Executive Summary:

Predictors of Contractor Fatalities and Serious Injuries

Prepared for ORC Worldwide

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Table of Contents

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Introduction

Occupational fatalities and serious injuries are a growing concern across the country, especially among contractors. ORC Worldwide, under the auspices of The Duke Energy Foundation, engaged The University of Utah to identify and study the causes of fatalities and serious injuries among contractors and to identify potential predictors that may be used in contractor prequalification program criteria. On April 10, 2008, the University of Utah issued a final draft report entitled, Contractor Safety Prequalification: Current Practices and Prospective Models, by Peter Philips, Ph.D., and Norman Waitzman, Ph.D., Professors of Economics. That report provides a number of insights on the economics of and drivers for establishing contractor prequalification programs. In July 2008, Rancour and Associates, LLC was asked by ORC Worldwide to conduct a review of contemporary safety literature to identify existing research findings around the issue of preventing fatalities and serious injuries, especially at it relates to contractors. This report provides the results of that review. Information contained in this report can be used to supplement the University of Utah research study and used to create a more robust, proactive contractor prequalification program model for reducing fatalities and serious injuries.

Approach

Studies, reports, and other professional safety and health literature we reviewed and analyzed to develop this executive summary. Key findings from the literature were summarized and are presented with applicable references. Potential implications to the design and development of a contractor prequalification model that targets fatalities and serious injuries are discussed throughout this document.

University of Utah Study – Summary of Potential Predictors of Fatalities and Serious Injuries

The University of Utah (Phillips and Waitzman, 2008) studied contractor safety and workers compensation performance data obtained from PICS, a service provider company. The study found the following associations:

- Past lost workday injury rates strongly and tightly predicted current lost workday injury rates for contractors.
- Experiencing a fatality in the past led to lower current lost workday injury rates. Each additional past fatality lowered the contractor's current lost workday injury rate by 7%.
- Lower lost workday injuries and/or lower experience modification rates (EMRs) correlated with lower current lost workday injury rates. Past lost

workday injury rate was a tighter, stronger predictor of current lost workday injuries compared to past EMR rates.

- Contractors with a behavior-based safety program had a lower predicted lost workday injury rate by about 64%, all other things being equal.
- Contractors with a company safety director had a lower predicted lost workday injury rate by about 72%.
- Contractors with a site safety representative had a lower predicted lost workday injury rate by about 44%,

The authors also cautioned that in choosing critical contractor attributes that, when incorporated into prequalification standards are most likely to enhance the safety performance of contractors, overall context must be considered:

"So to answer the question—What are the critical contractor-attributes that when incorporated into prequalification standards are most likely to enhance the safety performance of contractors?—there are layers of context needed. First, safety prequalification is only effective within a broader safety management plan including project risk assessment information provided to contractors and contractor site-orientation. Second, the characteristics placed in the prequalification standards will have to take into consideration the broader context of the contractor's envisioned work—not only whether the contractor will be at the center or on the edge of the project's safety risks, but also whether the contractor will be on-the-job briefly or a long time, and whether the contractor will be bringing subcontractors on the job. Third, and derivative of the safety context and work context, but determined also by many other factors, the critical contractor-attributes needed in the prequalification standard will be partly influenced by the economically feasible depth and periodicity of prequalification, and an optimization of a tradeoff between cheaper-less-predictive and expensive-more-predictive information about the contractor."

Potential Implications to Contractor Prequalification- The University of Utah study results indicate that historical lost workday injury rates and EMRs are useful predictors of current contractor serious injury rates. In addition, the existence of a basic safety accountability system, as evidenced by having a company safety director and on-site safety representatives, were positive predictors of favorable current performance. Existence of behavior-based safety programs, which are based on peer-to-peer task/hazard observation and feedback, had a positive correlation with favorable performance. The aforementioned potential predictors represent a balance between both traditional outcome or trailing metrics and upstream, process measures and are fairly objective criteria that could be incorporated into a contractor prequalification system.

