exposure to silica has greater lag time prior to onset of illnesses.	Silica exposure has greater lagtime before onset of illnesses	Silica Outcomes have Greater Lagtime
29. Require silica dust protection: Wet methods, vacuum or PPE.	Silica dust protections are wet methods, vacuum or PPE	Silica Regulations

28. New OSHA silica standard requires tasks be performed in specific ways, such as wet method or vacuuming to minimize dust.	Silica standard requires tasks are performed in certain ways	Silica Regulations
22. There is a standard regarding silica.	There is a silica standard	Silica Regulations
166. Worker experiences are similar across the board.	Similar Experiences Across Board	Similar Worker Experiences
116. Industry not willing to pay skilled labor wage creating shortage in skilled labor.	Not paying skilled labor wage creating shortage in skilled labor.	Skilled Labor Wage not Paid
299. Non-union requiring workers to have job skills training before getting hired.	Non-union requiring workers to have job	Skills Required Before Hire
324. We slowed down the job, we might have saved a life.	Slowing down a job may safe a life	Slow Down, Safe a Life
238. Small companies work with local insurance companies and use general Worker's Compensation Insurance.	Small companies use general Worker's Compensation Insurance	Small Companies Use Local Insurance Companies
420. Learn to use dynamic workforce and diversity as a positive source for solutions.	Dynamic workforce and diversity source for solutions	Solutions From Dynamic and Diverse Workforce
314. Stop work authority isn't acutally worked.	Stop work authority isn't acutally worked.	Stop Work Authority Accepted for Quality and Production
313. Stop work authority is more lip service than	Stop work authority is more lip service than reality.	Stop Work Authority Not Worked

reality.		
314. Stop work authority isn't acutally worked.	Stop work authority isn't acutally worked.	Stop Work Authority Not Worked
317. Stop work authority is accepted for quality and production but not safety.	Stop work authority accepted for quality and production but not safety	Stop Work Authority not Worked for Safety
325. Stop work on field - then get evil eye of project manager.	Stop worker on field then get evil eye of project manager	Stop Works Get Evil Eye
270. Strains and sprains are the largest portion of Worker's Compensation Insurance costs.	Strains and Sprains are largest portion of workers compensation insurance costs	Strains and Sprains Largest Insurance Costs
319. Mindset regarding safety needs to become very strict.	Need strict safety mindset	Strict Safety Mindset
206. Companies need to have a culture of strict enforcement of health and safety practices for workers.	Need strict enforcement of health and safety practices	Strict Safety Mindset
288. Need to develop stricter employer accountability.	Employers need stricter accountability	Stricter Employer Accountability
287. OSHA needs stricter fines and enforcement.	Stricter OSHA fines and enforcement	Stricter OSHA fines and enforcement

229. Superintendent and foreman are important for delivering consistent expectations messages to workers.	Superintendent and foreman are important for delivering consistent communication	Superintendent Important for Delivering Consistent Communication
372. Use of symbols	Symbol Use	Symbol Use
78. Human tendency to want to take advantage of a system such as Worker's Compensation Insurance.	Human tendency to take advantage of systems	Take Advantage of System
395. People's intuition regarding potential safety issues needs to be taken seriously.	People's intuition needs to be taken seriously	Take Intuition Seriously
194. Government agencies do targeted enforcement because can get money out of large budget projects.	Government does targeted enforcement because can get money out of large budget projects	Targeted Enforcement of Large Budget Projects
200. Larger financial projects is where heavier compliance and cooperation with different private or public entities is focused.	Heavier compliance and cooperation with private and public entities is focused on larger financial projects	Targeted Enforcement of Large Budget Projects
200. Larger financial projects is where heavier compliance and cooperation with different private or public entities is focused.	Heavier compliance and cooperation with private and public entities is focused on larger financial projects	Targeted Enforcement of Large Budget Projects

193. Department of Labor Wage and Hour have targeted large budget projects.	Department of Labor Wage and Hour target large budget projects	Targeted Enforcement of Large Budget Projects
133. Tax incentives for responsible businesses.	Tax incentives for responsible businesses.	Tax Incentives
48. Government tax incentives to manufacturers to reduce toxic ingredients in their products.	Tax incentives for manufacturers to reduce toxic ingredients in products	Tax Incentives for Manufacturers
48. Government tax incentives to manufacturers to reduce toxic ingredients in their products.	Tax incentives for manufacturers to reduce toxic ingredients in products	Tax Incentives for Manufacturers
87. Inter-government agency collaboration to provide financial incentives to manufacturers & 99% of the construction industry that is comprised of the small and mid-sized companies with less than 500 employees.	Government collaboration for financial incentives to manufacturers	Tax Incentives for Manufacturers
89. Government incentives for businesses that proactively address health and safety concerns.	Incentives for businesses proactively addressing health and safety concerns	Tax Incentives for Proactive Business
160. Incentives for individuals, workers, and owners to put energy into issues of cumulative health hazards needs to be explored.	Incentives for putting energy into health hazards needs exploration	Tax Incentives for Proactive Business

85. Government programs similar to tax incentives for solar energy can be developed for manufacturers to incentivize them to create safer products.	Tax incentives similar to solar energy can be developed for safer product creation	Tax Incentives for Safer Products
86. Potential government grants or tax subsidies for manufacturers switching to safer materials.	Grants and subsides for manufacturers switching to safer materials	Tax Incentives for Safer Products
423. Construction is about working as a team.	Work as a team	Teamwork
412. Incorporate technology into projects, but not replace all face to face interaction with technology.	Technology should not replace face to face interactions	Technology should not replace interactions
304. Labor Ready temporary employers create problems with worker skills.	Labor Ready temporary employers create problems with worker skills.	Temporary Labor Skill Problems
244. Safety and health needs to be tied to productivity.	Safety and health needs to be tied to productivity.	Tie Safety and Health with Productivity
128. Cost of time to acquire health and safety preventions is a Deterrent for small and mid-sized businesses.	Cost of time is a deterrent for acquiring health and safety preventions	Time is a Deterrent
374. Enemy of safety is time.	Time is enemy of safety	Time is Safety Enemy
407. Time savings is the main pressure to cut	Saving time, where time equals money is the main pressures to cut corners	Times Equals Money

corners because time equals money.		
189. Examine tools and materials for hazard reduction possibilities.	Examine tools and materials for possible hazard reduction	Tool and Material Hazard Reductions
277. Everyday consumer mindsets are changing with improved tool design.	Improved tool design changes consumer mindsets	Tool Design Changes Mindsets
284. Better tool design does not replace the need to educate workers on proper biomechanics of his/her work.	Education of proper biomechanics not replaced by better tool design.	Tool Design Does not Replace Education
52. Limitations of aging workforce can be mitigated via Preplanning and tool selection.	Preplanning and tools selection can mitigate limitations of aging workforce	Tool Selection Mitigates Aging Worker Limitations
95. Medicare can work to track occupations with the greatest retirees with silicosis.	Use Medicare to track occupations with greatest number of retirees with silicosis	Track Occupational Illnesses
96. Existing government medical programs do not associate illness of individual with previous occupations.	Government medical programs do not associate illnesses with occupations.	Track Occupational Illnesses
97. Government agency collaboration can be used to trace origin of illnesses to occupations and determine financial responsibility of that industry for failing to protect workers.	Trace origin of illness to occupations to determine financial responsibility of industry.	Track Occupational Illnesses

97. Government agency collaboration can be used to trace origin of illnesses to occupations and determine financial responsibility of that industry for failing to protect workers.	Trace origin of illness to occupations to determine financial responsibility of industry.	Track Occupational Illnesses
98. Development of Public Health Agency/Branch for OSHA or collaborate with the US Department of Health and Human Services to track industries with greater number of ill workers; and work to determine their financial liability.	Develop government and industry collaboration to track illnesses and financial responsibility of industries	Track Occupational Illnesses
82. Cumulative health issues cannot be traced to a root cause.	Health issues not traceable to root causes	Track Occupational Illnesses
93. Government agency collaboration could help to track onset of illnesses and financially responsible parties for adverse health outcomes developed by workers.	Government collaboration to track parties responsible for onset of illnesses	Tracking Parties Responsible for Illnesses
350. Trades need to communicate to general public economic opportunities it offers young people.	Trades need to communicate economic opportunities to young people	Trade Communication of Economic Opportunities
197. Different types of contractors are exposed to different types of trades.	Exposures are different depending upon the trade	Trade Hazard Exposures Different
18. Communication among	Communication of health hazards among trades	Trade Health Hazards Communication

trades regarding the introduction of health hazards.		
5. Worked around the world with travel opportunities.	Work opportunities around the world	Trade Opportunities Around World
188. Preplanning and trade scheduling/job sequencing can minimize worker exposure.	Preplanning, trade scheduling, and job sequencing can minimize worker exposure	Trade Scheduling
121. Trade work is extremely migratory.	Trade work is extremely migratory.	Trade Work Extremely Migratory
348. Trades offered young people the opportunity to have a pension savings plan earlier on.	Trades offer pension saving to young people	Trades Offer Pension Savings
432. Everything we do has been touched by the hands of a trades person.	Hands of trades people touch everything	Trades People Touch Everything
351. Trades require technical know how	Trades require technical knowledge	Trades require technical knowledge
352. Trades are not low skill.	Trades are not low skill	Trades require technical knowledge
203. Train young construction professionals to look for safer materials options.	Train young professional to look for safer materials	Train Regarding Material Dangers
205. Workers need to take personal accountability for their wellbeing when training/education and appropriate PPEs are provided.	Personal accountability of workers enhanced when training/education and PPE provided	Training Enhances Personal Accountability

396. Staff/worker training regarding health and safety training is essential for common starting points for diverse workforce.	Health and safety training for staff/workers is essential for a diverse workforce	Training Essential for Diverse Workforce
125. Trade skills are transferrable to other professions eg. Art, stone workers.	Trade skills transferrable to other professions	Transferrable Trades Skills
281. Workers need transferrable wage accounts so don't loose for example, travel funds.	Workers need transferrable wage accounts.	Transferrable Wage Accounts
100. Older experienced workers are transitioning to occupations less physically demanding.	Older workers transitioning to less physically demanding jobs	Transitions to Less Physically Demanding Jobs
179. Functional health and safety equipment is unaffordable to young workers who need the greatest protections due to inexperience with trade.	Functional health and safety equipment is unaffordable to young workers	Unaffordable Functional Health and Safety Equipment
210. Discomfort of health and safety equipment cited by workers.	Workers cite uncomfortable equipment	Uncomfortable Equipment
174. Individual companies/industry understanding of big picture regarding cost of health hazards can save companies/ industry money.	Understanding big picture regarding cost of health hazards to save money	Understand Big Picture of Health Hazards

406. Understand the process to do an activity that can help identify potential health and safety improvements.	Understand activity process to help identify health and safety improvements	Understand Processes to Identify Improvements
174. Individual companies/industry understanding of big picture regarding cost of health hazards can save companies/ industry money.	Understanding big picture regarding cost of health hazards to save money	Understanding Health Hazards Saves Money
303. Brain-drain more qualified people retiring than are back filling the trade positions.	More people retiring than filling trade positions	Unfilled Trade Positions
113. Lack of skilled trade people.	Lack of skilled trade people.	Unfilled Trade Positions
116. Industry not willing to pay skilled labor wage creating shortage in skilled labor.	Not paying skilled labor wage creating shortage in skilled labor.	Unfilled Trade Positions
147. Union apprenticeship programs offer job training to young workers.	Union apprenticeship programs offer job training to young workers.	Union Apprenticeship Job Training
295. Union workers have formalized education for their trade.	Union workers have formalized trade education	Union Apprenticeship Job Training
21. Brothers did not want to be union because they did not want to be micro-managed.	Union perceived as micro-managers	Union as Micromanagers

11. Junior partner of union company.	Union company	Union company
156. Not all states have union work available.	Union work not available in all states	Union Not in All States
150. Union work is not available in all states.	Union work is not available in all states.	Union Not in All States
171. Worker representation /Unions provides voice for workers exposed to health and safety rule violations.	Worker representation /Unions provides voice for workers exposed to health and safety violations.	Union Provides Workers a Voice
155. Union trade workers overlap skills depending upon job needs.	Union workers overlap job skills	Union Worker Skills Overlap
31. Unions work to inform affiliated industry owners about health and safety issues faced by workers.	Unions work to inform affiliated industry owners about worker issues	Unions Inform Owners About Issues
157. Unions offer various career options for workers.	Unions offer workers various career options	Unions Offer Career Options
177. Academic/University institutions can collaborate with health and safety equipment manufacturers to design function equipment.	Academic/University collaboration with manufacturers to design functional equipment	University Collaboration with Equipment Designers
402. Unnecessary deaths are opportunities for improving practices that can prevent future fatalities.	Unnecessary deaths are opportunities for improving practices	Unnecessary Deaths are Improvement Opportunities

402a. Unnecessary deaths are opportunities for improving practices that can prevent future fatalities.	Unnecessary deaths are opportunities for improving practices	Unnecessary Deaths are Improvement Opportunties
223. People justify unsafe practices because they know people who did them and lived well.	People justify unsafe practices	Unsafe Practices Justified
96. False sense of invincibility for workers who continually perform unsafe practices w/out injury.	Performing unsafe practices without injury gives false sense of invincibility	Unsafe Practices without Injury
126. Upper management needed education regarding hazards.	Hazard Education for Upper management	Upper Management Hazard Education
62. Experience using preplanning used in a job to prepare work method.	Experience using preplanning	Use Craftworker Experience
59. Experience with injuries utilized to remove job hazards.	Experience to remove job hazards	Use Craftworker Experience
54. Expertise of craftworkers should be utilized for work assessments and pre-planning.	Craftworker expertise need to be utilized for worker assessments and pre-planning	Use Craftworker Experience
426. Tapping into experience of older workers.	Tap experience of older workers	Use Craftworker Experience
413. Technology can be used to organize resources and communicate job	Use Technology to organize resources and communicate job issues	Use Technology to organize and communicate issues

issues.		
112. Need to tap into the experienced worker's knowledge.	Experienced workers knowledge needs to be utilized	Utilize Experienced Worker Knowledge
250. Safety has to be valued by organization at all levels.	Safety has to be valued at all levels	Value Safety at all Levels
211. Outside jobs have different health hazard controls than in-door jobs.	Outside jobs have different hazards than in-door jobs	Varying Environmental Hazards
233. Present OSHA program is voluntary.	OSHA program is voluntary	Voluntary OSHA Program
176. Irresponsible companies practice illegal wage actions to lower bid prices.	Illegal wage actions practiced to lower bid prices	Wage Cost Differences Pocketed
272. Wage documentation important for identifying appropriate worker classification.	Wage documentatin important for identifying worker classification.	Wage Documentation Identifies Worker Classification
273. 1099 classification places responsibility of wage documentation on workers.	1099 classification places responsibility of wage documentation on workers.	Wage Documentation Responsibility
192. Watch dog groups focus on large projects.	Watch dog groups focus on large projects	Watch Groups Focus on Large Projects
416. Women have strong analytical skills and approch jobs differently than men in some cases.	Woman approach jobs different than men	Woman Approach Jobs Differently
67. Open shops do not monitor payroll to ensure workers are classified	Open shops do not monitor payroll to ensure proper worker classification	Worker Classsification Not Monitored

correctly.		
244. Need for verification of worker classification to ensure honest wage practices.	Verification of worker classification needed to ensure honest wage practices.	Worker Classsification Not Monitored
269. Worker education is the largest hurdle to health and safety awareness.	Worker Education is Largest Hurdle	Worker Education is Largest Hurdle
74. Worker is the first step towards the execution of established business processes.	Worker is the first step in business process	Worker Executes Established Processes
26. Education needed for workers regarding trade hazards and exposure routes and mechanisms.	Hazard, exposure routes, and mechanisms education needed	Worker Hazards Education
26. Education needed for workers regarding trade hazards and exposure routes and mechanisms.	Hazard, exposure routes, and mechanisms education needed	Worker Hazards Education
132. Worker health and safety certifications similar to IRS payroll certification.	Worker health and safety certifications similar to IRS payroll certification.	Worker Health and Safety Certification
228. Continual reinforcement of clear expectations from management are important for protecting worker health.	Reinforcement of Clear Management Expectations Important for Protecting Worker Health	Worker Health Protections Important
261. Employers take advantage of worker ignorance regarding health and safety regulations.	Worker ignorance taken advantage	Worker Ignorance Exploited

43. Young men do not consider health and safety because of the mentality of invincibility.	Mentality of invicibility by young workers	Worker Invicibility Mentality
264. Workers need to follow example of previous labor movements, e.g., Black Lung	Workers need a labor movement	Worker Labor Movement Needed
263. Workers need to work together in a new labor movement to demand they are respected.	Workers need labor movement to demand respect	Worker Labor Movement Needed
255. Companies "encourage" workers to sign liability waivers prior to employing workers.	Workers encouraged to sign liability waivers	Worker Liability Waivers Encouraged
68. Misclassified workers impacts the legal protections of workers particularly regarding the ability to file Worker's Compensation Insurance claims.	Misclassification of worlers impacts ability to file worker's compensation claims	Worker Misclassification Impacts Compensation Filing
246. Illegal classification of worker practices clouds application of health and safety laws/policies for workers.	Illegal worker classification practices cloud application of worker health and safety laws	Worker Misclassification Impacts Laws
68. Misclassified workers impacts the legal protections of workers particularly regarding the ability to file Worker's Compensation Insurance claims.	Misclassification of workers impacts workers legal protections	Worker Misclassification Impacts Legal Protections

64. Industries need to begin to be accountable for public burden of sicknesses caused by its negligence to worker health.	Industries need to be accountable for sicknesses caused by negligence to worker health	Worker Pays Industry Negligence
157. Worker pays consequences of industry's negligence toward health hazards.	Worker pays consequences for industry negligence	Worker Pays Industry Negligence
205. Workers need to take personal accountability for their well being when training/education and appropriate PPEs are provided.	Workers need personal accountability to use training/education is provided	Worker Personal Accountability
211. Worker is personally accountable for using provided personal protections.	Using personal protections is the worker's responsibility.	Worker Responsible for Personal Protections
115. Gap in skill level of workers.	Gap in skill level of workers	Worker Skill Gaps
81. Need to change mindset of company medical to work with safety to protect workers rather than cover up symptoms of the development of worker adverse health conditions.	Change company mindset of covering up the Development of Adverse Health Conditions	Worker Symptom Cover Up
80. Company doctors treat workers and protect company/employer by giving medications that suppress worker symptoms of exposure to health hazards.	Workers given medications that suppress symptoms of exposure to health hazards	Worker Symptom Suppression Medication Provided

82. Workers had undetected secondary health impacts from the medications that company doctors provided to suppress the symptoms of exposure to dangerous materials/chemicals.	Medications provided to suppress symptoms of exposures to dangerous materials/chemicals	Worker Symptom Suppression Medication Provided
82. Workers had undetected secondary health impacts from the medications that company doctors provided to suppress the symptoms of exposure to dangerous materials/chemicals.	Medications provided to suppress symptoms of exposures to dangerous materials/chemicals	Worker Symptoms of Dangerous Exposures Suppressed
25. Workers attempt makeshift protection when protection is not provided.	Makeshift protection used when protection is not provided	Workers Attempt Makeshift Protections
156. Worker's Compensation Insurance system puts injured workers at a disadvantage.	Injured workers disadvantaged by workers compensation system.	Worker's Compensation Disadvantages Injured Workers
132. Worker's Compensation Insurance system not set up for chronic illnesses only acute injuries.	Chronic illnesses not covered by worker's compensation insurance	Worker's Compensation Does Not Cover Chronic Illness
152. Worker's Compensation Insurance system is not designed to support cumulative health hazards.	Cumulative health hazards not supported by worker's compensation	Worker's Compensation Does Not Cover Chronic Illness

85. Worker's Compensation Insurance program is set up as a litigation process.	Worker's compensation program is a litigation process	Worker's Compensation is a Litigation Process
167. Worker's Compensation Insurance is a long term employer investment.	Worker's Compensation Insurance is a long term employer investment.	Worker's Compensation is Long term Investment
83. Without a specific date for the onset of an injury workers are denied Worker's Compensation Insurance.	Without a specific date of injury workers denied workers compensation	Workers Compensation Requires Acute Incident
79. Worker's Compensation Insurance requires an acute incident for a worker to qualify.	Acute incident required to quality for workers compensation	Workers Compensation Requires acute Incident
84. Unless a health incident is acute a worker cannot file for Worker's Compensation Insurance.	Acute incident required to quality for workers compensation	Workers Compensation Requires acute Incident
91. Barrier for policy in general industry is the structure of the Worker's Compensation Insurance system.	Structure of worker's compensation system is the barrier	Worker's Compensation Structure is a Barrier
12. Sandblasting and gunite exposed worker to toxic gases/cumulative health hazards.	Workers exposed to toxic health hazards	Workers Exposed to Toxic Hazards
384. It’s still a worker exposed to hazards regardless of union or open shop.	Workers exposed to health hazards regardless of labor source	Workers Exposed to Toxic Hazards

161a. Worker's fearful to ask for protections for fear of losing their job.	Workers fear losing their job	Workers Fear Losing Job
161. Worker's fearful to ask for protections for fear of losing their job.	Worker's fearful to ask for protections	Worker's Fear Losing Job
73. Workers are a wealth of information regarding solutions to challenges.	Workers have solutions to challenges	Workers have Solutions
66. Employers illegally change worker classification for tax avoidance purposes.	Worker classification illegally changed for tax avoidance	Workers Misclassified to Avoid Taxes
271. Worker education regarding legal wage practices needed.	Worker education regarding legal wage practices needed.	Workers Need Wage and Labor Education
278. Worker education needed regarding how and what their wages consist of.	Worker education needed regarding wages	Workers Need Wage and Labor Education
276. Worker ignorance regarding wage and labor protections.	Workers ignorant regarding wage and labor protections	Workers Need Wage and Labor Education
6. Workers protect pedestrians but do not protect themselves.	Pedestrians protected but not workers	Workers Not Protected
25. Workers attempt makeshift protection when protection is not provided.	Makeshift protection used when protection is not provided	Workers Not Provided Protection
209. Workers defend employers who violate health and safety regulations because see	Workers see complaints against employer as a threat to their pay	Workers See Employer Complaints as Pay Threats

complaints against their employer as a threat to their pay.		
154. Industry unconsciously treats workers as disposable.	Workers unconsciously treated as disposable	Workers Treated as Disposable
155. Treatment of workers as disposable is contributing to worker shortages.	Treating workers as disposable contributes to worker shortages	Workers Treated as Disposable
4. Workers unaware of how certain noises can impact hearing loss.	Workers unaware of impacts to hearing loss	Workers Unaware of Hearing Loss
4. Workers unaware of how certain noises can impact hearing loss.	Workers unaware of impacts to hearing loss	Workers Unaware of Noise Impacts
262. Employer mindset is that workers are a replaceable commodity.	Employers consider workers a replaceable commodity	Workers Viewed as Replacable Commodity
141. Tap into young people in the industry without entrenched mindsets to develop solutions.	Tap into young people to develop solutions	Young People Develop Solutions
24. As a young worker ignorant of health and safety protections.	Young worker ignorant of health and safety protections	Young Worker Ignorance
145. Young people were taken advantage of by business owners and exposed young workers to health hazards.	Employers take advantage of young people and expose them to hazards	Young Workers Exploited

Table 2. Axial Codes Grouped by Similar Concepts and Resulting Selective Codes.