General Observations on the Causation of Fatalities and Serious Injuries

Dan Petersen (1998) made important, early observations on the causes of fatalities and serious injuries. In particular, he noted that causes of serious incidents are very different when compared to less severe incidents. Because of their complexity, efforts to control fatalities and serious injuries by focusing on reducing overall injury frequency are not effective. He supported the view that severe injury potential needs a special approach and suggested focusing attention on four work activities that are often associated with these cases:

"If we study any mass data, we can readily see that the types of accidents that results in temporary total disabilities are different from the types of accidents that resulting in permanent partial disabilities or in permanent total disabilities or fatalities.

The causes are different. There are different sets of circumstances surrounding severity. Thus, if we want to control serious injuries, we should try to predict where they will happen. Studies in recent years suggest that severe injuries are fairly predictable in certain situations. Some of those situations involve:

- Unusual, non-routine work.
- Non-production activities,
- Sources of high energy,
- Certain construction situations. "

Manuele (2006) also looked at the complex causation of fatalities and serious injuries. He reviewed and analyzed over 1,000 incident investigation reports and made the following conclusions:

- A large proportion of incidents resulting in severe injury occur in unusual and non-routine work, in non-production activities and where sources of high energy are present. They also occur in what can be described as at-plant construction operations.

- Causal factors for low-probability, high-consequence (LPHC) events are seldom represented in the analytical data on accidents that occur frequently (although some ergonomics-related incidents are the exception).
- Many incidents resulting in serious injury are unique and singular events, having multiple, complex causal factors that may have technical, operational systems, or cultural origins.

Potential Implications to Contractor Prequalification- Traditional (e.g. Heinrich) approaches to reducing total injury frequencies with the hope that fatalities and serious injuries will also be controlled do not work. Companies with great statistical injury and illness rates still continue to experience fatalities and serious injuries. Research suggests that other factors are in play. Contractor prequalification criteria must, therefore, focus on known predictors of serious incidents, such as performance of unusual, non-routine work, non-production activities, working near high energy sources, and construction activities. Many of these work activities are the “stock and trade” of contractors. The contractor’s ability to address risks associated with these predictors should form the basis for an effective contractor prequalification program. In addition, often there are even more complex, multiple causes of fatalities and serious injuries, such as technical issues, operational system effectiveness and safety culture. Therefore, contractor prequalification programs that assess contractor technical competency, efficiency and quality of ways of working/operating systems and how well personal safety is valued and demonstrated (culture) should be more effective than programs that do not deal with these factors.

Predictors of Low Probability, High Consequence Events in Operations Covered Under EPA's Risk Management Program

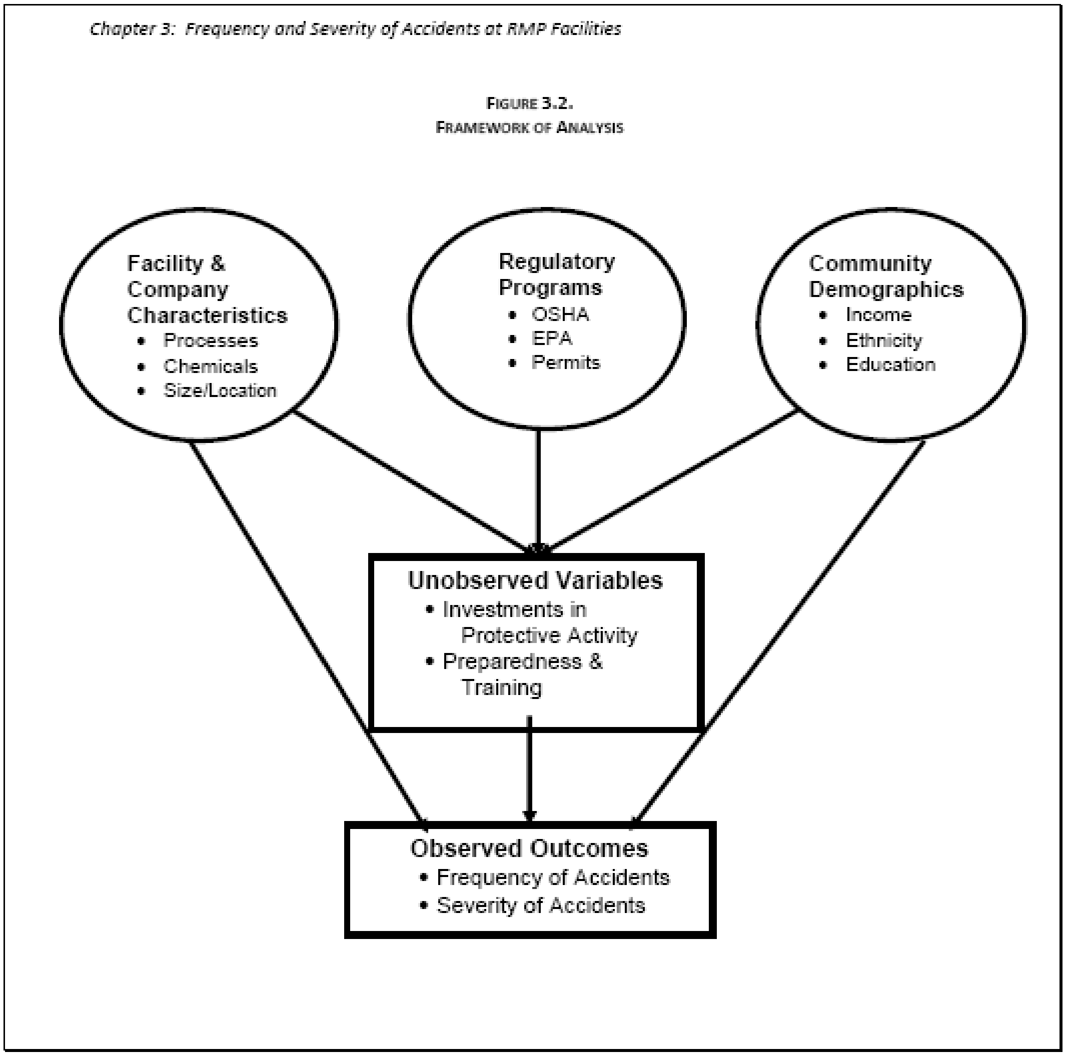
Research on predictors of low probability, high consequence (LPHC) chemical-related events (for example, events resulting in fatalities, serious injuries, and significant impacts to the community, the environment or commercial or personal property) provides very useful considerations on potential predictors of fatalities and serious injuries. Studies by Rosenthal et al (2006), EPA and Wharton School (2007), and Elliott et al. (2008) are particularly important. These insights can be leveraged to eventually design and develop an associated contractor prequalification model. The following summarizes key learnings:

- General Framework of Analysis for Predictors of Frequency and Severity of Accidents

The EPA's Office of Emergency Management and The Wharton School of the University of Pennsylvania, Wharton School, Risk Management and Decision Processes Center developed a conceptual model for predictors of

frequency and severity of accidents, (EPA and Wharton School (2007)).

The framework includes predictor categories covering facility and company characteristics, applicable regulatory programs (risk profile) and community demographics. Of particular note in the model is the inclusion of the predictor category of "unobserved variables". Unobserved variables include investments in "protective activity" and preparedness and training. Figure 3.2 from the study is shown below and graphically depicts the "Framework of Analysis". The authors discussed predictor categories relative to facility and company characteristics, regulatory programs and community demographics. Key conclusions and learnings that may be helpful for contractor prequalification criteria are discussed, below. With respect to the "unobserved variables" predictor category, the authors concluded that research is needed to further define and measure the potential influences of these and other "unobserved variables". Research will have to be carefully completed to ensure definition and isolation of the specific variables effects with elimination of confounding factors.