No.	Axial Codes	Selective Codes	

1	1099 Wage Documentation Responsibility	Payroll Certification	1
2	Open Shop Payroll Not Monitored		
3	Davis-Bacon Requires Payroll Certification		
4	Transferrable Wage Accounts	Transferrable Wage Accounts	2
5	Conversion of Lost Wage Accounts	Lost Wage Accounts	3
6	Illegal Wage Practices on Government Jobs		4
7	Avenue Against Unfair Labor Practices	Illegal Wage Practices	
8	1099 Classification Unfair Labor Practice		
9	Pervasive Illegal Wage Practices		
10	No Legal Wage Theft		

	Protection		
11	Wage Cost Differences Pocketed		
12	Ensuring Honest Wage Practices	Honest Wage Practices	5
13	Ignorance of Illegal Wage and Employment Practices	Ignorance of Illegal Wage Practices	6
14	Workers Need Wage and Labor Education	Worker Wage and Labor Education	7
15	Need Worker Wage and Labor Education		
16	Cost	Costs	8
17	Industry Negligence Increases Costs		
18	Pressures to Cut Corners		
19	Bottom Line Owners Main Interest		

20	Owners Like Sharing Ideas Not Costs		
21	Employee Training Resource Intensive		
22	Costs Drive Decisions		
23	Cost Algorithms	Cost Algorithms	9
24	Determining Hazard Elimination Cost Benefit	Cost Benefit Analysis	10
25	Cost Benefit Analysis		
26	Cost Benefit of Using Less Hazarous Materials		
27	Savings	Savings	11
28	Injury Reduction Saves Money		

29	Understanding Health Hazards Saves Money		
30	Reduction of injuries saves money		
31	Corners Cut to Increase Profits		12
32	Sell Safety as Profitable	Profits	
33	Profit Increases Prioritized		
34	Profits Drive Engrained Behaviors		
35	Manufacturers Profitable After Removing Hazards		

36	Sick Days Impact Profits	Sick Day Impacts	13
37	Available Capital Limits Practices		14
38	Health and Safety Not a Capital Investment		
39	Investment Captial Needed For Captive		
40	Baseline Beyond Financial Values	Capital Investments	
41	Budget Schedule Constraints		
42	Capital Investments for Companies		

43	Define Gains Beyond Financial		
44	Economic Losses of Non-functional Equipment	Investment Losses	15
45	Captive Costs above Deductible Shared	Captive Insurance Companies	16
46	Captive has Multiple Owners		
47	Captive Insurance Infeasible for Smaller companies		
48	Captive Insurance May Educate Owners		
49	Captive Owners Need to be Openminded		

50	Captive Owners Share Costs		
51	Captives Do Not Advise		
52	Captives Need Capital		
53	Education of Supervisors and Sub-Contractors		17
54	Upper Management Hazard Education		
55	Educate Authority	Educate Authority	
56	Employer Education of Adverse Health Outcomes		
57	Educate Owners on Illness Costs		

58	Employer Education of Illness Costs		
59	Awareness of Hazards by Small Shop Owners		
60	Poor Quality Project Unaffordable	Project Outcome	18
61	Change False Sense of Protection		19
62	Change Mindset of Hazard Acceptance	Prioritize Safety	
63	Change Mindset from Cover Up to Protection		
64	Asking for Protections Perceived as Nusance		
65	Change How Workers Work Mindset		
66	Mindset Shift from Prevention to Protection		
67	Prioritize Safety		

68	Promote Safety Mindset		
69	Safety is Everyone's Job Mindset		
70	Entrench New Safety Mindset		
71	Safety Part of Everyday		
72	Strict Safety Mindset		
73	Safety as Good Business Mindset		
74	Change Trade as Low Skill Perception	Worker Public Perception	20
75	Revise Construction Worker Public Perception		
76	Construction Image Makeover		
77	Respect		
78	Educate Trades to their Value	Worker Value	21
79	Change Worker Value Mindset		
80	Worker Executes Established		

	Processes		
81	Recognize Worker Value		
82	Shift Employees As Enemies Mindset		22
83	Negative Industry Culture to Workers	Culture of Employee Mistrust	
84	Culture of Employee Mistrust		
85	Workers Viewed as Replaceable Commodity	Disposable Workers	23
86	Workers Treated as Disposable		
87	Change		24
88	Change and awareness takes time	Change Takes Time	
89	Ego Limits Change		
90	Communicating OSHA Messages Takes Time		

91	New Design Introduction takes Time		
92	No Open Shop Career Development	No Open Shop Career Development	25
93	Open Shop Numbers Greater	More Open Shops	26
94	Open Shop Pays Higher Wages	Higher Open Shop Wages	27
95	No Open Shop Organizational Affiliations	No Open Shop Afflilations	28
96	Open Shop State		
97	Union company	Union Shops	29
98	Union Not in All States		
99	Union Provides Workers a Voice	Union Worker Representation	30
100	Unions Inform Owners About Issues		

101	Union as Micromanagers		
102	Career After High School	Union Apprenticeship/Career Training	31
103	Career Opportunities		
104	Unions Offer Career Options		
105	Union Apprenticeship Job Training		
106	Union Worker Skills Overlap		
107	Fewer Union Shops	Fewer Union Shops	32
108	Trades Offer Pension Savings		33

109	College Debt Versus Career Pension		
110	Immediate Trade Pay Versus College Debt	Trade Pay vs. College Debt	
111	Trade Communication of Economic Opportunities		
112	Schools Provide Opportunities to Educate	Defined Career Opportunities	34
113	Open Shop Collaboration with Local Schools		
114	Education Offers defined Career Paths		
115	Education Value Not Understood		35
116	Combined Trade and College Education Non-Existent	Combined Trade and College Opportunities Non-existent	
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717	Need Continuing Education for Health Hazards	Continuing Education	
718	Need Hazard Education at All Levels		
719	Need Impacting Educational Materials		
720	Industry Responsible for Worker Impacts	Worker Health Impacts	172
721	Companies protected at Worker Expense		

722	Worker Pays Industry Negligence		

APPENDIX K

FINAL PRACTICES, BARRIERS, AND CATALYSTS DEVELOPED FOR THE DELPHI SURVEYS

Code	Welding Fumes	Category	Number
	Less Toxic materials	Substitution	1
Less or Non-Toxic Consumables	Material and process substitution like high nickel alloys and manganese as filler	Substitution	1
	Orbital Welding	Substitution	1
	Stick Welding versus TIG welding (Less fumes with TIG)	Substitution	1
	Alternative type of welding	Substitution	1
	Gas Metal Arc Welding (GMAW) Processes	Engineering Controls	1
	Tig Welding instead of flexcore or submersion metal arc	Substitution	1
Equipment Maintenance	Condition of Equipment, i.e., is it old or new	Administrative Controls	1
	Education	Administrative Controls	1
Contract Strategies	Estimates start in Requests for Proposals	Administrative Controls	1
Hazard Communication	Notification to other contractors on project about hazard	Administrative Controls	1
Alternate Hazards Communication, e.g., Signs and Color Coding	Hazard Communication using symbols and colors	Administrative Controls	1
	Signs for Welding Fumes	Administrative Controls	1
Respiratory Protection Programs	Respiratory Protection Programs	Administrative Controls	1
	Monitoring	Engineering Controls	1
Barriers	Separation Barriers	Administrative Controls	
Proper Ventilation	Different types of fume hoods	Engineering Controls	1
	Down Draft Tables	Engineering Controls	1
Placement	Engineering Controls like local exhaust ventilation located 10 to 12 inches of the weld	Engineering Controls	1

Filter	HEPA Filters	PPE	1
Exhaust	HEPA Vacuuum clothes before entering eating areas	Engineering Controls	1
	Local exhausts	Engineering Controls	1
Code	**Welding Fumes**	**Category**	Number
Proper Ventilation	Welding Fume Capture Hood	Engineering Controls	1
	Vacuums	Engineering Controls	1
	Smoke Eaters	Engineering Controls	1
	Local exhausts	Engineering Controls	1
Prevention Through Design	Engineering Design	Engineering Controls	1
	Prevention through Design	Engineering Controls	1
	Prevention through Design	Engineering Controls	1
	Preengineered systems	Engineering Controls	1
Showers and Hand Washing Units	Hand Washing Units	Engineering Controls	1
Design of Alternative Connections and Components, e.g. Non-Welding	Mechanical installation versus welding installation	Engineering Controls	1
	Preweld Flanges	Engineering Controls	1
Off Site Fabrication	Off Site Fabrication	Engineering Controls	1
	Off Site Fabrication	Engineering Controls	1
Preassembly	Welding Offsite	Engineering Controls	1
Prefabrication	Prefabrication	Engineering Controls	1
Modularization	Modularization	Engineering Controls	1
Proper Use of Appropriate Respiratory Protection	Respiratory Protection	PPE	1
Automated Welding	Robots	Elimination	1
	Welder Machines	Engineering Controls	1
	Track Welders	Engineering Controls	1
Activity Sequencing	Sequencing	Engineering Controls	1

Respiratory Protection Programs		Engineering Controls	1
	Using Wind Patterns, Environmental Temperature, and Weather Conditions	Engineering Controls	1
Code	**Welding Fumes**	**Category**	Number
	Remove protective equipment and do wipe sampling to mitigate contamination of other areas		

Code	**Noise**	**Category**	Number
Audio Metric Testing	100% Review of Every Audiogram	Administrative Controls	1
	Annual Audio testing	Administrative Controls	1
	Annual Audio testing	Administrative Controls	1
	Annual Field Autometric Testing	Administrative Controls	1
	Audiometric Exams	Administrative Controls	1
	Audiometric Exams	Administrative Controls	1
Hearing Conservation Programs	Robust Hearing Conservation Program	Administrative Controls	1
	Volumetric Exams on Worker	Administrative Controls	1
	Personal Attenuation Ratings	Administrative Controls	1
Proper Fitting PPE	E-A-Rfit evaluations for earplug fitting	Administrative Controls	1
	E-A-Rfit evaluations for earplug fitting	Administrative Controls	1
	E-A-Rfit evaluations for earplug fitting	Administrative Controls	1
	VeriPro Fit Test	Administrative Controls	1
	Ensure every single employee has appropriate hearing protection	Administrative Controls	1
	Right or Left Handed Placing of Earplug in ears	Administrative Controls	1
	Shape of one ear canal compared to the other	Administrative Controls	1
Regulations	No OSHA Noise Regulations	Administrative Controls	1
	Only Certain Tools have Regulatory Requirements	Administrative Controls	1
	No Regulation for Noise Control	Administrative Controls	1
Noise Assessments	Exposure Assessments	Administrative Controls	1

Code	Noise	Category	Number
	Noise Level Studies	Administrative Controls	1
Noise Monitoring	Constant Monitoring	Administrative Controls	1
	Area monitoring with sound level meters	Administrative Controls	1
	Noise Monitoring	Administrative Controls	1
Noise Mapping	Noise Mapping	Administrative Controls	1
	Noise Mapping	Administrative Controls	1
Noise Surveys	Noise Surveys	Administrative Controls	1
Work Shifts	Shift work	Administrative Controls	1
Work Rotations	Worker Rotation to Minimize Exposures	Administrative Controls	1
	Use Shift Work	Administrative Controls	1
Training	Training	Administrative Controls	1
	Training	Administrative Controls	1
	Training to ensure proper use of PPE	Administrative Controls	1
Equipment Maintenance	Well Maintained Equipment	Administrative Controls	1
	Ensure proper calibration of equipment	Administrative Controls	1
	Equipment Maintenance	Engineering Controls	1
	Antiquated and Noisy Equipment	Engineering Controls	1
	Condition of Equipment	Engineering Controls	1
Shielding	Enclosures	Engineering Controls	1
	Enclosures	Engineering Controls	1
	Enclosures	Engineering Controls	1
	Enclosures	Engineering Controls	1
	Shielding	Engineering Controls	1
	Sound Absorption Panels	Engineering Controls	1
	Sound Proofing	Engineering Controls	1

Code	**Noise**	**Category**	Number
	Barriers to Enclose Noise	Engineering Controls	1
	Acoustic Sound Barriers	Engineering Controls	1
	Engineering Controls like Barriers	Engineering Controls	1
	Noise Barriers	Engineering Controls	1
	Insulation Around Noisy processes/Equipment	Engineering Controls	1
	Retrofitting	Engineering Controls	1
	Mufflers	Engineering Controls	1
	Temporary Walls	Engineering Controls	1
Distance	Distance Between Personnel and Equipment	Engineering Controls	1
	Isolate the Activities	Engineering Controls	1
	Use Different locations	Engineering Controls	1
	Distance Between Personnel and Equipment	Engineering Controls	1
Eliminating Noise	Remove the Noise	Elimnation	1
	Noise Limiters on Radios	Engineering Controls	1
Functional Tool Design	Saw Stop technology, i.e., equipment that won't injure	Sustitution	1
Proper Ventilation	Exhaust Systems	Engineering Controls	1
	Ventilation Systems	Engineering Controls	1
Functional PPE	Double Hearing Protection for 105 dB or Greater	PPE	1
	PPE for Women's Physiology	PPE	1
	PPE, e.g., ear plugs	PPE	1
	PPE, e.g., ear plugs	PPE	1
	Double Hearing Protection for 105 dB or Greater	Engineering Controls	1
	Rubber Mats	Engineering Controls	1
	Headsets with Noise Filters	Engineering Controls	1
	Comfortable and Functional	PPE	1

	PPE		
Code	**Noise**	**Category**	Number
	Less Noise Tools	Substitution	1
	Pneumatic tools	Substitution	1
	Pneumatic tools	Substitution	1
	Purchase Quieter Tools	Engineering Controls	1
	Substitution of Pneumatic Tools	Substitution	1
	vibration dampening	Engineering Controls	1
	Use different equipment with less noise	Substitution	1
Prefabrication	Prefabricated Blocks Delivered to Site	Engineering Controls	1
	Prefabrication	Engineering Controls	1
Signs	Signs	Administrative Controls	1
	Postings for Noisy Areas	Administrative Controls	1
Job Classification	Job Classification by activity	Administrative Controls	1
Job Sequencing	Job Sequencing	Administrative Controls	1
Age Considerations	Aging Workforce	Administrative Controls	1
BIM	BIM (Building Information Modeling)	Elimination	1

Code	Silica	Category	Number
Less or Non-Toxic Consumables	Avoid Creating it in the first place	Elimination	1
	Alternative media for Sand blasting	Substitution	1
	Hazardous Ingredients in commonly used equipment	Substitution	1
	Bead Blasting instead of Silica	Substitution	1
	Black Beauty - Slag rather than Silica	Substitution	1
Dust Control Plans	Cannot blow silica dust	Engineering Controls	1
	Cannot clean off clothes by dusting it off	Engineering Controls	1
	Dust Control Plans	Engineering Controls	1
	Dust Control Plans	Engineering Controls	1
OSHA Training	10 Hour OSHA	Administrative Controls	1
	30 Hour OSHA	Administrative Controls	1
Medical Surveillance	Medical Surveillance	Administrative Controls	1
	Exposure Time	Engineering Controls	1
	Air Monitoring	Administrative Controls	1
	Monitoring	Administrative Controls	1
Contract Strategies	Understanding the project scope	Administrative Controls	1
Work Rotations	Work Rotations	Administrative Controls	1
Hazard Analysis	Job Risk Analysis	Administrative Controls	1

Code	**Silica**	**Category**	Number
	Utilize Specialty Contractor for Hazard	Administrative Controls	1
	Staff Plan	Administrative Controls	1
Hazard Training	Training	Administrative Controls	1
	Training	Administrative Controls	1
	Dust Collection on Tools	Engineering Controls	1
	Dust Collection Systems	Engineering Controls	1
	Dust Collection Systems	Engineering Controls	1
	Vacuum Systems	Engineering Controls	1
	Vacuum Systems	Engineering Controls	1
	HEPA vacuums	Engineering Controls	1
	HEPA vacuums	Engineering Controls	1
	HEPA vacuums	Engineering Controls	1

Barriers	Enclosures	Engineering Controls	1
Code	**Silica**	**Category**	Number
	Protective Barriers	Engineering Controls	1
	Isolate the Silica	Engineering Controls	1
Shielding	Shielding	Engineering Controls	1
Distance	Distance	Engineering Controls	1
Cutting Stations	Cutting Stations	Engineering Controls	1
	Pre-cutting	Engineering Controls	1
Prefabrication	Prefabrication	Engineering Controls	1
Dust Collecting Tools	Tools and Equipment	Engineering Controls	1
	Equipment that minimizes dust creation	Engineering Controls	1

	Tools and Equipment with integrated dust collection systems	Engineering Controls	1
Code	**Silica**	**Category**	Number
	Ventilation	Engineering Controls	1
	Engineering Ventilation Systems	Engineering Controls	1
	Ventilation	Engineering Controls	1
Wet Methods	Wet Applications	Engineering Controls	1
	Wet cutting	Engineering Controls	1
	For wet methods consideration of downstream hazards when dust dries	Engineering Controls	1
	Wet Methods	Engineering Controls	1
	Wet the Area, i.e., Engineering Control	Engineering Controls	1
	Wetting	Engineering Controls	1
	Tools and Equipment with integrated water sprayers	Engineering Controls	1
	Wetting Materials	Engineering Controls	1
Functional PPE	PPE	PPE	1
	Respiratory Protection	PPE	1
	Tyvek Suits, i.e., PPE	PPE	1
	Respiratory Protection	Engineering Controls	1

Code	MSDs	Category	Number
Proper Biomechanics	Body mechanics and position	Elimination	1
	Body mechanics and position	Elimination	1
	Proper lifting techniques	Elimination	1
	Proper lifting techniques	Elimination	1
	Improved Ergonomic Positioning	Elimination	1
	Proper lifting techniques	Elimination	1
Ergonomic Programs	Two person handling for 50 pounds or more	Administrative Controls	1
	Specialized Teams for Certain Types of Work	Administrative Controls	1
	Team Lifting	Administrative Controls	1
	Warm ups before Shifts	Engineering Controls	1
	Early Reporting of Musculoskeletal Issues	Administrative Controls	1
	Voluntary Stretch Program	Administrative Controls	1
	Stretch and Flex Before Work and After Lunch	Administrative Controls	1
	Stretching and Exercise Programs Before Starting Shifts	Administrative Controls	1
	Stretching and Exercise Programs Before Starting Shifts	Administrative Controls	1
	Have an Ergonomics Team	Administrative Controls	1
	Intermittent Breaks	Administrative Controls	1

Code	MSDs	Category	Number
	Elevated Cutting Stations	Engineering Controls	1
Health and Wellness Programs	Physical Therapist visits Work Sites	Administrative Controls	1
	Exercise Programs	Administrative Controls	1
	General life habits	Substitution	1
	Employee Wellness Programs	Administrative Controls	1
	Medical Evaluations	Administrative Controls	1
Age Considerations	Limiting Older Workers to Certain Physical Tasks	Administrative Controls	1
	Positioning Materials so they are accessible	Engineering Controls	1
	Good Routes for Materials	Administrative Controls	1
	Clear Pathways from Point A to Point B	Administrative Controls	1
	Pre-stage Materials	Elimination	1
Mechanical Assists	Mechanical Means	Elimination	1
	Mechanical Means	Elimination	1
	Palletizers that Automate Repetitive Movements	Elimination	1
	Palletizers that Automate Repetitive Movements	Elimination	1
	Automation rather than physical lifting	Elimination	1
	Utilizing Mechanical Devices	Elimination	1
	Racks and Tables to Eliminate Lifting, Bending, Twisting	Elimination	1

Robotics	Robotic Interventions	Elimination	1
Code	**MSDs**	**Category**	**Number**
	Prefabrication	Elimination	1
	Prefabrication	Engineering Controls	1
	Prefabrication	Engineering Controls	1
Modularization	Modular Receptacles	Engineering Controls	1
	Modular Construction	Elimination	1
Preplanning	Preplanning	Administrative Controls	1
	Preplanning	Administrative Controls	1
	Preplanning	Administrative Controls	1
	Planning in Estimation Process	Administrative Controls	1
	Planning the Work	Administrative Controls	1
Power Structure	Stop Work Authority	Administrative Controls	1
Hazard Analysis	Job Analysis	Administrative Controls	1
	Job Evaluation for lifting materials	Administrative Controls	1
	Early recognition and assessment of hazards	Administrative Controls	1
	Behavior Based Safety Audits	Administrative Controls	1
	Conduct Field Evaluations	Administrative Controls	1
	Job Hazard Analysis	Administrative Controls	1
Functional Tool Design	Lower vibration tools and equipment	Substitution	1
	Ergonomically Designed Tools	Engineering Controls	1
	Material choices of	Engineering	1

	equipment, i.e., wood hammer versus metal hammer	Controls	
Code	**MSDs**	**Category**	**Number**
	Vibration Programs	Administrative Controls	1
	Comfortable and Attractive PPE	Engineering Controls	1
	Proper Rigging	Engineering Controls	1
	Rubberized Mats	Engineering Controls	1
	Make PPE Comfortable	PPE	1
Affordable PPE	Affordable PPE	Elimination	1
Education	Education	Administrative Controls	1
Safety Programs	Nothing Hits the Ground Programs	Administrative Controls	1

No.	Code	Welding Fumes	Noise	Silica	MSDs
1	Activity Sequencing	1			
2	Affordable PPE				1
3	Age Considerations		1		1
4	Alternate Hazards Communication, e.g., Signs and Color Coding	1			
5	Anthropometric Considerations				1
6	Audio Metric Testing		1		
7	Automated Welding	1			
8	Barriers	1			
9	Barriers		1	1	
10	BIM		1		
11	Contract Strategies	1		1	
12	Cutting Stations			1	
13	Design of Alternative Connections and Components, e.g. Non-Welding	1			
14	Distance		1	1	
15	Dust Collecting Tools			1	
16	Dust Collection Systems			1	
17	Dust Control Plans			1	
18	Education				1

19	Eliminating Noise		1		
20	Equipment Maintenance	1	1		
21	Ergonomic Programs				1
22	Exposure Assessments			1	
23	Functional PPE		1	1	1
24	Functional Tool Design		1		1
25	Hazard Analysis			1	1
26	Hazard Communication	1		1	
27	Hazard Training		1	1	
28	Health and Wellness Programs				1
29	Hearing Conservation Programs		1		
30	Job Classification		1		
31	Job Sequencing		1		
32	Less or Non-Toxic Consumables	1		1	
33	Mechanical Assists				1
34	Medical Surveillance			1	
35	Modularization	1			1
36	Noise Assessments		1		
37	Noise Mapping		1		
38	Noise Reduced Tools		1		
39	Noise Surveys		1		
40	Off Site Fabrication	1			

41	OSHA Training			1	
42	Power Structure				1
43	Preassembly	1			
44	Prefabrication	1	1	1	1
45	Preplanning				1
46	Prevention Through Design	1			
47	Proper Biomechanics				1
48	Proper Fitting PPE		1		
49	Proper Use of Appropriate Respiratory Protection	1			
50	Proper Ventilation	1	1	1	
51	Regulations		1		
52	Respiratory Protection Programs	1			
53	Respiratory Protection Programs	1			
54	Robotics				1
55	Safety Programs				1
56	Shielding		1	1	
57	Showers and Hand Washing Units	1			
58	Signs		1		
59	Wet Methods			1	
60	Work Flow Efficiency				1
61	Work Rotations		1	1	

62	Work Shifts		1		
	Total	19	25	20	18

Code	Worker Barriers	Category	Number
Traditional Practices	Tradition	Administrative Controls	1
	Buy-in Takes Time	Administrative Controls	1
	Old Habits	Administrative Controls	1
	Traditional Practices	Administrative Controls	1
	Perception and experience of how things have been done.	Elimination	1
	Time	Administrative Controls	1
	Archaic Practices	Administrative Controls	1
Age Considerations	Aging Workforce	Administrative Controls	1
	Workers are Older	Administrative Controls	1
	Aging Workforce	Administrative Controls	1
	Pain	Administrative Controls	1
	Chronic Injuries	Administrative Controls	1
Worker Habits/Accountability	Unsafe Personal Hobbies that Cause Injuries	Administrative Controls	1
	Drug Addiction	Administrative Controls	1
	Lack of Work Ethic	Administrative Controls	1
	Lack of Dedication	Administrative Controls	1
	Lack of Compliance to Safety Rules	Administrative Controls	1
	Attitude Toward Safety	Administrative Controls	1

	Need for intrinsic motivation to be safe	Administrative Controls	1
	Personal Accountability	Administrative Controls	1
	Not wanting to wear sampling pumps	Engineering Controls	1
	Adherence to Policies	Administrative Controls	1
Code	**Worker Barriers**	**Category**	**Number**
Worker Attitude	Macho Attitude Hides Fear of Asking Questions	Administrative Controls	1
	Macho Disposition of invincible	Administrative Controls	1
Power Structure	Involving the workers in their own protection efforts	Administrative Controls	1
	Safety is Overlooked	Administrative Controls	1
	Fear of Losing Job	Administrative Controls	1
	Pushed to Produce	Administrative Controls	1
	Individual has little control over exposures	Administrative Controls	1
Leadership Engagement	Inadequate communication of the hazard to the workers by occupational health	Administrative Controls	1
Language	Language	Administrative Controls	1
Inexperience	New to Hazards	Administrative Controls	1
	Ignorance regarding Hazards	Administrative Controls	1
	Overwhelmed by Industrial Construction	Administrative Controls	1
Training	Lack of Training	Administrative Controls	1
	Lack of Training	Administrative Controls	1
	Lack of Training	Administrative Controls	1
	Lack of Training	Administrative Controls	1
	Continuous Training of New Workers	Administrative Controls	1

	Awarness and Training	Administrative Controls	1
	Very Little Risk Training	Administrative Controls	1
	Need OSHA 10 or OSHA 30 Training	Administrative Controls	1
	Training and Education	Administrative Controls	1
Code	**Worker Barriers**	**Category**	**Number**
	Young Engineers not Trained in Health and Safety	Administrative Controls	1
Education	Education	Administrative Controls	1
	Education	Administrative Controls	1
	Education regarding hazards	Administrative Controls	1
	Lack of Education	Administrative Controls	1
	Lack of Education	Administrative Controls	1
	Unaware of Hazards	Administrative Controls	1
	Rural Areas Less Educated on Hazards	Administrative Controls	1
	Number one Barrier is Education	Administrative Controls	1
Lessons Learned Access	Awareness and Access to Lessons Learned	Administrative Controls	1
Worker Skills	Lack of skilled workers	Administrative Controls	1
	Variability of Skills	Administrative Controls	1
Worker Lifestyle	Fatigue Workforce	Administrative Controls	1
	Lifestyle off the Worksite	Administrative Controls	1
	Self Esteem	Administrative Controls	1
	Poor Nutrition	Administrative Controls	1
	Obese Workforce	Administrative Controls	1
	Shift Work Fatigue	Administrative	1