- Facility Employment Level

The probability of *a reportable RMP* accident* climbs from less than 3% for facilities with fewer than 10 employees to near 30% for firms with 1,000, then levels off for firms larger than 1,000. The probability of accidents actually appears to decline for the very largest facilities (those with 5,000 or more employees), but this decline is not statistically significant. Similar trends are seen for injury risk and property damage risk related to RMP events. (EPA and Wharton School (2007))

** Risk Management Program (RMP) accident as defined by the US EPA Clean Air Act, Section 112(r).*

Potential Implications to Contractor Prequalification- Facility employment level probably has no direct utility for contractor prequalification. However, it should be noted that the existence of effective contractor prequalification programs is increasingly critical as the employment levels of the host facility increases, with a peak of about 1,000 employees.

- Company Financial Health

Companies not under financial hardship were observed to have fewer RMP incidents. The authors recognized this as being consistent with normal economic expectations. Companies that are more debt-ridden are likely to be less concerned with long-term cash flows, as most of the risk is borne by creditors who are not represented in the company's decision making about risk mitigating investments. Similarly, companies with large sales have greater cash flows at risk from disruptive accidents and this provides stronger incentive to undertake greater care, leading to the observed lower accident and injury rates. (EPA and Wharton School (2007))

Potential Implications to Contractor Prequalification- Contractor financial stability may be potentially useful prequalification criteria. Contractors under financial duress may be less inclined and/or able to make the necessary investments in safety for prevention of fatalities and serious injuries.

- Community and Demographic Effects

Higher-risk facilities are more likely to be found in counties with sizeable poor and/or minority populations that disproportionately bear the collateral environmental, property, and health risks. An alternative, though related, perspective is that communities burdened by low socio-economic status and past or present discrimination may be willing to accept these risks in order to obtain the economic benefits of facility location, or that residents not willing to accept this risk move away. For facilities of a similar hazard level, those operated in counties with 10% or higher African-American populations appear to pose greater risk of accident than those in counties with less than 1% African-Americans. (EPA and Wharton School (2007))

Potential Implications to Contractor Prequalification- Community and demographic effects probably have no direct utility as predictors of safety and contractor prequalification criteria. The observation can be made; however, that contractor prequalification may be increasingly critical for host companies located in poorer counties and/or counties with high minority populations.

- The Existence of a Process Safety Management System

As discussed in Rosenthal et al. (2006), many practitioners continue to believe that an "effective" Process Safety Management (PSM)* system is the key to prevention, both for occupational injuries and incidents (OII) *as well as* for major incidents at RMP facilities. Testing the validity of this belief remains to be done. Testing will require the ability to define and identify the essential elements of 'effective' facility process safety management plans. Among other issues, it will be important to separate out the effects a given process safety management system has on everyday safety events from the effects, if any, that such a system might have in preventing or mitigating the consequences of larger events, including catastrophic failures.

*As defined by the OSHA Process Safety Management Standard, 29 CFR 1910.119

Potential Implications to Contractor Prequalification- By analogy with host employers, contractors who know, understand and follow process safety management system principles maybe less likely to have a major incident. There are 14 key PSM requirements, as noted below. These principles could be applied generally, beyond regulated industries. Research on the possible influence and importance of each element to contractor safety prequalification and safety performance have not been completed.

Key PSM Requirements

(1) Develop and maintain written safety information identifying workplace chemical and process hazards, equipment used in the processes, and technology used in the processes;

(2) Perform a workplace hazard assessment, including, as appropriate, identification of potential sources of accidental releases, identification of any previous release within the facility that had a potential for catastrophic consequences in the workplace, estimation of workplace effects of a range of releases, and estimation of the health and safety effects of such a range on employees;

(3) Consult with employees and their representatives on the development and conduct of hazard assessments and the development of chemical accident prevention plans and provide access to these and other records required under the standard;

(4) Establish a system to respond to the workplace hazard assessment findings, which shall address prevention, mitigation, and emergency responses;

(5) Review periodically the workplace hazard assessment and response system;

(6) Develop and implement written operating procedures for the chemical processes, including procedures for each operating phase, operating limitations, and safety and health considerations;

(7) Provide written safety and operating information for employees

and employee training in operating procedures, by emphasizing hazards and safe practices that must be developed and made available;

(8) Ensure contractors and contract employees are provided with appropriate information and training;

(9) Train and educate employees and contractors in emergency response procedures in a manner as comprehensive and effective as that required by the regulation promulgated pursuant to section 126(d) of the Superfund Amendments and Reauthorization Act;

(10) Establish a quality assurance program to ensure that initial process-related equipment, maintenance materials, and spare parts are fabricated and installed consistent with design specifications;

(11) Establish maintenance systems for critical process-related equipment, including written procedures, employee training, appropriate inspections, and testing of such equipment to ensure ongoing mechanical integrity;

(12) Conduct pre-startup safety reviews of all newly installed or modified equipment;

(13) Establish and implement written procedures managing change to process chemicals, technology, equipment and facilities; and

(14) Investigate every incident that results in or could have resulted in a major accident in the workplace, with any findings to be reviewed by operating personnel and modifications made, if appropriate.

It is interesting to also note that the aforementioned PSM elements have significant overlap with the twelve elements contained in the European Contractor Health and Safety Assessment Scheme (CHAS). See: http://www.chas.gov.uk and Table below. CHAS is a nonprofit contractor safety prequalification service owned by local public authorities.

	CORE CRITERIA	STANDARD TO BE ACHIEVED (BY THE CONTRACTOR)
1	H&S policy and organisation (five employees or over)	Have and implement an appropriate policy, regularly reviewed, and signed by the MD or equivalent. The policy should be relevant to the nature and scale of the work and set out responsibilities for health and safety (H&S) management at all levels in the company.
2	Arrangements for ensuring H&S measures	These should set out the arrangements for H&S management and should be relevant to the nature and scale of the work. They should set out how the company will discharge duties under CDM 2007 and other relevant H&S legislation, with a clear indication of how these arrangements are communicated to the workforce.
3	Competent advice - company and construction/sector related	The company and its employees must have ready access to competent H&S advice, preferably from within the company. The advisors must be able to provide general H&S advice, and advice relating to H&S issues on site.
4	Training and Information	Have in place, and implement, training arrangements to ensure employees have sufficient skills and understanding to discharge their various duties. Have a programme of refresher training (e.g. a CPD programme or life long learning) that will keep employees updated on legislation and good H&S practice. This applies throughout the company from top management to trainees.
5	Individual qualifications and experience	Employees should have the appropriate qualifications and experience for the assigned tasks, unless they are under controlled and competent supervision.
6	Monitoring, audit and review	Have a system for monitoring procedures, for auditing them at periodic intervals, and for reviewing them on an on-going basis.
7	Workforce involvement	Have, and implement, an established means of consulting with the workforce on H&S.
8	Accident reporting and enforcement action; follow up investigation	Records of all RIDDOR-reportable events for at least the last three years. Have a system for reviewing other incidents, and recording the action taken as a result. Record any enforcement action taken against the company in the last five years, and action taken to remedy any enforcement-related issues.
9	Sub-contracting/ consulting procedures (if applicable)	Have arrangements for appointing competent sub-contractors/consultants. Be able to demonstrate how to ensure that sub-contractors will also have arrangements for appointing competent sub-contractors or consultants. Have arrangements for monitoring sub-contractor performance.
10	Risk assessment (leading to a safe method of work if necessary)	Have procedures in place for carrying out risk assessments and for developing and implementing safe systems of work/ method statements. Note: this *should include* occupational health issues.
11	Co-operating with others and co-ordinating work with other contractors	Illustrate how co-operation and co-ordination of the work is achieved in practice, and how others are involved in drawing up method statements/safe systems of work.
12	Welfare provision	Able to show how the appropriate welfare facilities will be in place *before* people start work on site.