		Controls	
	Fitness for Duty	Administrative Controls	1
Capital	Finances	Administrative Controls	1
	Costly	Administrative Controls	1
Pay	Lower wages in Right to work States	Administrative Controls	1
Code	**Worker Barriers**	**Category**	**Number**
	High Worker Turnover	Administrative Controls	1
	Migrant Workers	Administrative Controls	1
	Migratory Workers not Certified	Administrative Controls	1
Environmental Variability	Variability of Welding Environments	Administrative Controls	1
	Work Location	Administrative Controls	1
Hazard Producing Tools	Hand Held Devices that make Dust	Engineering Controls	1
	Improper use of Engineering Controls - Not taking the local exhaust and moving it along as welding is performed	Engineering Controls	1
	Lack of visibility from Construction equipment	Engineering Controls	1
	Reengineer the Chop Saw: Workers Die Using a Chop Saw because does not automatically turn off	Engineering Controls	1
Non-Functional PPE	Not being provided w/proper PPE	PPE	1
	Unattractive PPE	PPE	1
	Uncomfortable PPE	Administrative Controls	1
	Uncomfortable PPE	PPE	1
	Inappropriate use of cassette that measures exposure levels	Engineering Controls	1
	Hazardous Equipment with Blind Spots	Engineering Controls	1
	Upgrading personal PPE	PPE	1

Worker's Compensation Structure	Worker's Compensation is a litigation system	Administrative Controls	1
	Worker's Compensation is not designed for Health issues	Administrative Controls	1
Family Influence	Family telling youth to stay away from trades	Administrative Controls	1
Sickness Lagtime	Slow Impact to Health so do not Notice Until After some time	Administrative Controls	1
	Hearing Loss is Gradual	PPE	1

Code	Industry Barriers	Category	Number
Power Structure	Treating Workers as Disposable Keeps Potential Workers Away	Administrative Controls	1
	Safety is not first	Administrative Controls	1
	Safety is Overlooked	Administrative Controls	1
	What's in it for me?	Administrative Controls	1
	Attitude of what can you do for the company NOT what can you do for the industry.	Administrative Controls	1
Pay	Do not pay prevailing wage	Administrative Controls	1
Traditional Practices	Need to change old unsafe traditions	Elimination	1
	Tradition	Administrative Controls	1
	Traditional Practices	Administrative Controls	1
	Not sharing Best Practices or Lessons Learned for fear of giving up a competitive advantage	Administrative Controls	1
	Old Habits	Administrative Controls	1
	Old Hazards Overlooked	Administrative Controls	1
	Buy-in Takes Time	Administrative Controls	1

Lessons Learned Access	Access to Lessons Learned	Administrative Controls	1
Language	Language	Administrative Controls	1
Inexperience	Designers with no experience of the actual work environment	Substitution	1
Hazard Analysis	Lack of Hazard Identification	Administrative Controls	1
	Too many unknowns	Administrative Controls	1
Regulations	Clarity of Regulation Requirements	Administrative Controls	1
	Lack of OSHA Regulations	Administrative Controls	1
	Cumbersome OSHA Process	Administrative Controls	1
Code	**Industry Barriers**	**Category**	**Number**
	OSHA is slow and outdated	Administrative Controls	1
	OSHA is the bear minimum	Administrative Controls	1
	Compliance Mentality	Administrative Controls	1
	Mandatory Compliance	Administrative Controls	1
	Noise is not a recognized hazard.	Administrative Controls	1
	Unregulated Environment for Noise	Administrative Controls	1
	OSHA Standards Weak for Hearing Conservation	Administrative Controls	1
	Outdated OSHA Standards	Administrative Controls	1
	Outdated Regulations	Administrative Controls	1
OSHA Resources	Lack of Recognition of Free Resources, i.e., OSHA	Administrative Controls	1
Communication	Effective Communication	Administrative Controls	1
	Increased Collaboration and Communication	Administrative Controls	1
	Effective Communication Channels	Administrative Controls	1

Realistic Policies	Effective Policy Implementation	Administrative Controls	1
	Policies Need to Reflect Reality of Work Environments	Administrative Controls	1
	Enforce policies that are in place	Administrative Controls	1
	Enforcement of Policies	Administrative Controls	1
Worker Turnover	High Worker Turnover	Administrative Controls	1
	High Worker Turnover	Administrative Controls	1
	Skilled Workers will not work for companies that do not provide proper training and tools	Substitution	1
Training	Lack of apprenticeship/training programs	Administrative Controls	1
Code	**Industry Barriers**	**Category**	**Number**
	Lack of promotion of trades	Administrative Controls	1
	Lack of Training for Workers	Administrative Controls	1
	Very Little Risk Training	Administrative Controls	1
	Do not provide Training	Administrative Controls	1
	Learning about new Technology	Substitution	1
Leadership Engagement	Leadership	Administrative Controls	1
	Leadership has to be consistent	Administrative Controls	1
	Lack of Owner Involvement	Administrative Controls	1
Environmental Variability	Trades are Continually Rotating	Administrative Controls	1
	Variability of Jobs	Administrative Controls	1

Worker's Compensation Structure	Worker's Compensation is a litigation system	Administrative Controls	1
	Fear of litigation	Administrative Controls	1
	Worker's Compensation is a litigation system	Administrative Controls	1
Capital	Interventions are Expensive	Engineering Controls	1
Productivity Metrics	Cost of Occupational Disease	Administrative Controls	1
	Productivity losses associated with workers needing to get medical testing, respirator fitting, and training	Administrative Controls	1
Material Procurement	Poor Quality Materials	Substitution	1
Public Perception of Workers	Public is Complacent About Construction Workers	Administrative Controls	1
	Public is Complacent About Construction Workers	Administrative Controls	1
Non-Functional Tools	Do not provide Proper Tools	Engineering Controls	1

Code	Organizational Barriers	Category	Number
Power Structure	Safety is not first	Administrative Controls	1
	Safety is Overlooked	Administrative Controls	1
	Negative Attitude About Worker's Bringing Safety Issues forward	Administrative Controls	1
	Taboo to Complain	Administrative Controls	1
	Fear of Making Changes	Administrative Controls	1
	Owner does not provide worker protections	Administrative Controls	1
	Worker wants to work for a company	Substitution	1

	that will protect his/her well being over a company that will not.		
	What's in it for me?	Administrative Controls	1
Pay	Do not pay prevailing wage	Administrative Controls	1
	Cheap Labor	Administrative Controls	1
Traditional Practices	Buy-in Takes Time	Administrative Controls	1
	Need to change old unsafe traditions	Elimination	1
	Antiquated Standards	Administrative Controls	1
	Archaic Practices	Administrative Controls	1
	Outdated Policies	Administrative Controls	1
	Old Habits	Administrative Controls	1
	Tradition	Administrative Controls	1
	Traditional Practices	Administrative Controls	1
Code	**Organizational Barriers**	**Category**	**Number**
	Too many unknowns	Administrative Controls	1
Lessons Learned Access	Access to Lessons Learned	Administrative Controls	1
Capital	Not Wanting to pay for upgraded equipment	Administrative Controls	1
	Not Wanting to spend resources on newer equipment	Administrative Controls	1
	Future Maintenance not Considered on Projects	Administrative Controls	1
	Priority List of	Administrative	1

	Budget Items	Controls	
	Capital Investments	Administrative Controls	1
	Focus on profit margins	Administrative Controls	1
	Timeframe for Payback	Administrative Controls	1
	Finances	Administrative Controls	1
	Interventions are Expensive	Engineering Controls	1
	Cost of Retrofitting	Administrative Controls	1
	Number two Barrier is funding	Administrative Controls	1
	Financial Barrier for interventions	Administrative Controls	1
	Limited Funding	Administrative Controls	1
	Belief that Early Reporting leads to high medical expenses	Administrative Controls	1
	People think regulations cost money	Administrative Controls	1
	Medical Costs	Administrative Controls	1
	Cost	Administrative Controls	1
	Cost	Administrative Controls	1
Code	**Organizational Barriers**	**Category**	**Number**
	Cumbersome OSHA Process	Administrative Controls	1
	OSHA is slow and outdated	Administrative Controls	1
	Slow Government Policy Updated Processes	Administrative Controls	1
	Lack of OSHA Regulations	Administrative Controls	1

	No OSHA Requirement for Noise	Administrative Controls	1
	Lack of Enforcement of Safety Rules	Administrative Controls	1
OSHA Resources	Lack of Recognition of Free Resources, i.e., OSHA	Administrative Controls	1
Leadership Engagement	Proper Stakeholders	Administrative Controls	1
	Stakeholders	Administrative Controls	1
	Lack of Owner Involvement	Administrative Controls	1
	Dedication of Upper Management	Administrative Controls	1
	Management Leadership	Administrative Controls	1
	Clear Expectations of Work by Foreman	Administrative Controls	1
	Owner Ethics	Administrative Controls	1
	Owner Ethics	Administrative Controls	1
	Training the Management	Administrative Controls	1
Realistic Policies	Enforce policies that are in place	Administrative Controls	1
	Enforcement of policies	Administrative Controls	1
	Guidance Documents	Administrative Controls	1
Code	**Organizational Barriers**	**Category**	**Number**
	Lack of policies regarding Hierarchy of Control	Administrative Controls	1
	Inconsistent Enforcement of policies	Administrative Controls	1
	Ability to Generalize Policies	Administrative Controls	1

Language	Language	Administrative Controls	1
Communication	Inconsistent Communication of Expectations	Administrative Controls	1
	Communication between engineering, procurement, and construction	Administrative Controls	1
	Effective Communication	Administrative Controls	1
	Effective Communication Channels	Administrative Controls	1
	Increased Collaboration	Administrative Controls	1
	Increased Communication		
Training	Lack of apprenticeship/training programs	Administrative Controls	1
	Lack of Training for Workers	Administrative Controls	1
	Not providing training and education in trades	Administrative Controls	1
	Learning about new Technology	Substitution	1
	Competent Staff	Adminstrative Controls	1
	Very Little Risk Training	Administrative Controls	1
Worker Skills	Lack of Crafts People	Administrative Controls	1
	Lack of skilled Crafts people	Administrative Controls	1
Code	**Organizational Barriers**	**Category**	**Number**
	Lack of Crafts People	Administrative Controls	1
Environmental Variability	Environment Variability	Administrative Controls	1
Worker's Compensation Structure	Fear of litigation	Administrative Controls	1

	Lawsuits	Administrative Controls	1
	Lots of Paperwork related to an Incident	Administrative Controls	1
	Self-Insured	Administrative Controls	1
	Litigation Strategies for Injuries	Administrative Controls	1
	Worker's Compensation is a litigation system	Administrative Controls	1
	Worker's Compensation penalizes last employer for injury even if worker wasn't injured by that employer	Administrative Controls	1
	Worker's Compensation Rates based on all construction companies - penalizes conscientious companies	Administrative Controls	1
Contract Bidding Strategies	Low bid strategies	Administrative Controls	1
	Lowest Contract not always the Best	Administrative Controls	1
Worker Turnover	Migratory Workers	Administrative Controls	1
	High Worker Turnover	Administrative Controls	1
Age Considerations	Older Workforce	Administrative Controls	1
	Aging Workforce	Administrative Controls	1
Hazard Analysis	Unaware of trade hazard impacts to other workers on job site	Administrative Controls	1
Code	**Organizational**	**Category**	**Number**

	Barriers		
	Hazard Analysis Needed	Administrative Controls	1
	Footprint of what needs Retrofitting	Engineering Controls	1
	Lack of Hazard Identification	Administrative Controls	1
Productivity Metrics	Waste on quality and production	Administrative Controls	1
	Lack of Quality Control	Administrative Controls	1
	Internal Processes	Administrative Controls	1
	Workday Losses	Administrative Controls	1
Procurement	Cheap Material	Administrative Controls	1
	Poor Quality Materials	Administrative Controls	1
Equipment Maintenance	Equipment Calibration	Engineering Controls	1
	Equipment that does what it says	Engineering Controls	1
Non-Functional PPE	Not providing Workers proper PPE	PPE	1
	Hand Held Devices that make Dust	Administrative Controls	1
Inexperience	Not All Jobs have a project manager	Administrative Controls	1
	Designers with no experience of the actual work environment	Administrative Controls	1
Sickness Lagtime	Lag time for onset of disease difficult to assess needed control measures	Administrative Controls	1

No.	Code	Worker Barriers	Industry Barriers	Organizational Barriers
1	Age Considerations	1		1
2	Capital	1	1	1
3	Communication		1	1
4	Contract Bidding Strategies			1
5	Education	1		
6	Environmental Variability	1	1	1
7	Equipment Maintenance			1
8	Family Influence	1		
9	Hazard Analysis		1	1
10	Hazard Producing Tools	1		
11	Inexperience	1	1	1
12	Inexperience		1	1
13	Language	1	1	1
14	Leadership Engagement	1	1	1
15	Lessons Learned Access	1	1	1
16	Non-Functional PPE	1		1
17	Non-Functional Tools		1	
18	OSHA Resources		1	1
19	Pay	1	1	1
20	Power Structure	1	1	1
21	Procurement		1	1
22	Productivity Metrics		1	1
23	Public Perception of Workers		1	
24	Realistic Policies		1	1
25	Regulations		1	1
26	Sickness Lagtime	1		1
27	Traditional Practices	1	1	1
28	Training	1	1	1
29	Worker Attitude	1		
30	Worker Habits/Accountability	1		
31	Worker Lifestyle	1		
32	Worker Skills	1		1
33	Worker Turnover	1	1	1
34	Worker's Compensation Structure	1	1	1
	Total	**22**	**22**	**26**

Code	Worker Catalysts	Category	Number
Worker Recognition	Thank you for a job well done	Administrative Controls	1
Leadership Engagement	Communication from Experienced Worker	Administrative Controls	1
	Open Communication	Administrative Controls	1
Education	Education	Administrative Controls	1
	Education	Administrative Controls	1
Training	Union workers informed about hazards asking questions of the Industrial hygienists	Administrative Controls	1
	Training	Administrative Controls	1
	Skills checks	Administrative Controls	1
	New Employee Orientation	Administrative Controls	1
	Training and Testing Facilities	Administrative Controls	1
	Understanding why need to do something	Administrative Controls	1
Hazard Analysis	Job Hazard Analysis	Administrative Controls	1
	Planned Observation	Administrative Controls	1
	Job Walks	Administrative Controls	1
Power Structure	Ownership of safety	Administrative Controls	1
	Stop Work Authority	Administrative Controls	1
Worker Habits/Accountability	Recognition of Personal Accountability	Administrative Controls	1
	Retiring Workers taking Bad habits with them	Administrative Controls	1
Functional Tools	Improved Tools	Engineering Controls	1
	Welding - Air purifying respirators that can be	Engineering Controls	1

	worn like a welding helmet		
Code	**Organizational Catalysts**	**Category**	**Number**
Regulations	Fines or Litigation	Elimination	1
	Regulatory Requirements	Elimination	1
	Forced by Regulation	Administrative Controls	1
Available Capital	Capital	Administrative Controls	1
Contract Strategies	Client Mandated Interventions	Administrative Controls	1
	Contract language holding contractor accountable	Administrative Controls	1
	Understanding the contracts	Administrative Controls	1
Leadership Engagement	Corporate Safety Group	Administrative Controls	1
	Development of Strong Safety Culture	Administrative Controls	1
	Promoting that asking for help is a good thing	Administrative Controls	1
	Executives are being held accountable for Worker injuries	Administrative Controls	1
	Make Safety a Value	Administrative Controls	1
	Recognizing Responsibility for Worker's Lives	Administrative Controls	1
Worker Habits/Accountability	Remove People who don't follow Safety Culture	Administrative Controls	1
Incentives	External Validation via Awards	Administrative Controls	1
	Bonuses	Administrative Controls	1
	Safety Incentive Awards	Administrative Controls	1
	Performance Awards tied to Safety Records	Administrative Controls	1
Hazard Analysis	Eliminate Hazard	Elimination	1
	Hazard Activity Analysis	Administrative	1

		Controls	
	Hazard Assessments on Work Practices	Elimination	1
	Internal Assessment Team	Administrative Controls	1
Code	**Organizational Catalysts**	**Category**	**Number**
	Use leading indicators to plan work	Administrative Controls	1
	Process in Place for Early Reporting of potential MSDs	Elimination	1
Reputational Considerations	Better Safety Record	Administrative Controls	1
	Improved Reputation	Administrative Controls	1
	Contractors Realizing Safety and Health Programs will make them more Competitive	Administrative Controls	1
	Recognition of Reputational Risks	Administrative Controls	1
OSHA Resources	OSHA Temporary Worker Initiative	Administrative Controls	1
	OSHA Voluntary Protection Program	Administrative Controls	1
Leadership Engagement	Leadership	Administrative Controls	1
	Owner Ethics	Administrative Controls	1
	Owner Ethics	Administrative Controls	1
	Owner Requirements	Administrative Controls	1
	Owner Involvement	Administrative Controls	1
Effective Communication	Open Communication	Administrative Controls	1
	Effective Communication that is not Dictatorial	Administrative Controls	1
Productivity Metrics	Safer Environments make more money	Administrative Controls	1
	Safer Environments make	Administrative	1

	more money	Controls	
	Safer job sites do not lose productivity	Administrative Controls	1
	Cost Savings of Interventions	Administrative Controls	1
	Return on Investments for Safety at least two-fold	Administrative Controls	1
Code	**Organizational Catalysts**	**Category**	**Number**
Job Hazards Education	Train the Foreman regarding job hazards	Administrative Controls	1
	Education	Administrative Controls	1
	Union Improving Training for Workers	Administrative Controls	1
Functional Tools	Improved Tools	Engineering Controls	1
Prevention Through Design	Prevention through Design	Engineering Controls	1
Worker's Compensation Structure	Worker's compensation run down of injuries	Administrative Controls	1
	Cost Sharing	Administrative Controls	1
	Discounts on Insurance	Administrative Controls	1
Record Keeping	Audits	Administrative Controls	1

Code	Industry Catalysts	Category	Number
Worker's Compensation Structure	Cost Sharing	Administrative Controls	1
	Discounts on Insurance	Administrative Controls	1
Education	Education	Administrative Controls	1
	Education	Administrative Controls	1
	CEO Need Hazard Education	Administrative Controls	1
	Education of Senior Corporate Managers	Administrative Controls	1
Leadership Engagement	Executives are being held accountable for Worker injuries	Administrative Controls	1
	Engaged Leadership	Administrative Controls	1
	Owner Involvement	Administrative Controls	1
	Owner Requirements	Administrative Controls	1
	Recognizing Responsibility for Worker's Lives	Administrative Controls	1
Effective Communication	Effective Communication that is not Dictatorial	Administrative Controls	1
	Open Communication	Administrative Controls	1
	Effective Leadership	Administrative Controls	1
	Buy-in from Senior Leadership	Administrative Controls	1
	Leadership Commitment to Education about Hazards	Administrative Controls	1
Regulations	Forced by Regulation	Administrative Controls	1
	Regulatory Requirements	Administrative Controls	1
	Regulatory Requirements	Administrative Controls	1

Code	Industry Catalysts	Category	Number
	OSHA Voluntary Protection Program	Administrative Controls	1
Productivity Metrics	Leading metrics versus lagging metrics	Administrative Controls	1
	Environmental Metrics	Administrative Controls	1
	Safety Metrics	Administrative Controls	1
	Industrial Hygiene Metrics	Administrative Controls	1
	Lack of Injuries saves money	Administrative Controls	1
	Safer job sites do not lose productivity	Administrative Controls	1
	Safer Environments make more money	Administrative Controls	1
	Return on Investments for Safety at least two-fold	Administrative Controls	1
	Larger Firms Seeing Benefits of Safety and Health Programs	Administrative Controls	1
Incentives	Corporate Health Achievement Awards	Administrative Controls	1
Reputational Considerations	Recognition of Reputational Risks	Administrative Controls	1
	Improved Reputation	Administrative Controls	1
Interventions	Work with manufacturers to produce safer products	Substitution	1
	Improved Tools	Engineering Controls	1
	Allow industry to make the intervention first	Administrative Controls	1
	Industry Driving the change	Administrative Controls	1
Power Structure	Development of	Administrative	1

	Strong Safety Culture	Controls	
	Make Safety a Value	Administrative Controls	1
Code	**Industry Catalysts**	**Category**	**Number**
Contract Strategies	Client Mandated Interventions	Administrative Controls	1
	Scope of work to include Safety	Administrative Controls	1
Work Ethic	Losing Work Ethic of Immigrants	Administrative Controls	1
Best Practices	Best Practices	Administrative Controls	1

No.	Code	Worker Catalysts	Industry Catalysts	Organizational Catalysts
1	Available Capital			
2	Best Practices		1	
3	Contract Strategies		1	1
4	Education	1	1	
5	Functional Tools	1		1
6	Hazard Analysis	1		1
7	Incentives		1	1
8	Interventions		1	
9	Job Hazards Education			1
10	Leadership Engagement	1	1	1
11	OSHA Resources		1	1
12	Pay	1		
13	Power Structure	1	1	
14	Prevention Through Design			1
15	Productivity Metrics		1	1
16	Record Keeping			1
17	Regulations		1	1
18	Reputational Considerations		1	1
19	Training	1		
20	Work Ethic		1	
21	Worker Habits/Accountability	1		
22	Worker Recognition	1		
23	Worker's Compensation Structure		1	1
	Total	**9**	**13**	**13**

APPENDIX L

SELECTIVE CODES ORGANIZED UNDER EACH MODEL QUADRANT

Selective Codes	Theory Code
Leadership Behaviors	System Power Source
Company Priorities	
Owner Priorities	
Owner Expectations	
Owner Ethics	

Selective Codes	Theory Code
Threats to Pay	Profits
Productivity	
Transferrable Wage Accounts	
Lost Wage Accounts	
Capital Investments	
Investment Losses	
Process Efficiency	
Sick Day Impacts	
Project Outcome	
Quality	
Trade Pay vs. College Debt	
Insurance Premiums	
Higher Open Shop Wages	

Selective Codes	Theory Code
Opportunities for Creative Solutions	Opportunities for Creative Solutions
Change Takes Time	Change Takes Time

Selective Codes	Theory Code
Tax Incentives	Incentives
Business Incentives	
Worker Retention Incentives	

Selective Codes	Theory Code
Regulatory Impacts	Fines
Compliance Based Practices	
Silica Regulations	

Selective Codes	Theory Code
Cost Algorithms	Costs
Cost Benefit Analysis	
Cost Tracking	

Selective Code	Theory Code
Savings	Savings

Selective Codes	**Theory Code**
False Sense of Health	Attention (-)
Sickness Lagtime	
Worker Health Impacts	
Adverse Health Symptom Suppression	
Silica Impacts	
Noise Impacts	
Chronic Injuries	
Life Style Impacts	
Absent Hazard Control Plans	
Sick Workers	
Worker Deaths	
Mandatory Work Training	
Media to Mislead	
Worker's Compensation Disadvantages	
Worker's Compensation Structure	
Legal Impacts of Worker Misclassification	
Cross Trade Hazard Exposures	
Makeshift Hazard Protections	

Impatience	
Macho Mindsets	
Selective Codes	**Theory Code**
Worker Public Perception	Attention (-) Continued
Lack of Hazards Education	
Construction Hazard Ignorance	
Immigrant Worker Ignorance	
Ignorance of Illegal Wage Practices	
Training and Health Disconnects	
Regulatory Influences	
Targeted Enforcement	
Lack of Consequences	
Liability Avoidance	
Non-Compulsory Health and Safety Programs	
Contract Bidding Practices	
Contributions to Worker Shortages	
Combined Trade and College Opportunities Non-existent	
No Open Shop Career Development	
No Open Shop Affiliations	
Unmonitored Worker Classification	
Worker Skill Gaps	

Selective Codes	Theory Code
Employees as Assets	Intention (Focused Attention)
Future Worker Asset Planning	
Maintaining Worker Health	
Prioritize Safety	
Hazard Information Availability	
Remove Health Hazards	
Manufacturer Influences	
Teamwork	
Job Hazards Analysis	
Health Hazards Education	
Worker Wage and Labor Education	
Develop Health Protocols	
Minimizing Exposures	
Worker Education	
Initial Worker Training	
Continuing Education	
Public Hazard Awareness	
Contract Enforcement	
Best Practices	

Selective Codes	Theory Codes
Union Worker Representation	Intention (Focused Attention) Continued
Require Health and Safety Business Licensing	
Stop Work Authority Practice	
Project Responsibility/Leadership	
Foreman Leadership	
Require Distribution of Health and Safety Information	
Worker Retention	
Contract Monitors	
Lessons Learned	
Educate Authority	
Trades Are Technical	
Worker Skill Assessments	
Worker Health and Safety Certification	

Selective Codes	Theory Code
Responsible Company Practices	Integrity (+)
Honest Wage Practices	
Employer Reputation	
Worker Accountability	
Industry Accountability	
Worker Value	
Safety Program Integrity	

Selective Codes	Theory Code
Culture of Employee Mistrust	Integrity (-)
Disposable Workers	
Worker Exploitation	
Falsifying Worker Qualifications	
Irresponsible Employers	
Illegal Wage Practices	
Project Type Mis-Classification	

Selective Codes	Theory Code
Industry/Experience Knowledge Transfer	Intuition
Safety as Good Business Mindset	
Business Integration of Health and Safety	
Diversity Benefits	
Family Influence	
Community Involvement	
Functional Equipment Selection	
Media Audience Access	
Public Service Campaign Models	

Selective Codes	Theory Code
Labor Movement	What Manifests
Engineering Controls	
Administrative Controls	
Payroll Certification	
Product Design	
Equipment Comfort	
Government/Industry Collaboration	
OSHA Partnerships	
OSH Expert Collaboration	
Insurance Industry Collaboration	
Technology Benefits	
Trade Scheduling	
Equipment Operations and Maintenance	
Product Procurement and Acquisition	
Injury and Illness Tracking	
Hearing Protection Standards	
Worker Program Funding	
Prefabrication	
Job Sequencing	
Preplanning	

APPENDIX M

FIRST DELPHI SURVEY ROUND WITH IDENTIFIED PRACTICES, BARRIERS AND CATALYSTS

Health Hazards Delphi Survey Instructions

Round 1

INTRODUCTION AND BACKGROUND INFORMATION

You are receiving this survey for your participation as a panel expert in the research project "Engaging Project Stakeholders in Strategies for the Early Prevention of Noise, Welding Fumes, Crystalline Silica Particles, and Musculoskeletal Disorders at Construction". During the summer months, we had the opportunity to interview 11 subject matter experts and inquire them on the prevention of worker exposure to the hazards of silica, welding fumes, noise, and musculoskeletal disorders. The analysis of the interview material has resulted in the **definition of prevention practices** specific to each health hazard, as well as in the **identification of general barriers against** and **catalysts for** the implementation of such prevention practices.

In order to complete the research project and build consensus around those practices, barriers, and catalysts, multiple rounds (typically 3) of Delphi surveys will be distributed among the same subject matter experts. The Delphi method is a consensus-building and expert communication process that encompasses an iterative and interactive survey inquiry to elicit the judgment of the independent experts and achieve a convergence of opinion. Indeed, this online survey form contains the first round of inquiry.

Time required to complete the survey. The present survey takes about 20 minutes to complete the 6 sections. We respectfully request you take no longer than **one week** to submit your responses. Your timely responses will be used to design the next round of the Delphi survey.

Confidential responses. Even though the questions in this survey do not require the sharing of personal information, all answers will still be sanitized, so that an answer cannot be traced back to the individual who responded to the corresponding question. The research protocol in this study has been reviewed and approved by the Institutional Review Board at Arizona State University, which ensures the protection of rights and welfare of the participants in this study.

Contact information. Please do not hesitate to contact Linda Tello at ltello@asu.edu with any comments or questions you may have. To move through the survey, please click on NEXT at the bottom right of each page.

Thank you very much for your time.

INSTRUCTIONS

A total of 6 sections are requested to complete the survey. Sections 1 – 4 address the practices identified for the prevention of exposures to Welding Fumes, Noise, Silica, and Musculoskeletal Disorders during the interviews. Sections 5 - 6, respectively, address barriers against and catalysts for the implementation of such prevention practices identified from the interviews.

Each section has 3 questions. The first question inquiries on your agreement with the definition of practices, barriers, or catalysts in the section –a table is used to list such practices, barriers, or catalysts. The second question inquires about the completeness of the practices, barriers and catalysts previously listed. Finally, the third question inquires on the name or definition of any additional prevention practices, barriers, or catalysts that, according to your opinion, was not captured from the interviews.

Prevention of Welding Fumes

1.1 Table 1 contains the practice codes for the prevention of Welding Fumes exposure as identified from the interviews. Based on your knowledge and experience, we ask you to let us know whether you agree with each individual prevention practice in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific code that we have used to define the practice or any other comments that you may have in the corresponding Comments box. In case you disagree (your answer is No) with the proposed prevention practice, we also ask you to kindly let us know your thoughts or reasons for such disagreement in the corresponding Comments box.

Table 1. Practice Codes for Welding Fumes

	Agree		
	Yes	No	Comments
Activity Sequencing	❍	❍	
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	❍	❍	
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	❍	❍	
Fume Protection Barriers	❍	❍	
Distancing On-Site Welding Activities	❍	❍	
Tool and Equipment Maintenance	❍	❍	
Automated Welding	❍	❍	
Use of Less or Non-Toxic Welding Consumables	❍	❍	
Modularization	❍	❍	
Off Site Fabrication	❍	❍	
Welding Fumes Hazards Training	❍	❍	
Appropriate Respiratory Protection (e.g., PPE)	❍	❍	
Proper Ventilation	❍	❍	
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker	❍	❍	

Exposure			
Availability of Showers and Hand Washing Units	❍	❍	
Monitoring of Contamination in Common Areas	❍	❍	
Exclusion Zones to Welding Areas	❍	❍	
Removing Contaminated PPE/Clothing before Entering Common Areas	❍	❍	
Design of Alternative Connections and Components, e.g. Bolted Connections	❍	❍	
Worker Rotations	❍	❍	
Chronologically Gifted/Aging Workforce Considerations	❍	❍	
Work Shifts	❍	❍	

1.2 In your expert opinion, are there additional practices that can be used to mitigate exposure to Welding Fumes and that have not been captured in the above list? Please click the Yes or the No tab.

❍ Yes
❍ No

1.3 If your answer to the above question is YES, please list those additional practices below, and any comment on such practice(s) that you may have.

Prevention of Noise

2.1 Table 2 contains the practice codes for the prevention of Noise exposure as identified from the interviews. Based on your knowledge and experience, we ask you to let us know whether you agree with each individual prevention practice in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific code that we have used to define the practice or any other comments that
you may have in the corresponding Comments box. In case you disagree (your answer is No) with the proposed prevention practice, we also ask you to kindly let us know your thoughts or reasons for such disagreement in the corresponding Comments box.

Table 2. Practice Codes for Noise

	Agree			
	Yes	No	Comments	
Chronologically-Gifted/Aging Workforce Considerations	❍	❍		
Periodic Audiometric Testing and Hearing Assessment	❍	❍		
Acoustic Sound Barriers	❍	❍		
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	❍	❍		
Distancing On-Site Noisy Activities	❍	❍		
Tool and Equipment Maintenance	❍	❍		
Appropriate Hearing Protection (e.g., PPE)	❍	❍		
Noise Hazard Training	❍	❍		
Exclusion Zones to Noisy Areas	❍	❍		
Activity Sequencing	❍	❍		
Modularization	❍	❍		
Off Site Fabrication	❍	❍		
On-Site Noise Monitoring and Mapping	❍	❍		
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	❍	❍		

Alternate Noise Hazards Communication, e.g., Signs and Color Coding	❍	❍		
Worker Rotations	❍	❍		
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	❍	❍		
Anthropometrically Fitting PPEs, e.g. Sizing across genders	❍	❍		
Individual Worker Training of Proper PPEs Use/Fit	❍	❍		
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	❍	❍		

2.2 In your expert opinion, are there additional practices that can be used to mitigate exposure to Noise and that have not been captured in the above list? Please click the Yes or the No tab.

❍ Yes
❍ No

2.3 If your answer to the above question is YES, please list those additional practices below, and any comment on such practice(s) that you may have.

Prevention of Crystalline Silica

3.1 Table 3 contains the practice codes for the prevention of Crystalline Silica exposure as identified from the interviews. Based on your knowledge and experience, we ask you
to let us know whether you agree with each individual prevention practice in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific code that we have used to define the practice or any other comments that you may have in
the corresponding Comments box. In case you disagree (your answer is No) with the proposed prevention practice, we also ask you to kindly let us know your thoughts or reasons for such disagreement in the corresponding Comments box.

Table 3. Practice Codes for Crystalline Silica

	Agree		
	Yes	No	Comments
Silica Dust Protections and/or Containment Barriers	❍	❍	
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	❍	❍	
Isolation of Cutting Stations	❍	❍	
Distancing On-Site Airborne Producing Silica Activities	❍	❍	
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	❍	❍	
Airborne Silica Monitoring and Sampling	❍	❍	
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	❍	❍	
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	❍	❍	
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	❍	❍	
Planning for Water	❍	❍	

Supply Connection for Wet Methods (e.g., handheld tools)			
Silica Hazard Training	❍	❍	
Low or Non-Silica Content in Materials	❍	❍	
Activity Sequencing	❍	❍	
Appropriate Respiratory Protection	❍	❍	
Off Site Fabrication (e.g., Pre-Cast Concrete)	❍	❍	
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	❍	❍	
Worker Rotations	❍	❍	
Exclusion Zones to Silica Hazard Areas	❍	❍	
Chronologically Gifted/Aging Workforce Considerations	❍	❍	
Work Shifts	❍	❍	

3.2 In your expert opinion, are there additional practices that can be used to mitigate exposure to Silica and that have not been captured in the above list? Please click the Yes or the No tab.

❍ Yes
❍ No

3.3 If your answer to the above question is YES, please list those additional practices below, and any comment on such practice(s) that you may have.

Prevention of Musculoskeletal Disorders

4.1 Table 4 contains the practice codes for the prevention of Musculoskeletal Disorders as identified from the interviews. Based on your knowledge and experience, we ask you to let us know whether you agree with each individual prevention practice in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific code that we have used to define the practice or any other comments that you may
have in the corresponding Comments box. In case you disagree (your answer is No) with the proposed prevention practice, we also ask you to kindly let us know your thoughts or reasons for such disagreement in the corresponding Comments box.

Table 4. Practice Codes for Musculoskeletal Disorders

	Agree		
	Yes	No	Comments
Early Recognition and Reporting of Musculoskeletal Symptoms	❍	❍	
Chronologically-Gifted/Aging Workforce Considerations	❍	❍	
Alternate Hazards Communication, e.g., Signs and Color Coding for Lifting Hazards	❍	❍	
Safe and Functional Tool Design and Proper Use (e.g., Anti-vibration Devices, Impact Energy Absorbing Materials, i.e., wood vs. steel)	❍	❍	
Ergonomic Audits of Individual Workers	❍	❍	
On-Site Ergonomic Program (e.g., Proper Biomechanics Training, Flex and Stretch, Team lifting, Two-Step Lifting, etc.)	❍	❍	
Health and Wellness Programs (e.g., Nutrition, Exercise)	❍	❍	
Anthropometric Work Evaluations (e.g., adjustable height workstations)	❍	❍	
Platforms for	❍	❍	

Elevated Work			
Anthropometrically Fitting PPE, e.g. Sizing across genders	❍	❍	
Availability and Utilization of Mechanical Assists to Eliminate Lifting, Bending, and Twisting	❍	❍	
Modularization	❍	❍	
Constructability Assessment	❍	❍	
Off Site Fabrication	❍	❍	
Preassembling on the Ground (e.g., Steel Components)	❍	❍	
Worker Rotations	❍	❍	
Robotics and Automation	❍	❍	
Biomechanics Coaching From Experienced Workers (e.g. formal and/or informal)	❍	❍	
Planning and Site Layout (Reduction of Repetitive Motions, e.g., multiple handling of materials)	❍	❍	

4.2 In your expert opinion, are there additional practices that can be used to mitigate Musculoskeletal Disorders and that have not been captured in the above list? Please click the Yes or the No tab.

❍ Yes
❍ No

4.3 If your answer to the above question is YES, please list those additional practices below, and any comment on such practice(s) that you may have.

Barriers

5.1 Table 5 contains barriers against the implementation of the previous prevention practices for the health hazards of welding fumes, noise, crystalline silica, and musculoskeletal disorders as identified from the interviews. Based on your knowledge and experience,
we ask you to let us know whether you agree with each individual barrier in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific Code that we have used to define the barrier or any other comments that you may have in the corresponding Comments box. In case you disagree (your answer is No) with the proposed barrier, we also ask you to kindly let us know your thoughts or reasons for
such disagreement in the corresponding Comments box.

Table 5. Barriers

	Agree		
	Yes	No	Comments
Chronologically-Gifted/Aging Workforce	❍	❍	
Limited Capital	❍	❍	
Ineffective Job Hazards Communication	❍	❍	
Unenforceable Contract Health Provisions	❍	❍	
Temporary Labor, e.g., Day Laborers	❍	❍	
Varying Project Conditions	❍	❍	
Improper Equipment and Tool condition	❍	❍	
Lack of Proper Trainer Credentials	❍	❍	
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws	❍	❍	
Worker Trade Inexperience	❍	❍	
Management Inexperience with Health Hazards	❍	❍	
Language Barrier e.g., employer unwilling to provide training in other than English	❍	❍	
Non-Functional PPE	❍	❍	
Non-Functional Tools	❍	❍	
Tool and PPE	❍	❍	

Procurement Cost Driven			
Ineffective or Nonexistent Health Processes and Procedures at Organization	❍	❍	
False Sense of Worker Health due to Delayed Health Impact	❍	❍	
Resistance to Change	❍	❍	
Macho Type Attitude	❍	❍	
Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking	❍	❍	
High Worker Turnover	❍	❍	

5.2 In your expert opinion, are there additional barriers that have not been captured in the above list? Please click the Yes or the No tab.

❍ Yes
❍ No

5.3 If your answer to the above question is YES, please list those additional barriers below, and any comment on such barrier(s) that you may have.

Catalysts

6.0 The following table lists catalysts that can facilitate the implementation of the prevention practices for the health hazards of welding fumes, noise, crystalline silica, and musculoskeletal disorders as identified from the interviews. Based on your knowledge and experience, we ask you to let us know whether you agree with each individual catalyst in the table by checking the corresponding either Yes or No column. In case you agree (i.e. your answer is Yes), we ask you to let us know of any comment regarding the specific Code that we have used to define the catalyst or any other comments that you may have in the corresponding Comments box. In case you disagree (your answer is No) with the proposed catalyst, we also ask you to kindly let us know your thoughts or reasons for such disagreement in the corresponding Comments box.

Table 6. Catalysts

	Agree		
	Yes	No	Comments
Available Capital	❍	❍	
Lessons Learned Program	❍	❍	
Inclusion of Contract Health Provisions	❍	❍	
Health Hazard Awareness and Education	❍	❍	
Job Hazard Analysis	❍	❍	
Occupational Health Programs, e.g., Hearing Conservation Program	❍	❍	
Clear Return on Investment	❍	❍	
Incentivization, e.g., Reporting of Health Hazard Exposures	❍	❍	
Specific Job Hazards Awareness and Education	❍	❍	
Continued Leadership Commitment	❍	❍	
OSHA Tools & Training Awareness	❍	❍	
Job Coaching from Experienced Workers	❍	❍	
Worker Voice(s) leveraged by Management	❍	❍	
Apprenticeship Programs	❍	❍	
Regulatory Enforcement	❍	❍	
Proper Hazard Training	❍	❍	
Media Exposure (Reputation)	❍	❍	
Worker Accountability/Attitude	❍	❍	
Worker	❍	❍	

Recognition/Appreciation			

6.2 In your expert opinion, are there additional catalysts that have not been captured in the above list? Please click the Yes or the No tab.

- ❍ Yes
- ❍ No

6.3 If your answer to the above question is YES, please list those additional catalysts below, and any comment on such catalyst(s) that you may have.

Thank you for your participation. Please click NEXT on the bottom right to submit your survey.

APPENDIX N

REVISED PRACTICE CODES

Revised Practice Codes for Welding Fumes, Crystalline Silica, Noise, and MSDs

Welding Fumes	
Original Code	**Revised Code**
Activity Sequencing	Activity Sequencing, e.g., activity planning and execution to minimize/reduce fume exposures
Chronologically Gifted/ Aging Workforce Considerations	Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker
Work Shifts	Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers

Noise	
Original Code	**Revised Code**
Modularization	Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions

Silica	
Original Code	**Revised Code**
Worker Rotations	Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)

Musculoskeletal	
Original Code	**Revised Code**
Constructability Assessment	Constructability Assessment, e.g., incorporation of construction knowledge and experience in the design and planning phase so that project can be effectively built, inclusive of ergonomics and anthropometric feasiblility and considerations
Off Site Fabrication	Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Worker Rotations	Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)

Barriers	
Original Code	**Revised Code**
Varying Project Conditions	Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations
Improper Equipment and Tool condition	Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment

Catalysts	
Original Code	**Revised Code**
Clear Return on Investment	Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized
Worker Voice(s)heard and leveraged by Management	Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns

APPENDIX O

LIST OF PREVENTION PRACTICES, BARRIERS, AND CATALYSTS IDENTIFIED FROM THE FIRST ROUND OF THE DELPHI SURVEY

Welding Fume Practices
Welding Fumes Hazards Training
Appropriate Respiratory Protection (e.g., PPE)
Proper Ventilation
Tool and Equipment Maintenance
Availability of Showers and Hand Washing Units
Exclusion Zones to Welding Areas
Fume Protection Barriers
Monitoring of Contamination in Common Areas
Distancing On-Site Welding Activities
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Removing Contaminated PPE/Clothing before Entering Common Areas
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding
Design of Alternative Connections and Components, e.g. Bolted Connections
Activity Sequencing, e.g., activity planning and execution to minimize/reduce fume exposures
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Use of Less or Non-Toxic Welding Consumables
Automated Welding
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker

Noise Prevention Practices
Appropriate Hearing Protection (e.g., PPE)
Noise Hazard Training
Acoustic Sound Barriers
Individual Worker Training of Proper PPEs Use/Fit
Periodic Audiometric Testing and Hearing Assessment
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation
Exclusion Zones to Noisy Areas
Tool and Equipment Maintenance
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Alternate Noise Hazards Communication, e.g., Signs and Color Coding
Anthropometrically Fitting PPEs, e.g. Sizing across genders
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Distancing On-Site Noisy Activities
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods
On-Site Noise Monitoring and Mapping
Activity Sequencing
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)

Crystalline Silica Practice
Isolation of Cutting Stations
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)
Silica Hazard Training
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)
Appropriate Respiratory Protection
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Alternate Silica Hazards Communication, e.g., Signs and Color Coding
Low or Non-Silica Content in Materials
Silica Dust Protections and/or Containment Barriers
Activity Sequencing
Exclusion Zones to Silica Hazard Areas
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers
Distancing On-Site Airborne Producing Silica Activities
Airborne Silica Monitoring and Sampling
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Chronologically Gifted/Aging Workforce Assistive Devices or Methods

MSD Prevention Practices
Early Recognition and Reporting of Musculoskeletal Symptoms
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods
Alternate Hazards Communication, e.g., Signs and Color Coding for Lifting Hazards
Safe and Functional Tool Design and Proper Use (e.g., Anti-vibration Devices, Impact Energy Absorbing Materials, i.e., wood vs. steel)
Ergonomic Audits of Individual Workers
On-Site Ergonomic Program (e.g., Proper Biomechanics Training, Flex and Stretch, Team lifting, Two-Step Lifting, etc.)
Health and Wellness Programs (e.g., Nutrition, Exercise)
Anthropometric Work Evaluations (e.g., adjustable height workstations)
Platforms for Elevated Work
Anthropometrically Fitting PPE, e.g. Sizing across genders
Availability and Utilization of Mechanical Assists to Eliminate Lifting, Bending, and Twisting
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Constructability Assessment, e.g., incorporation of construction knowledge and experience in the design and planning phase so that project can be effectively built, inclusive of ergonomics and anthropometric feasibilility and considerations
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Preassembling on the Ground (e.g., Steel Components)
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Robotics and Automation
Biomechanics Coaching From Experienced Workers (e.g. formal and/or informal)
Planning and Site Layout (Reduction of Repetitive Motions, e.g., multiple handling of materials)

Barriers
Limited Capital
Management Inexperience with Health Hazards
Resistance to Change
False Sense of Worker Health due to Delayed Health Impact
Worker Trade Inexperience
Ineffective or Nonexistent Health Processes and Procedures at Organization
Macho Type Attitude
Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking
Ineffective Job Hazards Communication
Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations
Language Barrier e.g., employer unwilling to provide training in other than English
Tool and PPE Procurement Cost Driven
High Worker Turnover
Unenforceable Contract Health Provisions
Temporary Labor, e.g., Day Laborers
Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws
Non-Functional PPE
Non-Functional Tools
Lack of Proper Trainer Credentials
Chronologically-Gifted/Aging Workforce

Catalysts
Worker Recognition/Appreciation
Continued Leadership Commitment
Available Capital
Worker Accountability/Attitude
Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized
Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns
Lessons Learned Program
Inclusion of Contract Health Provisions
Job Coaching from Experienced Workers
Incentivization, e.g., Reporting of Health Hazard Exposures
Occupational Health Programs, e.g., Hearing Conservation Program
Health Hazard Awareness and Education
Job Hazard Analysis
Specific Job Hazards Awareness and Education
OSHA Tools & Training Awareness
Proper Hazard Training
Media Exposure (Reputation)
Apprenticeship Programs
Regulatory Enforcement

APPENDIX P

SECOND DELPHI SURVEY ROUND QUESTIONS

Health Hazards Delphi Survey Instructions
Round 2

INTRODUCTION AND BACKGROUND INFORMATION

You are receiving this survey for your participation as a panel expert in the research project "Engaging Project Stakeholders in Strategies for the Early Prevention of Noise, Welding Fumes, Crystalline Silica Particles, and Musculoskeletal Disorders at Construction". During the summer months, we had the opportunity to interview 11 subject matter experts and inquire them on the prevention of worker exposure to the hazards of silica, welding fumes, noise, and musculoskeletal disorders. The analysis of the interview material has resulted in the definition of prevention practices specific to each health hazard, as well as in the identification of general barriers against and catalysts for the implementation of such prevention practices.

This second survey inquires on 1) the effectiveness and feasibility of implementation and sustained used of each practice, and 2) the intensity of barriers against and catalysts for the adoption of the practices. The survey differentiates between the prevention of the PRIMARY EXPOSURE OF THE WORKER(S) THAT GENERATE THE HAZARD and the prevention of the SECONDARY EXPOSURE OF THE WORKER(S) IN PROXIMITY TO THE SOURCE OF THE HAZARD, BUT WHO DO NOT GENERATE THE HAZARD. Finally, the survey also inquiries on the intensity of barriers against and catalysts for the adoption of such practices.

Time required to complete the survey. The present survey takes about 30 minutes to complete. We respectfully request you take no longer than **one week** to submit your responses. Your timely responses will be used to design the next and likely last round of the Delphi survey.

Confidential responses. Even though the questions in this survey do not require the sharing of personal information, all answers will still be sanitized, so that an answer cannot be traced back to the individual who responded to the corresponding question. The research protocol in this study has been reviewed and approved by the Institutional Review Board at Arizona State University, which ensures the protection of rights and welfare of the participants in this study.

Contact information. Please do not hesitate to contact Linda Tello at ltello@asu.edu with any comments or questions you may have.

To move through the survey, please click on NEXT at the bottom right of each page.

Thank you very much for your time and expert responses.

INSTRUCTIONS

A total of 6 sections are requested to complete the survey. Sections 1 – 4 characterize the effectiveness and feasibility of implementation and sustained use of practices specific for the prevention of exposures to Welding Fumes, Noise, Silica, and Musculoskeletal Disorders. Sections 5 - 6, respectively, determine the intensity of barriers against and catalysts for the implementation of such prevention practices.

To move through the survey, please click on NEXT at the bottom right of each page. To return to a previous section, please use the BACK button at the bottom left of each page.