- Occupational Injury and Illness (OII) Rates

Elliott et al. (2008) examined whether there is any relationship between the performance of chemical facilities on everyday safety (defined in terms of regularly reported occupational illnesses and injuries—“OII rates”) and major accidents reported under the RMP rule in the U.S. for the first filing period of RMP, covering accidents during the period 1994 -2000. The approach pursued was to link RMP info reporting facilities to OII reports provided to OSHA during the 1996-2000 RMP*Info reporting period where both types of data was clearly available for the same facility. Correlation between OII incidence and RMP accident incidence would suggest that a company culture or management team that is motivated and capable of creating effective OII management systems is also motivated and capable of generating practices that are effective in ensuring safe chemical process operations. Conversely, lack of correlation may indicate the existence of a positive safety culture but absence of capability, longer term focus and the know-how needed to design an chemical process safety system, or perhaps lack of the motivation to do so: good OII performance is relatively quickly reflected in significant reductions in workers’ compensation costs, while the savings from avoiding process accidents are less tangible, certainly less predictable, and more long term, and this may reduce management motivation to act. *What Elliott and his colleagues found was that there are no strong positive correlations between OII reports and RMP low-probability, high-consequence (LPHC) events. Facilities with injuries, deaths, major property damage, or substantial offsite consequences from RMP reported events actually tended to have lower OII/Year/FTE than facilities without these types of* *incidents.* However, this negative correlation is a function of RMP-reporting facilities, with higher OIIs tending to have lower hazard measures and thus lower rates of RMP*Info-reported accidents. After adjusting for this confounding between OII rates and the underlying hazardousness of the process, no statistically significant associations were found between OII rates and either RMP*Info reported injuries or RMP*Info-reported major property damage and other consequence measures of severity of accidents.

Potential Implications to Contractor Prequalification- Historical safety performance rates appear to be a weak or non-predictor of low-probability, high- consequence events in *theRMP regulated community*. This conflicts with results mentioned earlier for the contractor safety study conducted by Phillips and Waitzman i.e. that lost workday rates are good predictors of future serious events. The difference may be due to the relatively low incidence rates in RMP regulated industries compared to general contractors. Further studies may be necessary to clarify this point.

Bureau of Labor Statistics (BLS) Studies

A review of fatal occupational injuries (all industries) by event or exposure for the period from 2001 - 2006 reveals the following, (see Table 1), (BLS, 2001-2006)

- Transportation incidents, accounted for 42% of all fatalities. Highway incidents were responsible for over half of all transportation fatalities. This was followed by collision between vehicles/mobile equipment.
- Contact with objects and equipment was the second most overall cause of fatalities at 17%, followed by, falls (14%), assaults and violent acts (13%), and exposure to harmful substances or environments (9%).
- With respect to fall fatalities, the predominant type of fall causing a fatality was “fall to lower level”.
- With respect to exposure to harmful substance or environments, the majority of incidents were caused by “contact with electric current”.

Table 1.

Fatal occupational injuries by event or exposure,

2001-2006

	Fatalities			
	average	Number		Percent
Total	5,704	5,734	5,703	100
Transportation incidents	2,451	2,493	2,413	42
Highway	1,394	1,437	1,329	23
Collision between vehicles, mobile equipment	686	718	644	11
Moving in same direction	151	175	152	3
Moving in opposite directions, oncoming	254	265	234	4
Moving in intersection	137	134	138	2
Vehicle struck stationary object or equipment in roadway	27	27	19	(3)
Vehicle struck stationary object, equipment on side of road	310	345	337	6
Noncollision	335	318	297	5
Jack-knifed or overturned-no collision	274	273	248	4
Nonhighway (farm, industrial premises)	335	340	342	6
Overturned	175	182	165	3
Worker struck by a vehicle	369	391	372	7
Rail vehicle	60	83	65	1
Water vehicle	82	88	89	2
Aircraft	206	149	215	4
Assaults and violent acts	850	792	754	13
Homicides	602	567	516	9
Shooting	465	441	417	7
Stabbing	60	60	38	1
Self-inflicted injuries	207	180	199	3
Contact with objects and equipment	952	1,005	983	17
Struck by object	560	607	583	10
Struck by falling object	345	385	378	7
Struck by flying object	50	53	69	1
Caught in or compressed by equipment or objects	256	278	281	5
Caught in running				