SECTION 1 - WELDING FUMES

Effectiveness of Practices in the Prevention of Primary Exposures to Welding Fumes

1.0 Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **EXPOSURE OF WELDING FUMES TO THE WORKER(S) GENERATING THE HAZARD - PRIMARY EXPOSURE.** Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 1.0 Effectiveness of Practices in the Prevention of Primary Exposures to Welding Fumes.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Ineffective or Effective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Activity Sequencing, e.g., activity planning and execution to miminze/reduce fume exposures	○	○	○	○	○	○	○	○	○
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	○	○	○	○	○	○	○	○	○
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Fume Protection Barriers	○	○	○	○	○	○	○	○	○
Distancing On-Site Welding Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Automated Welding	○	○	○	○	○	○	○	○	○
Use of Less or Non-Toxic Welding Consumables	○	○	○	○	○	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○

Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Welding Fumes Hazards Training	○	○	○	○	○	○	○	○	○
Appropriate Respiratory Protection (e.g., PPE)	○	○	○	○	○	○	○	○	○
Proper Ventilation	○	○	○	○	○	○	○	○	○
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure	○	○	○	○	○	○	○	○	○
Availability of Showers and Hand Washing Units	○	○	○	○	○	○	○	○	○
Monitoring of Contamination in Common Areas	○	○	○	○	○	○	○	○	○
Exclusion Zones to Welding Areas	○	○	○	○	○	○	○	○	○
Removing Contaminated PPE/Clothing before Entering Common Areas	○	○	○	○	○	○	○	○	○
Design of Alternative Connections and Components, e.g. Bolted Connections	○	○	○	○	○	○	○	○	○

Design of Alternative Connections and Components, e.g. Bolted Connections	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker	○	○	○	○	○	○	○	○	○
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers	○	○	○	○	○	○	○	○	○

COMMENTS

Effectiveness of Practices in the Prevention of Secondary Exposures to Welding Fumes

1A. Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **EXPOSURE OF WELDING FUMES TO THE WORKER(S) IN PROXIMITY** to the source of the hazard, **BUT NOT GENERATING THE HAZARD - SECONDARY EXPOSURE.** Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 1A. Effectiveness of Practices in the Prevention of Secondary Exposures to Welding Fumes.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Ineffective or Effective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Activity Sequencing, e.g., activity planning and execution to miminze/reduce fume exposures	○	○	○	○	○	○	○	○	○
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	○	○	○	○	○	○	○	○	○
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Fume Protection Barriers	○	○	○	○	○	○	○	○	○
Distancing On-Site Welding Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Automated Welding	○	○	○	○	○	○	○	○	○
Use of Less or Non-Toxic Welding Consumables	○	○	○	○	○	○	○	○	○

Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Welding Fumes Hazards Training	○	○	○	○	○	○	○	○	○
Appropriate Respiratory Protection (e.g., PPE)	○	○	○	○	○	○	○	○	○
Proper Ventilation	○	○	○	○	○	○	○	○	○
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure	○	○	○	○	○	○	○	○	○
Availability of Showers and Hand Washing Units	○	○	○	○	○	○	○	○	○
Monitoring of Contamination in Common Areas	○	○	○	○	○	○	○	○	○
Exclusion Zones to Welding Areas	○	○	○	○	○	○	○	○	○

Removing Contaminated PPE/Clothing before Entering Common Areas	○	○	○	○	○	○	○	○	○
Design of Alternative Connections and Components, e.g. Bolted Connections	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker	○	○	○	○	○	○	○	○	○
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers	○	○	○	○	○	○	○	○	○

COMMENTS

Implementation and Sustained Use of Welding Fume Exposure Prevention Practices

1.B Based on your knowledge and experience, **PLEASE ASSESS THE FEASIBILITY OF IMPLEMENTATION AND SUSTAINED USE OF EACH PRACTICE IN THE PREVENTION OF EXPOSURE TO WELDING FUMES**. Please assess on a scale from 1 (Extremely Infeasible and Unsustainable) to 9 (Extremely Feasible and Sustainable).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 1.B Feasibility of Implementation and Sustained Use of Practices for the Prevention of Welding Fume Exposures.

	Extremely Infeasible and Unsustainable (1)	Very Infeasible and Unsustainable (2)	Moderately Infeasible and Unsustainable (3)	Slightly Infeasible and Unsustainable (4)	Neither Feasible/Sustainable Nor Infeasible/Unsustainable (5)	Slightly Feasible and Sustainable (6)	Moderately Feasible and Sustainable (7)	Very Feasible and Sustainable (8)	Extremely Feasible and Sustainable (9)
Activity Sequencing, e.g., activity planning and execution to miminze/reduce fume exposures	○	○	○	○	○	○	○	○	○
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	○	○	○	○	○	○	○	○	○
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Fume Protection Barriers	○	○	○	○	○	○	○	○	○
Distancing On-Site Welding Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Automated Welding	○	○	○	○	○	○	○	○	○
Use of Less or Non-Toxic Welding Consumables	○	○	○	○	○	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○

Welding Fumes Hazards Training									
Appropriate Respiratory Protection (e.g., PPE)									
Proper Ventilation									
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure									
Availability of Showers and Hand Washing Units									
Monitoring of Contamination in Common Areas									
Exclusion Zones to Welding Areas									
Removing Contaminated PPE/Clothing before Entering Common Areas									
Design of Alternative Connections and Components, e.g. Bolted Connections									
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)									
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker									
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers									

COMMENTS

SECTION TWO - NOISE

Effectiveness of Noise Prevention Practices for Primary Exposures

2.0 Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **EXPOSURE OF NOISE TO THE WORKER(S) GENERATING THE HAZARD - PRIMARY EXPOSURE.** Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 2.0 Effectiveness of Noise Prevention Practices for Primary Exposures.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Effective nor Ineffective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	○	○	○	○	○
Periodic Audiometric Testing and Hearing Assessment	○	○	○	○	○	○	○	○	○
Acoustic Sound Barriers	○	○	○	○	○	○	○	○	○
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	○	○	○	○	○	○	○	○	○
Distancing On-Site Noisy Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Appropriate Hearing Protection (e.g., PPE)	○	○	○	○	○	○	○	○	○
Noise Hazard Training	○	○	○	○	○	○	○	○	○
Exclusion Zones to Noisy Areas	○	○	○	○	○	○	○	○	○
Activity Sequencing	○	○	○	○	○	○	○	○	○

Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
On-Site Noise Monitoring and Mapping	○	○	○	○	○	○	○	○	○
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Alternate Noise Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	○	○	○	○	○	○	○	○	○
Anthropometrically Fitting PPEs, e.g. Sizing across genders	○	○	○	○	○	○	○	○	○
Individual Worker Training of Proper PPEs Use/Fit	○	○	○	○	○	○	○	○	○
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	○	○	○	○	○	○	○	○	○

COMMENTS

Prevention of Secondary Exposure(s) to Noise

2.A Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **SECONDARY EXPOSURE OF NOISE TO THE WORKER(S) IN PROXIMITY** to the source of the hazard, **BUT NOT GENERATING THE HAZARD**. Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 2A. Effectiveness of Practices for the Prevention of Hearing Loss/Noise for Secondary Exposures.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Effective nor Ineffective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	○	○	○	○	○
Periodic Audiometric Testing and Hearing Assessment	○	○	○	○	○	○	○	○	○
Acoustic Sound Barriers	○	○	○	○	○	○	○	○	○
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	○	○	○	○	○	○	○	○	○
Distancing On-Site Noisy Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Appropriate Hearing Protection (e.g., PPE)	○	○	○	○	○	○	○	○	○
Noise Hazard Training	○	○	○	○	○	○	○	○	○
Exclusion Zones to Noisy Areas	○	○	○	○	○	○	○	○	○
Activity Sequencing	○	○	○	○	○	○	○	○	○

Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
On-Site Noise Monitoring and Mapping	○	○	○	○	○	○	○	○	○
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Alternate Noise Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	○	○	○	○	○	○	○	○	○
Anthropometrically Fitting PPEs, e.g. Sizing across genders	○	○	○	○	○	○	○	○	○
Individual Worker Training of Proper PPEs Use/Fit	○	○	○	○	○	○	○	○	○
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	○	○	○	○	○	○	○	○	○

COMMENTS

Feasibility and Sustained Use of Noise/Hearing Loss Prevention Practices

2B. Based on your knowledge and experience, **PLEASE ASSESS THE FEASIBILITY OF IMPLEMENTATION AND SUSTAINED USE OF EACH PRACTICE IN THE PREVENTION OF HEARING LOSS/NOISE**. Please assess the feasibility of implementation and sustainability on a scale from 1 (Extremely Infeasible and Unsustainable) to 9 (Extremely Feasible and Sustainable).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 2.B Feasibility of Implementation and Sustained Use of Practices for Prevention of Primary Exposures to Noise.

	Extremely Infeasible and Unsustainable (1)	Very Infeasible and Unsustainable (2)	Moderately Infeasible and Unsustainable (3)	Slightly Infeasible and Unsustainable (4)	Neither Feasible/Sustainable nor Infeasible/Unsustainable (5)	Slightly Feasible and Sustainable (6)	Moderately Feasible and Sustainable (7)	Very Feasible and Sustainable (8)	Extremely Feasible and Sustainable (9)
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	○	○	○	○	○
Periodic Audiometric Testing and Hearing Assessment	○	○	○	○	○	○	○	○	○
Acoustic Sound Barriers	○	○	○	○	○	○	○	○	○
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	○	○	○	○	○	○	○	○	○
Distancing On-Site Noisy Activities	○	○	○	○	○	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	○	○	○	○	○
Appropriate Hearing Protection (e.g., PPE)	○	○	○	○	○	○	○	○	○
Noise Hazard Training	○	○	○	○	○	○	○	○	○
Exclusion Zones to Noisy Areas	○	○	○	○	○	○	○	○	○
Activity Sequencing	○	○	○	○	○	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○

Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
On-Site Noise Monitoring and Mapping	○	○	○	○	○	○	○	○	○
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Alternate Noise Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	○	○	○	○	○	○	○	○	○
Anthropometrically Fitting PPEs, e.g. Sizing across genders	○	○	○	○	○	○	○	○	○
Individual Worker Training of Proper PPEs Use/Fit	○	○	○	○	○	○	○	○	○
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	○	○	○	○	○	○	○	○	○

COMMENTS

SECTION THREE - CRYSTALLINE SILICA

Effectiveness of Crystalline Silica Practices for Primary Exposures

3.0 Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **EXPOSURE OF CRYSTALLINE SILICA TO THE WORKER(S) GENERATING THE HAZARD - PRIMARY EXPOSURE.** Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 3.0 Effectiveness of Crystalline Silica Practices for Primary Exposures.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Ineffective nor Effective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Silica Dust Protections and/or Containment Barriers	○	○	○	○	○	○	○	○	○
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	○	○	○	○	○	○	○	○	○
Isolation of Cutting Stations	○	○	○	○	○	○	○	○	○
Distancing On-Site Airborne Producing Silica Activities	○	○	○	○	○	○	○	○	○
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	○	○	○	○	○	○	○	○	○
Airborne Silica Monitoring and Sampling	○	○	○	○	○	○	○	○	○
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	○	○	○	○	○	○	○	○	○
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○

Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)
Silica Hazard Training
Low or Non-Silica Content in Materials
Activity Sequencing
Appropriate Respiratory Protection
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Exclusion Zones to Silica Hazard Areas
Chronologically Gifted/Aging Workforce Considerations
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers

COMMENTS

Prevention of Secondary Exposure(s) to Crystalline Silica

3A. Based on your knowledge and experience, please assess the effectiveness of each practice in preventing the **SECONDARY EXPOSURE OF CRYSTALLINE SILICA TO THE WORKER(S) IN PROXIMITY** to the source of the hazard, **BUT NOT GENERATING THE HAZARD**. Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 3A. Effectiveness of Practices in the Prevention of Secondary Exposures to Crystalline Silica.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Ineffective nor Effective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Silica Dust Protections and/or Containment Barriers	○	○	○	○	○	○	○	○	○
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	○	○	○	○	○	○	○	○	○
Isolation of Cutting Stations	○	○	○	○	○	○	○	○	○
Distancing On-Site Airborne Producing Silica Activities	○	○	○	○	○	○	○	○	○
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	○	○	○	○	○	○	○	○	○
Airborne Silica Monitoring and Sampling	○	○	○	○	○	○	○	○	○
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	○	○	○	○	○	○	○	○	○
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	○	○	○	○	○	○	○	○	○
Silica Hazard Training	○	○	○	○	○	○	○	○	○

Low or Non-Silica Content in Materials	○	○	○	○	○	○	○	○	○
Activity Sequencing	○	○	○	○	○	○	○	○	○
Appropriate Respiratory Protection	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Exclusion Zones to Silica Hazard Areas	○	○	○	○	○	○	○	○	○
Chronologically Gifted/Aging Workforce Considerations	○	○	○	○	○	○	○	○	○
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers	○	○	○	○	○	○	○	○	○

COMMENTS

Feasibility and Sustained Use of Crystalline Silica Exposure Prevention Practices

3.B Based on your knowledge and experience, **PLEASE ASSESS THE FEASIBILITY OF IMPLEMENTATION AND SUSTAINED USE OF EACH PRACTICE IN THE PREVENTION OF CRYSTALLINE SILICA EXPOSURE(S)**. Please assess on a scale from 1 (Extremely Infeasible and Unsustainable) to 9 (Extremely Feasible and Sustainable).

Also, below the practices, please use the comment column to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice, and/or for understanding your perspective or insights with regard to your response.

Table 3.B Feasibility of Implementation and Sustained Use of Crystalline Silica Prevention Practices.

	Extremely Infeasible and Unsustainable (1)	Very Infeasible and Unsustainable (2)	Moderately Infeasible and Unsustainable (3)	Slightly Infeasible and Unsustainable (4)	Neither Infeasible/Unsustainable nor Feasible/Sustainable (5)	Slightly Feasible and Sustainable (6)	Moderately Feasible and Sustainable (7)	Very Feasible and Sustainable (8)	Extremely Feasible and Sustainable (9)
Silica Dust Protections and/or Containment Barriers	○	○	○	○	○	○	○	○	○
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	○	○	○	○	○	○	○	○	○
Isolation of Cutting Stations	○	○	○	○	○	○	○	○	○

Distancing On-Site Airborne Producing Silica Activities	○	○	○	○	○	○	○	○	○
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	○	○	○	○	○	○	○	○	○
Airborne Silica Monitoring and Sampling	○	○	○	○	○	○	○	○	○
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	○	○	○	○	○	○	○	○	○
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	○	○	○	○	○
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	○	○	○	○	○
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	○	○	○	○	○	○	○	○	○
Silica Hazard Training	○	○	○	○	○	○	○	○	○
Low or Non-Silica Content in Materials	○	○	○	○	○	○	○	○	○
Activity Sequencing	○	○	○	○	○	○	○	○	○

Appropriate Respiratory Protection	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Exclusion Zones to Silica Hazard Areas	○	○	○	○	○	○	○	○	○
Chronologically Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	○	○	○	○	○
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers	○	○	○	○	○	○	○	○	○

COMMENTS

SECTION FOUR - MUSCULOSKELETAL DISORDERS

Effectiveness of Musculoskeletal Disorder(s) Prevention Practices.

4.0 Based on your knowledge and experience, please assess the effectiveness of each practice in preventing **MUSCULOSKELETAL DISORDERS (TO THE WORKER(S).** Please assess the effectiveness on a scale from 1 (Extremely Ineffective) to 9 (Extremely Effective).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 4.0 Effectiveness of Musculoskeletal Disorder(s) Prevention Practices.

	Extremely Ineffective (1)	Very Ineffective (2)	Moderately Ineffective (3)	Slightly Ineffective (4)	Neither Effective nor Ineffective (5)	Slightly Effective (6)	Moderately Effective (7)	Very Effective (8)	Extremely Effective (9)
Early Recognition and Reporting of Musculoskeletal Symptoms	○	○	○	○	○	○	○	○	○
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	○	○	○	○	○
Alternate Hazards Communication, e.g., Signs and Color Coding for Lifting Hazards	○	○	○	○	○	○	○	○	○
Safe and Functional Tool Design and Proper Use (e.g., Anti-vibration Devices, Impact Energy Absorbing Materials, i.e., wood vs. steel)	○	○	○	○	○	○	○	○	○

Ergonomic Audits of Individual Workers	○	○	○	○	○	○	○	○	○
On-Site Ergonomic Program (e.g., Proper Biomechanics Training, Flex and Stretch, Team lifting, Two-Step Lifting, etc.)	○	○	○	○	○	○	○	○	○
Health and Wellness Programs (e.g., Nutrition, Exercise)	○	○	○	○	○	○	○	○	○
Anthropometric Work Evaluations (e.g., adjustable height workstations)	○	○	○	○	○	○	○	○	○
Platforms for Elevated Work	○	○	○	○	○	○	○	○	○
Anthropometrically Fitting PPE, e.g. Sizing across genders	○	○	○	○	○	○	○	○	○

Availability and Utilization of Mechanical Assists to Eliminate Lifting, Bending, and Twisting	○	○	○	○	○	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Constructability Assessment, e.g., incorporation of construction knowledge and experience in the design and planning phase so that project can be effectively built, inclusive of ergonomics and anthropometric feasiblility and considerations	○	○	○	○	○	○	○	○	○

Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Preassembling on the Ground (e.g., Steel Components)	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Robotics and Automation	○	○	○	○	○	○	○	○	○
Biomechanics Coaching From Experienced Workers (e.g. formal and/or informal)	○	○	○	○	○	○	○	○	○
Planning and Site Layout (Reduction of Repetitive Motions, e.g., multiple handling of materials)	○	○	○	○	○	○	○	○	○

COMMENTS

Implementation and Sustained Use of Musculoskeletal Disorder Prevention Practices

4.A Based on your knowledge and experience, please assess the **FEASIBILITY OF IMPLEMENTATION AND SUSTAINED USE** of each practice in preventing **MUSCULOSKELETAL DISORDERS TO THE WORKER(S)**. Please assess the effectiveness on a scale from 1 (Extremely Infeasible and Unsustainable) to 9 (Extremely Feasible and Sustainable).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the effectiveness of the practice(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 4.A Feasibility of Implementation and Sustained Use of Musculoskeletal Disorder(s) Prevention Practices.

	Extremely Infeasible and Unsustainable (1)	Very Infeasible and Unsustainable (2)	Moderately Infeasible and Unsustainable (3)	Slightly Infeasible and Unsustainable (4)	Neither Infeasible/Unsustainable nor Feasible/Sustainable (5)	Slightly Feasible and Sustainable (6)	Moderately Feasible and Sustainable (7)	Very Feasible and Sustainable (8)	Extremely Feasible and Sustainable (9)
Early Recognition and Reporting of Musculoskeletal Symptoms									
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods									
Alternate Hazards Communication, e.g., Signs and Color Coding for Lifting Hazards									
Safe and Functional Tool Design and Proper Use (e.g., Anti-vibration Devices, Impact Energy Absorbing Materials, i.e., wood vs. steel)									
Ergonomic Audits of Individual Workers									
On-Site Ergonomic Program (e.g., Proper Biomechanics Training, Flex and Stretch, Team lifting, Two-Step Lifting, etc.)									
Health and Wellness Programs (e.g., Nutrition, Exercise)									

Anthropometric Work Evaluations (e.g., adjustable height workstations)	○	○	○	○	○	○	○	○	○
Platforms for Elevated Work	○	○	○	○	○	○	○	○	○
Anthropometrically Fitting PPE, e.g. Sizing across genders	○	○	○	○	○	○	○	○	○
Availability and Utilization of Mechanical Assists to Eliminate Lifting, Bending, and Twisting	○	○	○	○	○	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Constructability Assessment, e.g., incorporation of construction knowledge and experience in the design and planning phase so that project can be effectively built, inclusive of ergonomics and anthropometric feasiblility and considerations	○	○	○	○	○	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	○	○	○	○	○
Preassembling on the Ground (e.g., Steel Components)	○	○	○	○	○	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	○	○	○	○	○
Robotics and Automation	○	○	○	○	○	○	○	○	○
Biomechanics Coaching From Experienced Workers (e.g. formal and/or informal)	○	○	○	○	○	○	○	○	○
Planning and Site Layout (Reduction of Repetitive Motions, e.g., multiple handling of materials)	○	○	○	○	○	○	○	○	○

COMMENTS

SECTION FIVE - BARRIERS

Intensity of Barrier(s) in Preventing and/or Opposing the Implementation of Practices

5.0 Based on your knowledge and experience, and in consideration of the current industry context, please assess the **INTENSITY OF EACH BARRIER IN PREVENTING AND/OR OPPOSING THE ADOPTION** of the previous prevention practices. Please consider the average and/or medium intensity of each barrier across the four health hazards and practices identified above and in the current and general industry context. Please assess the effectiveness on a scale from 1 (Extremely Un-intense) to 9 (Extremely Intense).

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the intensity of the barrier(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 5.0 Intensity of Barrier(s) in Preventing and/or Opposing the Implementation of Practices.

	Extremely Un-intense (1)	Very Un-intense (2)	Moderately Un-intense (3)	Slightly Un-intense (4)	Neither Intense nor Un-intense (5)	Slightly Intense (6)	Moderately Intense (7)	Very Intense (8)	Extremely Intense (9)
Chronologically-Gifted/Aging Workforce	○	○	○	○	○	○	○	○	○
Limited Capital	○	○	○	○	○	○	○	○	○
Ineffective Job Hazards Communication	○	○	○	○	○	○	○	○	○
Unenforceable Contract Health Provisions	○	○	○	○	○	○	○	○	○
Temporary Labor, e.g., Day Laborers	○	○	○	○	○	○	○	○	○
Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations	○	○	○	○	○	○	○	○	○
Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment	○	○	○	○	○	○	○	○	○
Lack of Proper Trainer Credentials	○	○	○	○	○	○	○	○	○
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws	○	○	○	○	○	○	○	○	○
Worker Trade Inexperience	○	○	○	○	○	○	○	○	○
Management Inexperience with Health Hazards	○	○	○	○	○	○	○	○	○

Language Barrier e.g., employer unwilling to provide training in other than English	○	○	○	○	○	○	○	○	○
Non-Functional PPE	○	○	○	○	○	○	○	○	○
Non-Functional Tools	○	○	○	○	○	○	○	○	○
Tool and PPE Procurement Cost Driven	○	○	○	○	○	○	○	○	○
Ineffective or Nonexistent Health Processes and Procedures at Organization	○	○	○	○	○	○	○	○	○
False Sense of Worker Health due to Delayed Health Impact	○	○	○	○	○	○	○	○	○
Resistance to Change	○	○	○	○	○	○	○	○	○
Macho Type Attitude	○	○	○	○	○	○	○	○	○
Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking	○	○	○	○	○	○	○	○	○
High Worker Turnover	○	○	○	○	○	○	○	○	○

COMMENTS

SECTION SIX - CATALYSTS

Opportunity of the Catalyst in Enabling the Implementation of the Practices

6.0 In Table 6.0, based on your knowledge and experience, and in consideration of the current industry context, please assess the **OPPORTUNITY OF EACH CATALYST IN ENABLING THE ADOPTION** of the previous prevention practices. Please consider the intensity of each catalyst across the four health hazards and practices identified above and in the current and general industry context. Please assess the effectiveness on a scale from 1 (Extremely Non-Enabling) to 9 (Extremely Enabling).

Also, please use the comments section at the bottom to add any information that you feel is valuable or necessary to communicate regarding the intensity of the catalyst(s), and/or for understanding your perspective or insights with regard to your response(s).

Table 6.0 Opportunity of the Catalyst in Enabling the Implementation of the Practices.

	Extremely Non-Enabling (1)	Very Non-Enabling (2)	Moderately Non-Enabling (3)	Slightly Non-Enabling (4)	Neither Non-Enabling nor Enabling (5)	Slightly Enabling (6)	Moderately Enabling (7)	Very Enabling (8)	Extremely Enabling (9)
Available Capital	○	○	○	○	○	○	○	○	○
Lessons Learned Program	○	○	○	○	○	○	○	○	○
Inclusion of Contract Health Provisions	○	○	○	○	○	○	○	○	○
Health Hazard Awareness and Education	○	○	○	○	○	○	○	○	○
Job Hazard Analysis	○	○	○	○	○	○	○	○	○
Occupational Health Programs, e.g., Hearing Conservation Program	○	○	○	○	○	○	○	○	○
Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized	○	○	○	○	○	○	○	○	○
Incentivization, e.g., Reporting of Health Hazard Exposures	○	○	○	○	○	○	○	○	○
Specific Job Hazards Awareness and Education	○	○	○	○	○	○	○	○	○

Continued Leadership Commitment	○	○	○	○	○	○	○	○	○
OSHA Tools & Training Awareness	○	○	○	○	○	○	○	○	○
Job Coaching from Experienced Workers	○	○	○	○	○	○	○	○	○
Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns	○	○	○	○	○	○	○	○	○
Apprenticeship Programs	○	○	○	○	○	○	○	○	○
Regulatory Enforcement	○	○	○	○	○	○	○	○	○
Proper Hazard Training	○	○	○	○	○	○	○	○	○
Media Exposure (Reputation)	○	○	○	○	○	○	○	○	○
Worker Accountability/Attitude	○	○	○	○	○	○	○	○	○
Worker Recognition/Appreciation	○	○	○	○	○	○	○	○	○

COMMENTS

Thank you for your participation. Please click SUBMIT on the bottom right to submit your survey.