equipment or machinery...	128	121	148	3
Caught in or crushed in collapsing materials.......	118	109	107	2
Falls........................	763	770	809	14
Fall to lower level.........	669	664	728	13
Fall from ladder..........	125	129	129	2
Fall from roof............	154	160	184	3
Fall from scaffold, staging..................	87	82	88	2
Fall on same level..........	73	84	59	1
Exposure to harmful substances or environments..............	498	501	525	9
Contact with electric current....................	265	251	247	4
Contact with overhead power lines..............	118	112	108	2
Contact with temperature extremes..................	44	55	53	1
Exposure to caustic, noxious, or allergenic substances.................	114	136	153	3
Inhalation of substance...	56	66	58	1
Oxygen deficiency...........	74	59	64	1
Drowning, submersion......	54	48	50	1
Fires and explosions..........	174	159	201	4

1 Based on the 1992 BLS Occupational Injury and Illness Classification Manual. Includes other events and exposures, such as bodily reaction, in addition to those shown separately.
2 The BLS news release issued August 10, 2006, reported a total of 5,702 fatal work injuries for calendar year 2005. Since then, an additional 32 job-related fatalities were identified, bringing the total job-related fatality count for 2005 to 5,734.
3 Less than or equal to 0.5 percent.
NOTE: Totals for 2006 are preliminary. Totals for major categories may include subcategories not shown separately. The average count excludes fatalities from the September 11, 2001 terrorist attacks. Percentages may not add to totals because of rounding.
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, in cooperation with State, New York City, District of Columbia, and Federal agencies, Census of Fatal Occupational Injuries

BLS also made the following observations relative to fatal occupational injuries in 2006, (BLS, 2006):

- Of 5,703 total fatalities, 937 cases (16.5%) were among Hispanic or Latino workers in 2006 was up from the 923 fatal work injuries in 2005 and represented the largest annual total since the fatality census began in 1992. Due to increased employment, however, the fatality rate for Hispanic or Latino workers was lower (4.7 fatalities per 100,000 workers in 2006 versus 4.9 per 100,000 in 2005). Among foreign-born Hispanic or Latino workers, fatalities decreased slightly after reaching a series high in 2005. Fatalities among White workers, Black or African-American workers, and Asian, Native Hawaiian, or Pacific Islander workers were all lower.

- Construction accounted for 1,226 fatal work injuries, the most of any industry sector. The total for construction represented an increase of 3 percent over the 2005 total. Fatalities among specialty trade contractors rose 6 percent (from 677 fatalities in 2005 to 721 in 2006), due primarily to higher numbers of fatal work injuries among building finishing contractors and roofing contractors. Fatalities in building construction and in heavy and civil engineering construction decreased in 2006.

Potential Implications to Contractor Prequalification- The BLS fatality data suggest that when designing a contractor prequalification program for prevention of fatalities and serious injuries, host employers should carefully evaluate the existence and efficacy of contractor safety programs for controlling the following exposures, as applicable:

- transportation and vehicle safety,
- fall prevention,
- prevention of violence in the workplace,
- fall prevention,
- electrical safety, and
- construction work.

In addition, the data suggest host employers should include contractor safety prequalification criteria that probes the effectiveness of safety training and communications with minority workers, especially Hispanic or Latino workers.

Denver International Airport Construction Safety Study

The Denver International Airport (DIA) construction project provided a rare opportunity to identify risk factors for injury on a large construction project for which 769 contractors were hired to complete 2,843 construction contracts. The University of Colorado, School of Medicine undertook a study of various factors associated with total and lost work time (LWT) injuries, (Lowrey et. al, 1998).

Results from the study showed that injury rates were highest during the first year of construction, at the beginning of contracts, and among older workers. Risk for total and non-LWT injuries was elevated for building construction contracts, contracts for special trades companies (SIC 17), contracts with payrolls over $1 million, and those with overtime payrolls greater than 20%. Risk for LWT injuries only was increased for site development contracts and contracts starting in the first year of construction. Contracts experiencing one or more minor injuries were four times as likely to have at least one major injury.