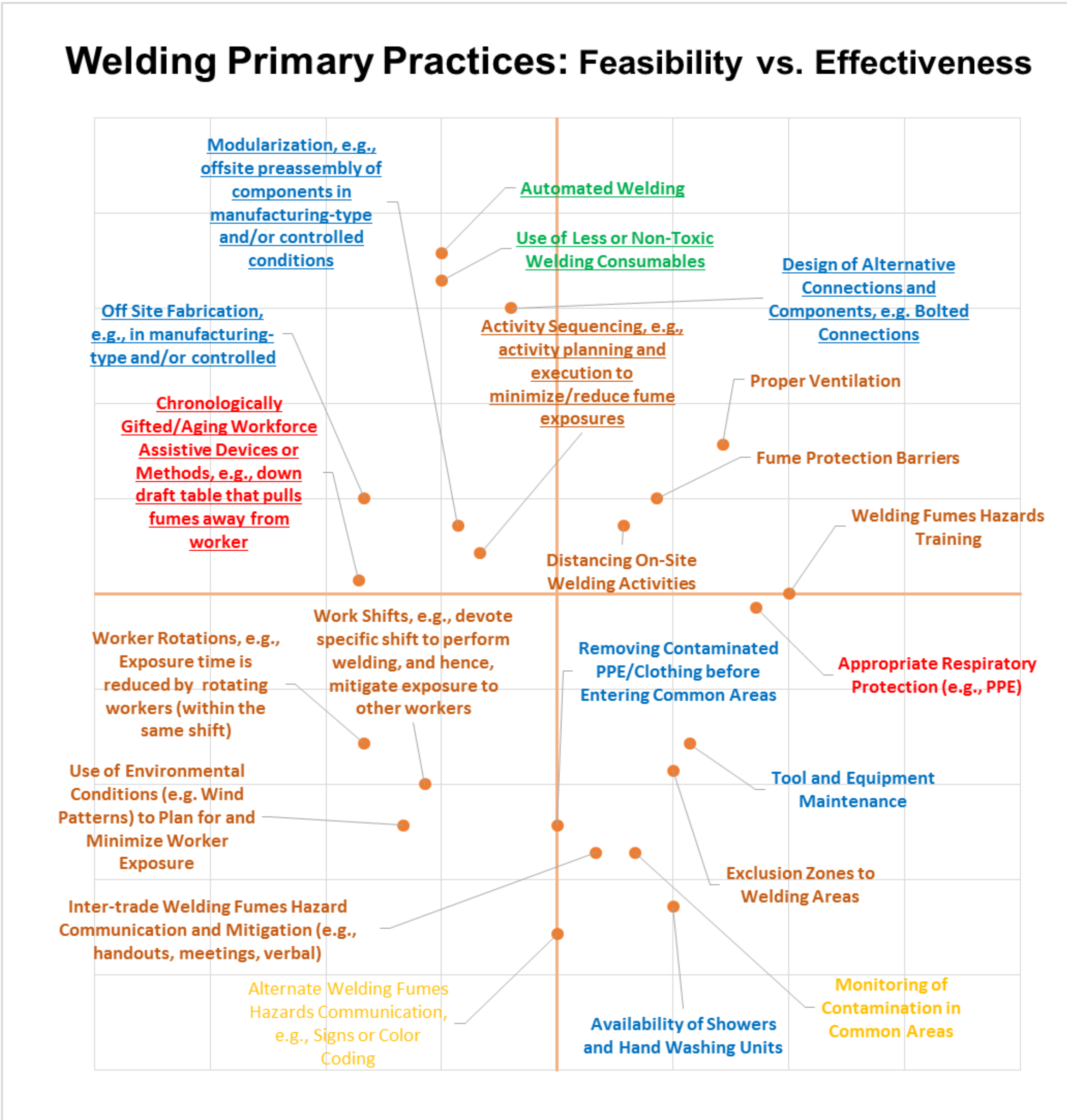
APPENDIX Q

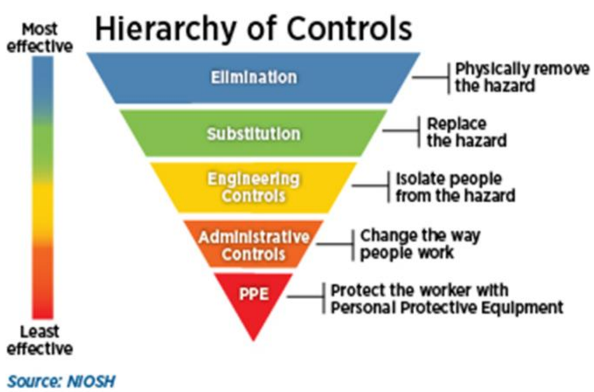
COMPLETE LIST OF THE PREVENTION PRACTICES PER EACH HEALTH HAZARD AND

GRAPHIC OF THE FEASIBILITY VERSUS EFFECTIVENESS OF EACH PREVENTION PRACTICE FOR EACH HEALTH HAZARD

Welding Fume Practices – Primary	X-Mean Feasibility	Y-Mean Effectiveness
Welding Fumes Hazards Training	8	6.5
Appropriate Respiratory Protection (e.g., PPE)	7.857142857	6.428571429
Proper Ventilation	7.714285714	7.285714286
Tool and Equipment Maintenance	7.571428571	5.714285714
Availability of Showers and Hand Washing Units	7.5	4.857142857
Exclusion Zones to Welding Areas	7.5	5.571428571
Fume Protection Barriers	7.428571429	7
Monitoring of Contamination in Common Areas	7.333333333	5.142857143
Distancing On-Site Welding Activities	7.285714286	6.857142857
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	7.166666667	5.142857143
Removing Contaminated PPE/Clothing before Entering Common Areas	7	5.285714286
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	7	4.714285714
Design of Alternative Connections and Components, e.g. Bolted Connections	6.8	8
Activity Sequencing, e.g., activity planning and execution to minimize/reduce fume exposures	6.666666667	6.714285714

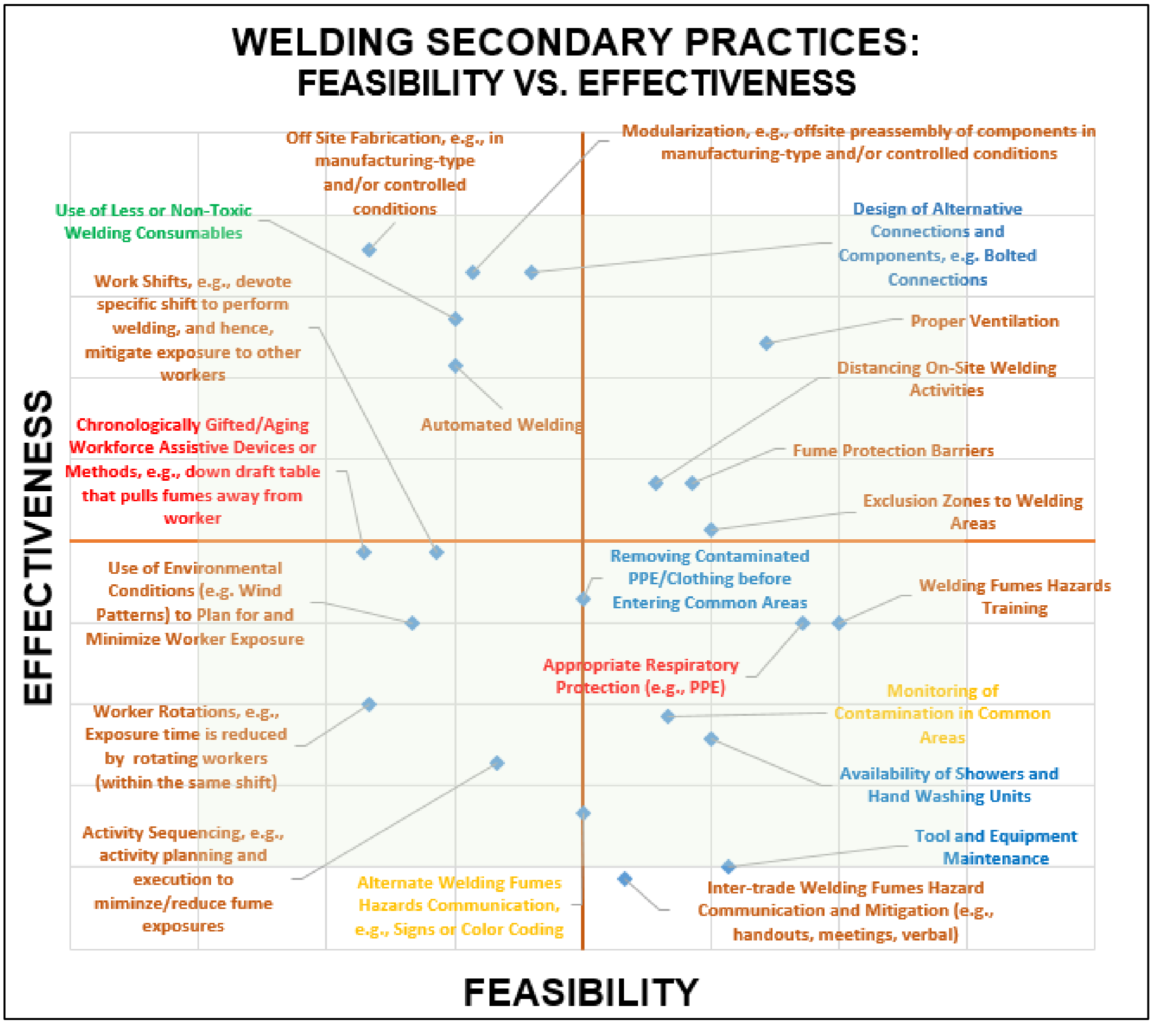
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	6.571428571	6.857142857
Use of Less or Non-Toxic Welding Consumables	6.5	8.142857143
Automated Welding	6.5	8.285714286
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers	6.428571429	5.5
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure	6.333333333	5.285714286
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	6.166666667	5.714285714
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	6.166666667	7
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker	6.142857143	6.571428571

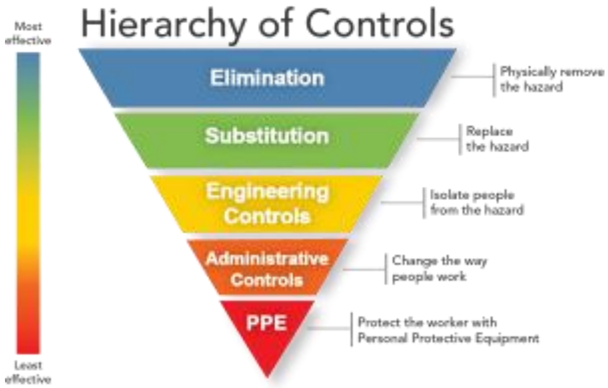

Welding Primary Practices: Feasibility vs. Effectiveness
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Automated Welding
Use of Less or Non-Toxic Welding Consumables
Design of Alternative Connections and Components, e.g. Bolted Connections
Off Site Fabrication, e.g., in manufacturing-type and/or controlled
Activity Sequencing, e.g., activity planning and execution to minimize/reduce fume exposures
Proper Ventilation
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker
Fume Protection Barriers
Welding Fumes Hazards Training
Distancing On-Site Welding Activities
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Removing Contaminated PPE/Clothing before Entering Common Areas
Appropriate Respiratory Protection (e.g., PPE)
Tool and Equipment Maintenance
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure
Exclusion Zones to Welding Areas
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Monitoring of Contamination in Common Areas
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding
Availability of Showers and Hand Washing Units


Most effective
Hierarchy of Controls
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Least effective
Source: NIOSH

Welding Practices - Secondary	Feasibility Mean (X)	Effectiveness Mean (Y)
Welding Fumes Hazards Training	8	6
Appropriate Respiratory Protection (e.g., PPE)	7.857142857	6
Proper Ventilation	7.714285714	7.714285714
Tool and Equipment Maintenance	7.571428571	4.5
Availability of Showers and Hand Washing Units	7.5	5.285714286
Exclusion Zones to Welding Areas	7.5	6.571428571
Fume Protection Barriers	7.428571429	6.857142857
Monitoring of Contamination in Common Areas	7.333333333	5.428571429
Distancing On-Site Welding Activities	7.285714286	6.857142857
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	7.166666667	4.428571429
Removing Contaminated PPE/Clothing before Entering Common Areas	7	6.142857143
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	7	4.833333333
Design of Alternative Connections and Components, e.g. Bolted Connections	6.8	8.142857143

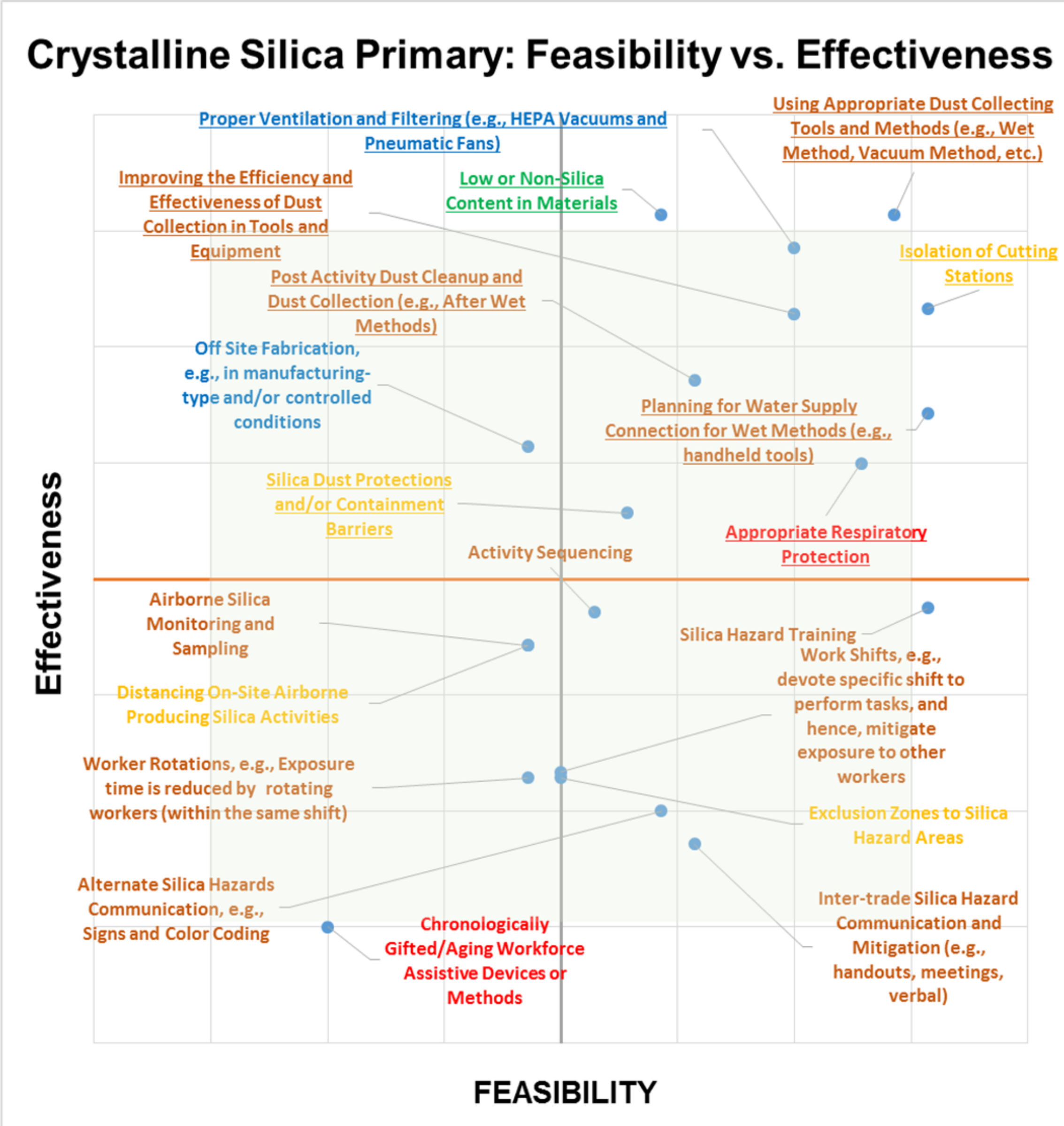
Activity Sequencing, e.g., activity planning and execution to minimize/reduce fume exposures	6.666666667	5.142857143
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	6.571428571	8.142857143
Use of Less or Non-Toxic Welding Consumables	6.5	7.857142857
Automated Welding	6.5	7.571428571
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers	6.428571429	6.428571429
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure	6.333333333	6
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	6.166666667	5.5
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	6.166666667	8.285714286
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker	6.142857143	6.428571429


WELDING SECONDARY PRACTICES:
FEASIBILITY VS. EFFECTIVENESS
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Use of Less or Non-Toxic Welding Consumables
Design of Alternative Connections and Components, e.g. Bolted Connections
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers
Proper Ventilation
Distancing On-Site Welding Activities
Automated Welding
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker
Fume Protection Barriers
Exclusion Zones to Welding Areas
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure
Removing Contaminated PPE/Clothing before Entering Common Areas
Welding Fumes Hazards Training
Appropriate Respiratory Protection (e.g., PPE)
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Monitoring of Contamination in Common Areas
Availability of Showers and Hand Washing Units
Activity Sequencing, e.g., activity planning and execution to miminze/reduce fume exposures
Tool and Equipment Maintenance
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
EFFECTIVENESS
FEASIBILITY

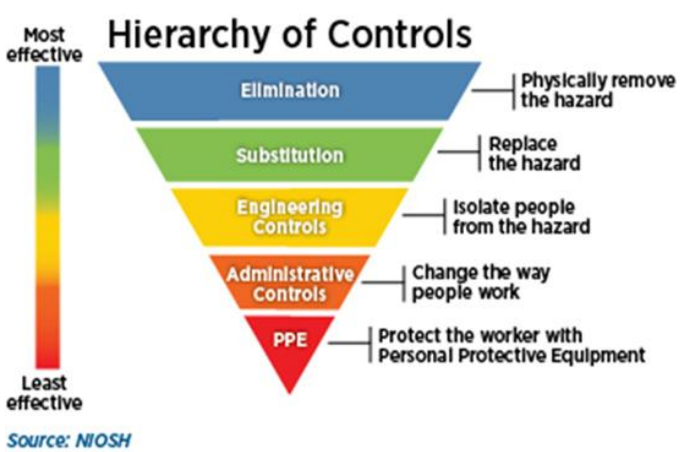

Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment

Crystalline Silica Practice	Feasibility Mean (X)	Effectiveness Mean (Y)
Isolation of Cutting Stations	7.571428571	7.166666667
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	7.571428571	6.714285714
Silica Hazard Training	7.571428571	5.875
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	7.428571429	7.571428571
Appropriate Respiratory Protection	7.285714286	6.5
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	7	7.142857143
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	7	7.428571429
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	6.571428571	6.857142857
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	6.571428571	4.857142857
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	6.428571429	5
Low or Non-Silica Content in Materials	6.428571429	7.571428571
Silica Dust Protections and/or Containment	6.285714286	6.285714286

Barriers		
Activity Sequencing	6.142857143	5.857142857
Exclusion Zones to Silica Hazard Areas	6	5.142857143
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers	6	5.166666667
Distancing On-Site Airborne Producing Silica Activities	5.857142857	5.714285714
Airborne Silica Monitoring and Sampling	5.857142857	5.714285714
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	5.857142857	6.571428571
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	5.857142857	5.142857143
Chronologically Gifted/Aging Workforce Assistive Devices or Methods	5	4.5



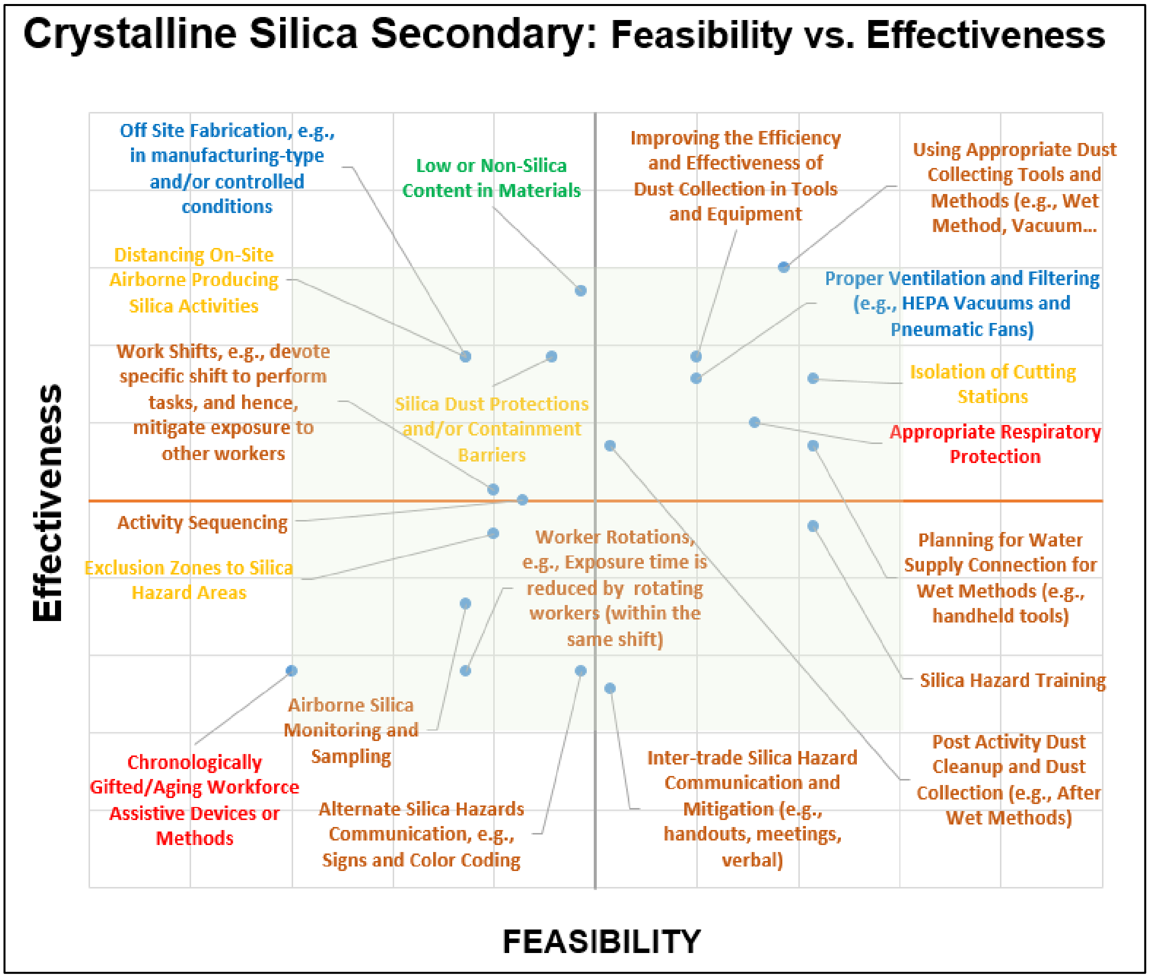
Crystalline Silica Primary: Feasibility vs. Effectiveness
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment
Low or Non-Silica Content in Materials
Isolation of Cutting Stations
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)
Silica Dust Protections and/or Containment Barriers
Appropriate Respiratory Protection
Activity Sequencing
Airborne Silica Monitoring and Sampling
Silica Hazard Training
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers
Distancing On-Site Airborne Producing Silica Activities
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Exclusion Zones to Silica Hazard Areas
Alternate Silica Hazards Communication, e.g., Signs and Color Coding
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Chronologically Gifted/Aging Workforce Assistive Devices or Methods
Effectiveness
FEASIBILITY

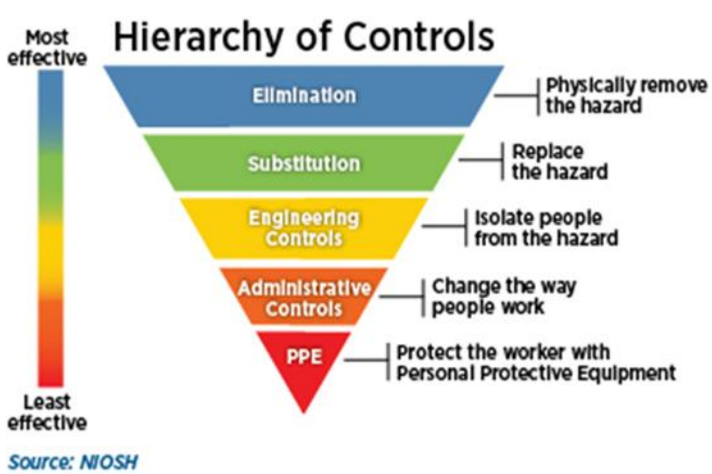


Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Source: NIOSH

Crystalline Silica Practice	Feasibility Mean (X)	Effectiveness Mean (Y)
Isolation of Cutting Stations	7.571428571	7.285714286
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	7.571428571	6.857142857
Silica Hazard Training	7.571428571	6.333333333
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	7.428571429	8
Appropriate Respiratory Protection	7.285714286	7
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	7	7.428571429
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	7	7.285714286
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	6.571428571	6.857142857
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	6.571428571	5.285714286
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	6.428571429	5.4
Low or Non-Silica Content in Materials	6.428571429	7.857142857

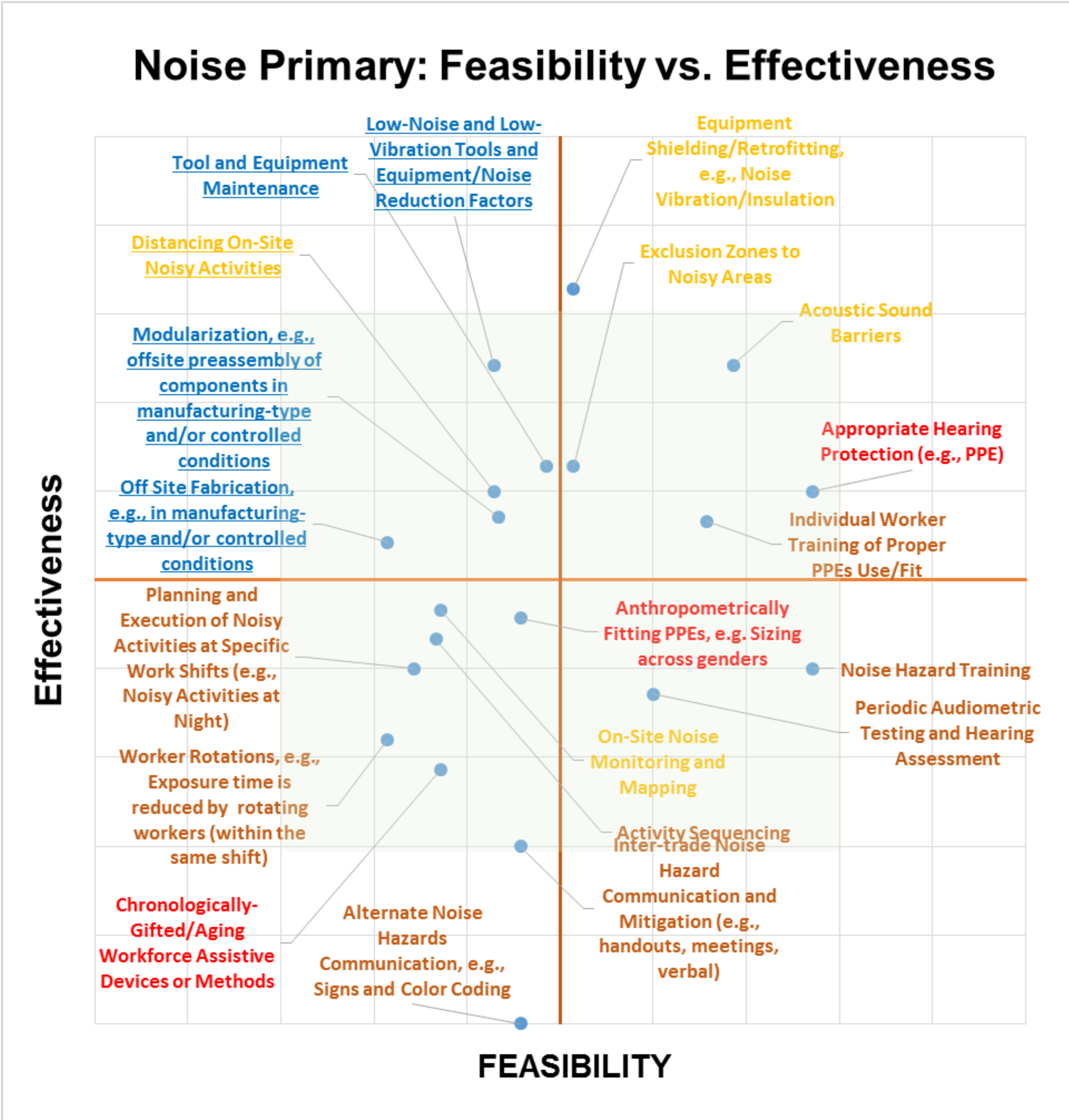
Silica Dust Protections and/or Containment Barriers	6.285714286	7.428571429
Activity Sequencing	6.142857143	6.5
Exclusion Zones to Silica Hazard Areas	6	6.285714286
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers	6	6.571428571
Distancing On-Site Airborne Producing Silica Activities	5.857142857	7.428571429
Airborne Silica Monitoring and Sampling	5.857142857	5.833333333
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	5.857142857	7.428571429
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	5.857142857	5.4
Chronologically Gifted/Aging Workforce Assistive Devices or Methods	5	5.4

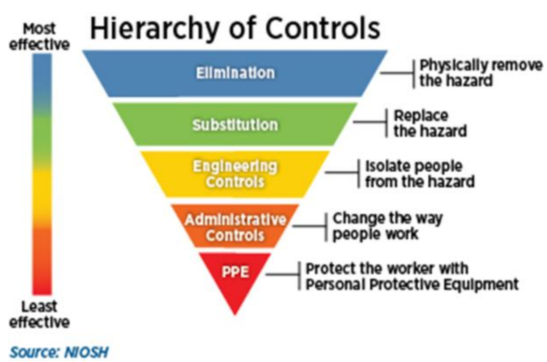

Crystalline Silica Secondary: Feasibility vs. Effectiveness
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Low or Non-Silica Content in Materials
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum...
Distancing On-Site Airborne Producing Silica Activities
Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)
Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers
Silica Dust Protections and/or Containment Barriers
Isolation of Cutting Stations
Appropriate Respiratory Protection
Activity Sequencing
Exclusion Zones to Silica Hazard Areas
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)
Silica Hazard Training
Airborne Silica Monitoring and Sampling
Chronologically Gifted/Aging Workforce Assistive Devices or Methods
Alternate Silica Hazards Communication, e.g., Signs and Color Coding
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)
Effectiveness
FEASIBILITY


Hierarchy of Controls
Most effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Least effective
Source: NIOSH

Noise Prevention Practices - Primary	Feasibility Mean (X)	Effectiveness Mean (Y)
Appropriate Hearing Protection (e.g., PPE)	7.857142857	7
Noise Hazard Training	7.857142857	6
Acoustic Sound Barriers	7.428571429	7.714285714
Individual Worker Training of Proper PPEs Use/Fit	7.285714286	6.833333333
Periodic Audiometric Testing and Hearing Assessment	7	5.857142857
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	6.571428571	8.142857143
Exclusion Zones to Noisy Areas	6.571428571	7.142857143
Tool and Equipment Maintenance	6.428571429	7.142857143
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	6.285714286	5
Alternate Noise Hazards Communication, e.g., Signs and Color Coding	6.285714286	4
Anthropometrically Fitting PPEs, e.g. Sizing across genders	6.285714286	6.285714286
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	6.166666667	6.857142857

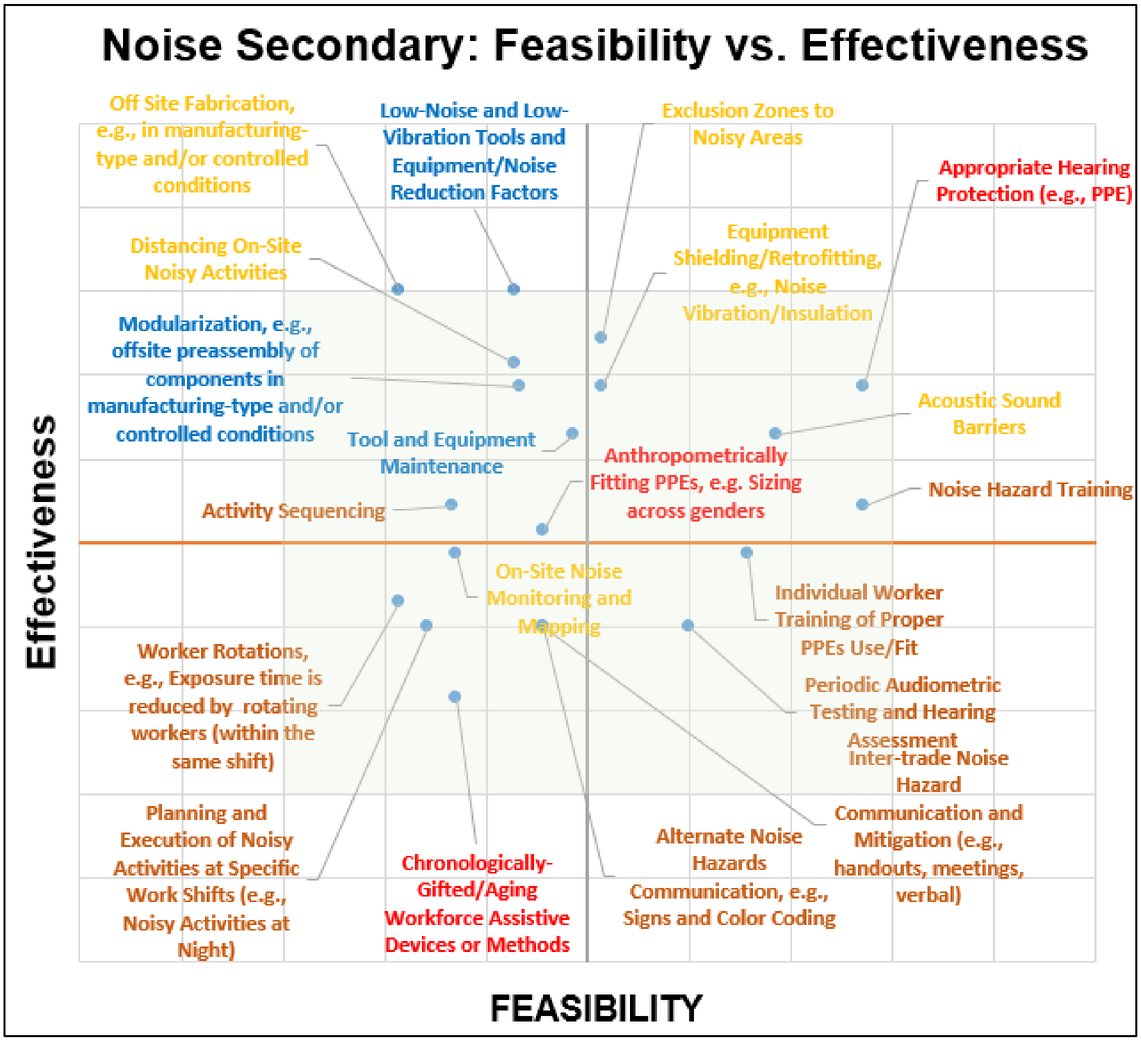
Distancing On-Site Noisy Activities	6.142857143	7
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	6.142857143	7.714285714
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	5.857142857	5.428571429
On-Site Noise Monitoring and Mapping	5.857142857	6.333333333
Activity Sequencing	5.833333333	6.166666667
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	5.714285714	6
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	5.571428571	6.714285714
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	5.571428571	5.6

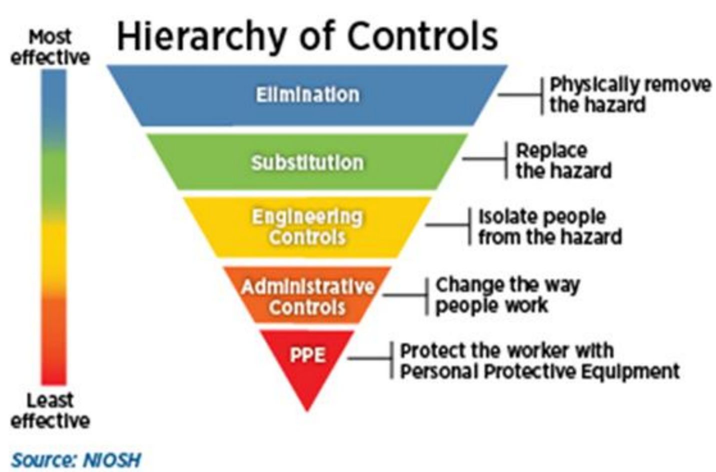

Noise Primary: Feasibility vs. Effectiveness
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors
Tool and Equipment Maintenance
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation
Distancing On-Site Noisy Activities
Exclusion Zones to Noisy Areas
Acoustic Sound Barriers
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Appropriate Hearing Protection (e.g., PPE)
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Individual Worker Training of Proper PPEs Use/Fit
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)
Anthropometrically Fitting PPEs, e.g. Sizing across genders
Noise Hazard Training
Periodic Audiometric Testing and Hearing Assessment
On-Site Noise Monitoring and Mapping
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Activity Sequencing
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods
Alternate Noise Hazards Communication, e.g., Signs and Color Coding
Effectiveness
FEASIBILITY


Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Source: NIOSH

Noise Prevention Practices - Secondary	Feasibility Mean (X)	Effectiveness Mean (Y)
Appropriate Hearing Protection (e.g., PPE)	7.857142857	7.428571429
Noise Hazard Training	7.857142857	6.714285714
Acoustic Sound Barriers	7.428571429	7.142857143
Individual Worker Training of Proper PPEs Use/Fit	7.285714286	6.428571429
Periodic Audiometric Testing and Hearing Assessment	7	6
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	6.571428571	7.428571429
Exclusion Zones to Noisy Areas	6.571428571	7.714285714
Tool and Equipment Maintenance	6.428571429	7.142857143
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	6.285714286	6
Alternate Noise Hazards Communication, e.g., Signs and Color Coding	6.285714286	6
Anthropometrically Fitting PPEs, e.g. Sizing across genders	6.285714286	6.571428571
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	6.166666667	7.428571429
Distancing On-Site Noisy Activities	6.142857143	7.571428571

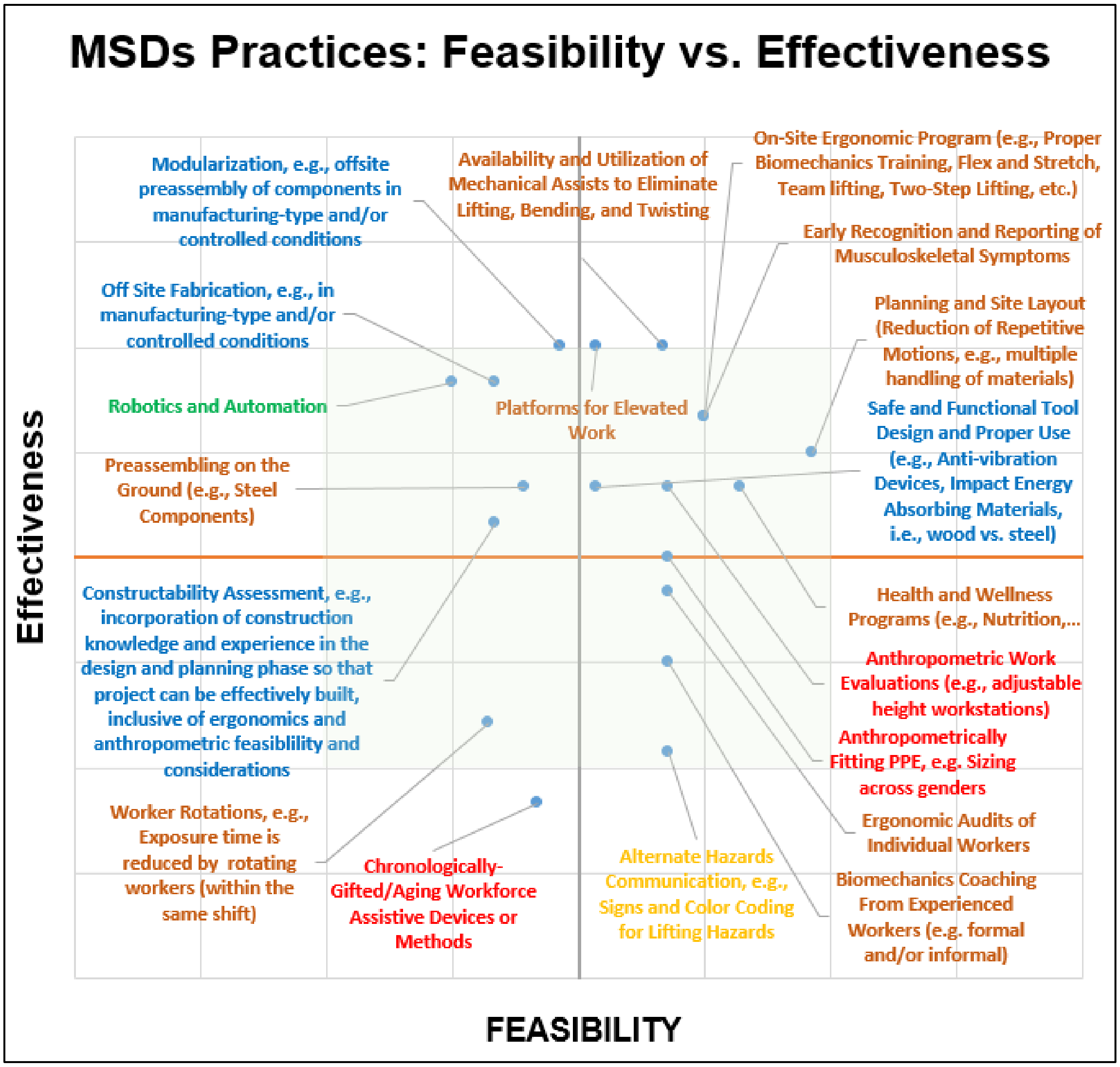
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	6.142857143	8
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	5.857142857	5.571428571
On-Site Noise Monitoring and Mapping	5.857142857	6.428571429
Activity Sequencing	5.833333333	6.714285714
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	5.714285714	6
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	5.571428571	8
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	5.571428571	6.142857143

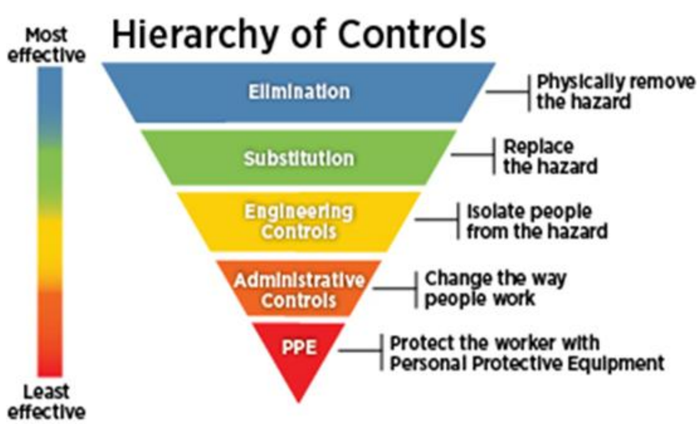

Noise Secondary: Feasibility vs. Effectiveness
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors
Exclusion Zones to Noisy Areas
Appropriate Hearing Protection (e.g., PPE)
Distancing On-Site Noisy Activities
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions
Acoustic Sound Barriers
Tool and Equipment Maintenance
Anthropometrically Fitting PPEs, e.g. Sizing across genders
Activity Sequencing
Noise Hazard Training
On-Site Noise Monitoring and Mapping
Individual Worker Training of Proper PPEs Use/Fit
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)
Periodic Audiometric Testing and Hearing Assessment
Inter-trade Noise Hazard
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods
Alternate Noise Hazards
Communication, e.g., Signs and Color Coding
Communication and Mitigation (e.g., handouts, meetings, verbal)
Effectiveness
FEASIBILITY


Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment
Source: NIOSH

MSD Prevention Practices	Feasibility Mean (X)	Effectiveness Mean (Y)
Early Recognition and Reporting of Musculoskeletal Symptoms	7	7.166666667
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	6.333333333	5.333333333
Alternate Hazards Communication, e.g., Signs and Color Coding for Lifting Hazards	6.857142857	5.571428571
Safe and Functional Tool Design and Proper Use (e.g., Anti-vibration Devices, Impact Energy Absorbing Materials, i.e., wood vs. steel)	6.571428571	6.833333333
Ergonomic Audits of Individual Workers	6.857142857	6.333333333
On-Site Ergonomic Program (e.g., Proper Biomechanics Training, Flex and Stretch, Team lifting, Two-Step Lifting, etc.)	7	7.166666667
Health and Wellness Programs (e.g., Nutrition, Exercise)	7.142857143	6.833333333
Anthropometric Work Evaluations (e.g., adjustable height workstations)	6.857142857	6.833333333
Platforms for Elevated Work	6.571428571	7.5
Anthropometrically Fitting PPE, e.g. Sizing across genders	6.857142857	6.5

Availability and Utilization of Mechanical Assists to Eliminate Lifting, Bending, and Twisting	6.833333333	7.5
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	6.428571429	7.5
Constructability Assessment, e.g., incorporation of construction knowledge and experience in the design and planning phase so that project can be effectively built, inclusive of ergonomics and anthropometric feasiblility and considerations	6.166666667	6.666666667
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	6.166666667	7.333333333
Preassembling on the Ground (e.g., Steel Components)	6.285714286	6.833333333
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	6.142857143	5.714285714
Robotics and Automation	6	7.333333333
Biomechanics Coaching From Experienced Workers (e.g. formal and/or informal)	6.857142857	6
Planning and Site Layout (Reduction of Repetitive Motions, e.g., multiple handling of materials)	7.428571429	7





Source: NIOSH

APPENDIX R

THIRD DELPHI SURVEY ROUND QUESTIONS

<u>**Health Hazards Delphi Survey Instructions**</u>
Round 3

<u>**INTRODUCTION AND BACKGROUND INFORMATION**</u>
You are receiving this survey for your participation as a panel expert in the research project "Engaging Project Stakeholders in Strategies for the Early Prevention of Noise, Welding Fumes, Crystalline Silica Particles, and Musculoskeletal Disorders at Construction". During the summer months, we had the opportunity to interview 11 subject matter experts and inquire them on the prevention of worker exposure to the hazards of silica, welding fumes, noise, and musculoskeletal disorders. The analysis of the interview material has resulted in the definition of prevention practices specific to each health hazard, as well as in the identification of general barriers against and catalysts for the implementation of such prevention practices.

This third and final survey inquires on whether the practices for each hazard are more effective in preventing the exposure of primary or secondary health hazards. Therefore, for this survey in relation to the health hazard, please assess the degree of effectiveness of each practice in the prevention of **primary exposures (by workers actually working with or generating the hazard), or secondary exposures (by workers not working or generating the hazard, but near or around the source of the hazard, and hence susceptible to its impact).** For each practice, please assess the degree of effectiveness in a scale of 1 to 9, where 1) represents Only Effective for Primary Exposure Prevention, 9) represents Only Effective for Secondary Exposure Prevention, and 5) represents Equally Effective for both primary and secondary exposures. **The survey also inquiries on the frequency of barriers to and catalysts for the adoption of the identified prevention practices.**

There is a comment section at the bottom of each section to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

<u>Time required to complete the survey</u>. The present survey takes about 20 minutes to complete. We respectfully request you take no longer than **one week** to submit your responses. Your timely responses will be used to design the next and likely last round of the Delphi survey.

<u>Confidential responses</u>. Even though the questions in this survey do not require the sharing of personal information, all answers will still be sanitized, so that an answer cannot be traced back to the individual who responded to the corresponding question. The research protocol in this study has been reviewed and approved by the Institutional Review Board at Arizona State University, which ensures the protection of rights and welfare of the participants in this study.

<u>Contact information</u>. Please do not hesitate to contact Linda Tello at ltello@asu.edu with any comments or questions you may have.

To move through the survey, please click on NEXT at the bottom right of each page.

Thank you very much for your time and expert responses.

0.1.
<u>**INSTRUCTIONS**</u>

A total of 5 sections are requested to complete the survey. Sections 1 – 3 inquire on whether the practices for each hazard of welding fumes, crystalline silica, and noise are more effective in preventing primary or secondary health hazards exposures. Where for this survey, please assess for each health hazard the degree of effectiveness of each practice in the prevention of **primary exposures (by workers actually working with or generating the hazard), or secondary exposures (by workers not working or generating the hazard, but near or around the source of the hazard, and hence susceptible to its impact).** The degree of effectiveness is scaled from 1 to 9, where 1) represents Only Effective for Primary Exposure Prevention, 9) represents Only Effective for Secondary Exposure Prevention, and 5) represents Equally Effective for both primary and secondary exposures.

Sections 4 - 5, respectively, determine the frequency of the barriers to and catalysts for the implementation of such prevention practices.

To move through the survey, please click on NEXT at the bottom right of each page. To return to a previous section, please use the BACK button at the bottom left of each page.

SECTION ONE - WELDING FUMES

1.0. Effectiveness of Practices in the Prevention of Primary vs. Secondary Exposures to Welding Fumes

1.01.
1.0 In relation to **WELDING FUMES**, please assess the degree of effectiveness of each practice in the prevention of **primary exposures (by workers actually working with or generating the hazard) or secondary exposures (by workers not working or generating the hazard but near or around the source of the hazard and hence susceptible to its impact).** For each practice, please assess the degree of effectiveness in a scale of 1 to 9, where 1) represents Only Effective for Primary Exposure Prevention, 9) represents Only Effective for Secondary Exposure Prevention, and 5) represents Equally Effective for both primary and secondary exposures.

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

Q36.