Enhancement of DIA's safety infrastructure during the second year of construction appears to have been effective in reducing serious (LWT) injuries. The absence of correlation between injury rates among contracts belonging to the same company suggests targeting of safety resources at the level of the contract may be an effective approach to injury prevention. Interventions focused on high-risk contracts, including those with considerable overtime work, contracts held by special trades contractors (SIC 17), and contracts belonging to small and mid-sized companies, and on high-risk workers, such as those new to a construction site or new to a contract may reduce injury burden on large construction sites. The joint occurrence of minor and major injuries on a contract level suggests that surveillance of minor injuries may be useful in identifying opportunities for prevention of major injuries.

Potential Implications to Contractor Prequalification- Results of the Denver International Airport contractor safety study provide some insights on possible predictors of serious injuries that may be used in the design of a contractor prequalification program targeting fatality and serious injury prevention. These potential predictors include:

- contractor company size (large contractors have fewer serious events compared to small and mid-size contractor companies),
- contractor intervention methods for high risk workers (contractors with robust orientation, training, buddy-systems, etc. for those workers new to the job site had fewer serious events).

In addition, host companies may want to carefully scrutinize specialized contractor safety programs, as this group had higher serious injury rates. Also, the study determined that contractors experiencing multiple minor injuries among their workforces were four times more likely to have a lost time injury.

Construction Industry Studies

Findley et al. (2004) surveyed 305 member companies of the Tennessee Chapter of the Associated General Contractors of America (AGC) to identify safety programs, plans and processes commonly used within the construction industry and to determine if they improve safety performance. The authors reported that the following significant factors were related to safety performance and EMR:

- Company Size. 68% of small companies (< 50 employees) reported an EMR less than 1.0, compared to 85% of medium size companies (51 to 100 employees) and 95% of large companies.
- Full Time Safety Manager,
- Clearly defined safety roles and responsibilities,
- Drug testing,
- Pre-job safety briefs, and
- Attendance at Industry Group (AGC) safety conferences.

Findley et al. (2004) also reviewed and reported on similar studies in the construction industry, by Liska and Goodloe, Jaselskis and Meridian:

Liska and Goodloe (1993) identified seven program elements among construction contracting companies that contributed to a reduction in recordable incidence rates of more than 50% and lost workday case rate of more than 65%. In their study, the authors attributed the 10,000 fewer injuries and estimated $350 million savings to implementation of the Construction Industry Institute's Zero Accident Culture Program which contains the following elements:

- top management commitment,
- safety pre-project and pre-task planning,
- safety orientation and training programs,
- managing contractor safety,
- accident/incident investigation and reporting,
- alcohol and substance abuse programs, and
- written safety incentive programs

Jaselskis et al. (1996) identified strategies for improving safety performance based on a survey of 48 construction companies. Their research found significant relationships between safety performance and several company and project-specific factors. Improved safety performance and EMRs were related to:

- upper management support of the safety coordinator,
- time devoted to safety by the safety coordinator,
- number of inspections conducted by the safety coordinator,
- safety training and meetings with field representatives and craft workers,
- company safety expenditures,

- written drug and alcohol prevention program, and
- length and detail of the company's written safety program.

Meridian Research Group (1994) found support for implementation of safety management system elements as essential for successful programs in construction. Management system elements associated with the more successful safety programs included:

- management commitment,
- employee involvement,
- hazard analysis,
- hazard prevention and control, and
- safety training.

Potential Implications to Contractor Prequalification- The construction industry study results, while not specific to fatalities and serious injuries, provide valuable insights on potential predictors for inclusion in the design of a contractor prequalification program targeting fatality and serious injury prevention. Specific factors are as listed above. Of particular note are common findings about the importance of pre-job/pre-task planning, top management support, safety training, drug and alcohol testing and existence of safety management system.

Conclusions / Suggested Next Steps

This literature review has discussed a number of useful studies that reveal potential predictors of fatalities and serious injuries. Taken together with the University of Utah report, this information can form the basis for developing a robust draft model program for contractor prequalification that effectively targets fatalities and serious injuries. Following pilot testing, a draft model could then be finalized and shared with the host employers and contractors to improve worker protection.

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