Table 1.0 Effectiveness of Practices in the Prevention of Primary vs. Secondary Exposures to Welding Fumes

	(1) Only Effective for Primary Exposure Prevention	(2)	(3)	(4)	(5) Equally Effective	(6)	(7)	(8)	(9) Only Effective for Secondary Exposure Prevention
Activity Sequencing, e.g., activity planning and execution to miminze/reduce fume exposures	○	○	○	○	◉	○	○	○	○
Alternate Welding Fumes Hazards Communication, e.g., Signs or Color Coding	○	○	○	○	◉	○	○	○	○
Inter-trade Welding Fumes Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	◉	○	○	○	○
Fume Protection Barriers	○	○	○	○	◉	○	○	○	○
Distancing On-Site Welding Activities	○	○	○	○	◉	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	◉	○	○	○	○
Automated Welding	○	○	○	○	◉	○	○	○	○
Use of Less or Non-Toxic Welding Consumables	○	○	○	○	◉	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	◉	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	◉	○	○	○	○
Welding Fumes Hazards Training	○	○	○	○	◉	○	○	○	○
Appropriate Respiratory Protection (e.g., PPE)	○	○	○	○	◉	○	○	○	○
Proper Ventilation	○	○	○	○	◉	○	○	○	○
Use of Environmental Conditions (e.g. Wind Patterns) to Plan for and Minimize Worker Exposure	○	○	○	○	◉	○	○	○	○
Availability of Showers and Hand Washing Units	○	○	○	○	◉	○	○	○	○

Monitoring of Contamination in Common Areas	○	○	○	○	◉	○	○	○	○
Exclusion Zones to Welding Areas	○	○	○	○	◉	○	○	○	○
Removing Contaminated PPE/Clothing before Entering Common Areas	○	○	○	○	◉	○	○	○	○
Design of Alternative Connections and Components, e.g. Bolted Connections	○	○	○	○	◉	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	◉	○	○	○	○
Chronologically Gifted/Aging Workforce Assistive Devices or Methods, e.g., down draft table that pulls fumes away from worker	○	○	○	○	◉	○	○	○	○
Work Shifts, e.g., devote specific shift to perform welding, and hence, mitigate exposure to other workers	○	○	○	○	◉	○	○	○	○

Q46. **COMMENTS**

Q55. **SECTION TWO - NOISE**

2.0. **Effectiveness of Noise Prevention Practices in Primary vs. Secondary Exposures**

2.01.
2.0 In relation to **Noise**, please assess the degree of effectiveness of each practice in the prevention of **primary exposures (by workers actually working with or generating the hazard) or secondary exposures (by workers not working or generating the hazard but near or around the source of the hazard and hence susceptible to its impact).** For each practice, please assess the degree of effectiveness in a scale of 1 to 9, where 1) represents Only Effective for Primary Exposure Prevention, 9) represents Only Effective for Secondary Exposure Prevention, and 5) represents Equally Effective for both primary and secondary exposures.

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

2.1.
Table 2.0 Effectiveness of Noise Prevention Practices in Primary vs. Secondary Exposures

	(1) Only Effective for Primary Exposure Prevention	(2)	(3)	(4)	(5) Equally Effective	(6)	(7)	(8)	(9) Only Effective for Secondary Exposure Prevention
Chronologically-Gifted/Aging Workforce Assistive Devices or Methods	○	○	○	○	◉	○	○	○	○
Periodic Audiometric Testing and Hearing Assessment	○	○	○	○	◉	○	○	○	○
Acoustic Sound Barriers	○	○	○	○	◉	○	○	○	○
Equipment Shielding/Retrofitting, e.g., Noise Vibration/Insulation	○	○	○	○	◉	○	○	○	○
Distancing On-Site Noisy Activities	○	○	○	○	◉	○	○	○	○
Tool and Equipment Maintenance	○	○	○	○	◉	○	○	○	○
Appropriate Hearing Protection (e.g., PPE)	○	○	○	○	◉	○	○	○	○
Noise Hazard Training	○	○	○	○	◉	○	○	○	○
Exclusion Zones to Noisy Areas	○	○	○	○	◉	○	○	○	○
Activity Sequencing	○	○	○	○	◉	○	○	○	○
Modularization, e.g., offsite preassembly of components in manufacturing-type and/or controlled conditions	○	○	○	○	◉	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	◉	○	○	○	○
On-Site Noise Monitoring and Mapping	○	○	○	○	◉	○	○	○	○
Inter-trade Noise Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	◉	○	○	○	○

Alternate Noise Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	◉	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	◉	○	○	○	○
Planning and Execution of Noisy Activities at Specific Work Shifts (e.g., Noisy Activities at Night)	○	○	○	○	◉	○	○	○	○
Anthropometrically Fitting PPEs, e.g. Sizing across genders	○	○	○	○	◉	○	○	○	○
Individual Worker Training of Proper PPEs Use/Fit	○	○	○	○	◉	○	○	○	○
Low-Noise and Low-Vibration Tools and Equipment/Noise Reduction Factors	○	○	○	○	◉	○	○	○	○

Q47. **COMMENTS**

Q56. **SECTION THREE - CRYSTALLINE SILICA**

3.0. **Effectiveness of Crystalline Silica Prevention Practices in Primary vs. Secondary Exposures**

3.01.
3.0 In relation to **Crystalline Silica**, please assess the degree of effectiveness of each practice in the prevention of **primary exposures (by workers actually working with or generating the hazard) or secondary exposures (by workers not working or generating the hazard but near or around the source of the hazard and hence susceptible to its impact).** For each practice, please assess the degree of effectiveness in a scale of 1 to 9, where 1) represents Only Effective for Primary Exposure Prevention, 9) represents Only Effective for Secondary Exposure Prevention, and 5) represents Equally Effective for both primary and secondary exposures.

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

3.1.
Table 3.0 Effectiveness of Crystalline Silica Prevention Practices in Primary vs. Secondary Exposures

	(1) Only Effective for Primary Exposure Prevention	(2)	(3)	(4)	(5) Equally Effective	(6)	(7)	(8)	(9) Only Effective for Secondary Exposure Prevention
Silica Dust Protections and/or Containment Barriers	○	○	○	○	◉	○	○	○	○
Improving the Efficiency and Effectiveness of Dust Collection in Tools and Equipment	○	○	○	○	◉	○	○	○	○
Isolation of Cutting Stations	○	○	○	○	◉	○	○	○	○
Distancing On-Site Airborne Producing Silica Activities	○	○	○	○	◉	○	○	○	○
Using Appropriate Dust Collecting Tools and Methods (e.g., Wet Method, Vacuum Method, etc.)	○	○	○	○	◉	○	○	○	○
Airborne Silica Monitoring and Sampling	○	○	○	○	◉	○	○	○	○
Post Activity Dust Cleanup and Dust Collection (e.g., After Wet Methods)	○	○	○	○	◉	○	○	○	○
Alternate Silica Hazards Communication, e.g., Signs and Color Coding	○	○	○	○	◉	○	○	○	○
Inter-trade Silica Hazard Communication and Mitigation (e.g., handouts, meetings, verbal)	○	○	○	○	◉	○	○	○	○
Planning for Water Supply Connection for Wet Methods (e.g., handheld tools)	○	○	○	○	◉	○	○	○	○
Silica Hazard Training	○	○	○	○	◉	○	○	○	○
Low or Non-Silica Content in Materials	○	○	○	○	◉	○	○	○	○
Activity Sequencing	○	○	○	○	◉	○	○	○	○
Appropriate Respiratory Protection	○	○	○	○	◉	○	○	○	○
Off Site Fabrication, e.g., in manufacturing-type and/or controlled conditions	○	○	○	○	◉	○	○	○	○

Proper Ventilation and Filtering (e.g., HEPA Vacuums and Pneumatic Fans)	○	○	○	○	◉	○	○	○	○
Worker Rotations, e.g., Exposure time is reduced by rotating workers (within the same shift)	○	○	○	○	◉	○	○	○	○
Exclusion Zones to Silica Hazard Areas	○	○	○	○	◉	○	○	○	○
Chronologically Gifted/Aging Workforce Considerations	○	○	○	○	◉	○	○	○	○

Work Shifts, e.g., devote specific shift to perform tasks, and hence, mitigate exposure to other workers	○	○	○	○	◉	○	○	○	○

Q47. **COMMENTS**

Q59. **SECTION FOUR - BARRIERS**

5.0. **Frequency of Barrier(s) in Preventing and/or Opposing the Implementation of Practices**

5.01. **4.0** Based on your knowledge and experience in the construction industry and in consideration of the general industry environment, please assess the frequency of each barrier preventing, opposing, or difficulting the consideration and/or implementation of the previous hazard prevention/mitigation practices in construction projects.

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

5.1. **Table 4.0 Presence/Frequency of Barrier(s) in Preventing and/or Opposing the Consideration/Implementation of Practices.**

	Extremely Infrequently (1)	Very Infrequently (2)	Moderately Infrequently (3)	Slightly Infrequently (4)	Neither Frequently nor Infrequently (5)	Slightly Frequently (6)	Moderately Frequently (7)	Very Frequently (8)	Extremely Frequently (9)
Chronologically-Gifted/Aging Workforce	○	○	◉	○	○	○	○	○	○
Limited Capital	○	○	◉	○	○	○	○	○	○
Ineffective Job Hazards Communication	○	○	◉	○	○	○	○	○	○
Unenforceable Contract Health Provisions	○	◉	○	○	○	○	○	○	○
Temporary Labor, e.g., Day Laborers	○	○	◉	○	○	○	○	○	○
Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations	○	○	◉	○	○	○	○	○	○
Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment	○	○	◉	○	○	○	○	○	○
Lack of Proper Trainer Credentials	○	○	◉	○	○	○	○	○	○
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws	○	○	◉	○	○	○	○	○	○
Worker Trade Inexperience	○	○	◉	○	○	○	○	○	○
Management Inexperience with Health Hazards	○	◉	○	○	○	○	○	○	○
Language Barrier e.g., employer unwilling to provide training in other than English	○	○	◉	○	○	○	○	○	○
Non-Functional PPE	○	◉	○	○	○	○	○	○	○
Non-Functional Tools	○	○	◉	○	○	○	○	○	○
Tool and PPE Procurement Cost Driven	○	○	○	◉	○	○	○	○	○
Ineffective or Nonexistent Health Processes and Procedures at Organization	○	○	◉	○	○	○	○	○	○
False Sense of Worker Health due to Delayed Health Impact	○	◉	○	○	○	○	○	○	○
Resistance to Change	○	○	◉	○	○	○	○	○	○
Macho Type Attitude	○	◉	○	○	○	○	○	○	○

Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking	○	◉	○	○	○	○	○	○	○
High Worker Turnover	○	◉	○	○	○	○	○	○	○

Q52. **COMMENTS**

Q60. **SECTION FIVE - CATALYSTS**

6.0. **Frequency of Catalysts in Construction Projects for the Implementation of the Practices**

6.01.
5.0 Based on your knowledge and experience in the construction industry and in consideration of the general industry environment, please assess the frequency of each catalyst in facilitating, supporting, and/or enabling the consideration and/or implementation of the previous hazard prevention/mitigation practices in construction projects.

Also, please use the comment section at the bottom to add any information that you feel is valuable or necessary to communicate your perspective or insights with regard to your response(s).

6.1.
Table 5.0 Presence/Frequency of Catalysts in Construction Projects for the Consideration/Implementation of the Practices.

	Extremely Infrequently (1)	Very Infrequently (2)	Moderately Infrequently (3)	Slightly Infrequently (4)	Neither Frequently nor Infrequently (5)	Slightly Frequently (6)	Moderately Frequently (7)	Very Frequently (8)	Extremely Frequently (9)
Available Capital	○	○	○	○	○	○	◉	○	○
Lessons Learned Program	○	○	○	○	○	◉	○	○	○
Inclusion of Contract Health Provisions	○	○	○	○	○	◉	○	○	○
Health Hazard Awareness and Education	○	○	○	○	○	◉	○	○	○
Job Hazard Analysis	○	○	○	○	○	◉	○	○	○
Occupational Health Programs, e.g., Hearing Conservation Program	○	○	○	○	○	○	◉	○	○
Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized	○	○	○	○	○	○	○	◉	○
Incentivization, e.g., Reporting of Health Hazard Exposures	○	○	○	○	○	○	◉	○	○
Specific Job Hazards Awareness and Education	○	○	○	○	○	○	◉	○	○
Continued Leadership Commitment	○	○	○	○	○	○	○	◉	○
OSHA Tools & Training Awareness	○	○	○	○	◉	○	○	○	○
Job Coaching from Experienced Workers	○	○	○	○	○	◉	○	○	○
Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns	○	○	○	○	○	○	○	◉	○

Apprenticeship Programs	○	○	○	○	○	○	◉	○	○
Regulatory Enforcement	○	○	○	○	◉	○	○	○	○
Proper Hazard Training	○	○	○	○	○	○	◉	○	○
Media Exposure (Reputation)	○	○	○	○	◉	○	○	○	○
Worker Accountability/Attitude	○	○	○	○	○	○	○	◉	○
Worker Recognition/Appreciation	○	○	○	○	○	○	○	◉	○

Q53. **COMMENTS**

7.0. **Thank you for your participation. Please click SUBMIT on the bottom right to submit your survey.**

APPENDIX S

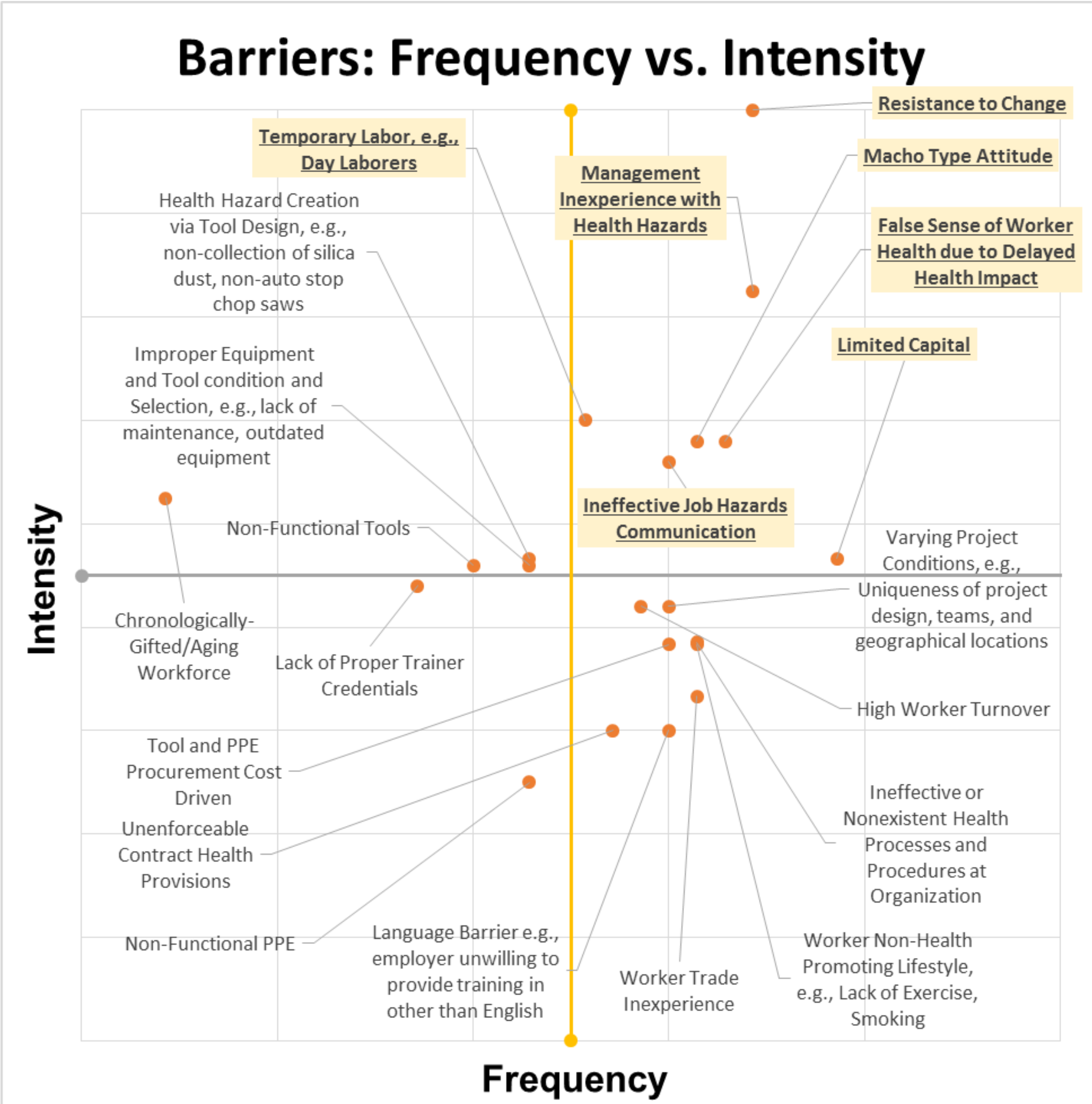
THIRD ROUND DELPHI SURVEY RESULTS:

BARRIERS - FREQUENCY VERSUS INTENSITY, AND

CATALYSTS – FREQUENCY VERUS ENABLING

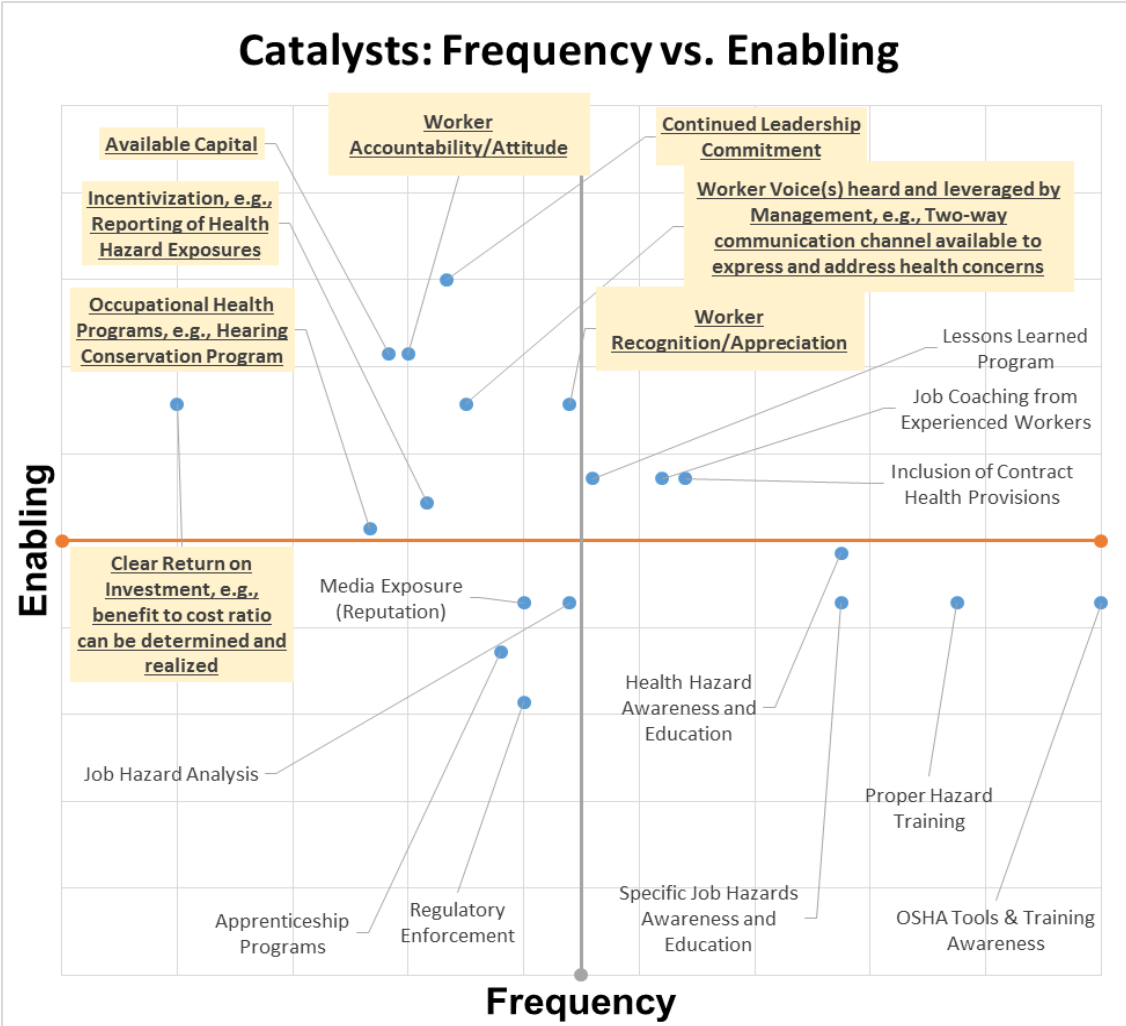
Barriers	Frequency Mean (X)	Intensity Mean (Y)
Resistance to Change	7.428571429	13
Management Inexperience with Health Hazards	7.428571429	11.25
Temporary Labor, e.g., Day Laborers	6.571428571	10
False Sense of Worker Health due to Delayed Health Impact	7.285714286	9.8
Macho Type Attitude	7.142857143	9.8
Ineffective Job Hazards Communication	7	9.6
Chronologically-Gifted/Aging Workforce	4.428571429	9.25
Limited Capital	7.857142857	8.66666666
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws	6.285714286	8.66666666
Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment	6.285714286	8.6
Non-Functional Tools	6	8.6

Lack of Proper Trainer Credentials	5.714285714	8.4
Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations	7	8.2
High Worker Turnover	6.857142857	8.2
Ineffective or Nonexistent Health Processes and Procedures at Organization	7.142857143	7.85714285
Tool and PPE Procurement Cost Driven	7	7.83333333
Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking	7.142857143	7.83333333
Worker Trade Inexperience	7.142857143	7.33333333
Unenforceable Contract Health Provisions	6.714285714	7
Language Barrier e.g., employer unwilling to provide training in other than English	7	7
Non-Functional PPE	6.285714286	6.5


Barriers: Frequency vs. Intensity
Intensity
Frequency
Resistance to Change
Temporary Labor, e.g., Day Laborers
Management Inexperience with Health Hazards
Macho Type Attitude
False Sense of Worker Health due to Delayed Health Impact
Health Hazard Creation via Tool Design, e.g., non-collection of silica dust, non-auto stop chop saws
Limited Capital
Improper Equipment and Tool condition and Selection, e.g., lack of maintenance, outdated equipment
Ineffective Job Hazards Communication
Non-Functional Tools
Varying Project Conditions, e.g., Uniqueness of project design, teams, and geographical locations
Chronologically-Gifted/Aging Workforce
Lack of Proper Trainer Credentials
High Worker Turnover
Tool and PPE Procurement Cost Driven
Unenforceable Contract Health Provisions
Ineffective or Nonexistent Health Processes and Procedures at Organization
Non-Functional PPE
Language Barrier e.g., employer unwilling to provide training in other than English
Worker Trade Inexperience
Worker Non-Health Promoting Lifestyle, e.g., Lack of Exercise, Smoking

Catalyst	Frequency Mean (X)	Enabling Mean (Y)
OSHA Tools & Training Awareness	13	6.142857143
Proper Hazard Training	11.75	6.142857143
Health Hazard Awareness and Education	10.75	6.428571429
Specific Job Hazards Awareness and Education	10.75	6.142857143
Inclusion of Contract Health Provisions	9.4	6.857142857
Job Coaching from Experienced Workers	9.2	6.857142857
Lessons Learned Program	8.6	6.857142857
Job Hazard Analysis	8.4	6.142857143
Worker Recognition/Appreciation	8.4	7.285714286
Regulatory Enforcement	8	5.571428571
Media Exposure (Reputation)	8	6.142857143
Apprenticeship Programs	7.8	5.857142857
Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns	7.5	7.285714286
Continued Leadership Commitment	7.3333333	8
Incentivization, e.g., Reporting of	7.1666667	6.714285714

Health Hazard Exposures		
Worker Accountability/Attitude	7	7.571428571
Available Capital	6.8333333	7.571428571
Occupational Health Programs, e.g., Hearing Conservation Program	6.6666667	6.571428571
Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized	5	7.285714286


Catalysts: Frequency vs. Enabling
Available Capital
Worker Accountability/Attitude
Continued Leadership Commitment
Incentivization, e.g., Reporting of Health Hazard Exposures
Worker Voice(s) heard and leveraged by Management, e.g., Two-way communication channel available to express and address health concerns
Occupational Health Programs, e.g., Hearing Conservation Program
Worker Recognition/Appreciation
Lessons Learned Program
Job Coaching from Experienced Workers
Inclusion of Contract Health Provisions
Enabling
Clear Return on Investment, e.g., benefit to cost ratio can be determined and realized
Media Exposure (Reputation)
Health Hazard Awareness and Education
Job Hazard Analysis
Proper Hazard Training
Apprenticeship Programs
Regulatory Enforcement
Specific Job Hazards Awareness and Education
OSHA Tools & Training Awareness
Frequency