FINAL PROGRESS REPORT

Surveillance Research Methods in Construction Injury

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List of Abbreviations

BLS	Bureau of Labor Statistics
DIA	Denver International Airport
GC	General Contractor
ICD-9	International Classification of Diseases, version 9
LWT	Lost Work Time
OSHA	Occupational Safety and Health Administration (part of the federal Department of Labor
RC 1	Research Complex 1
ROCIP	Rolling Owner Controlled Insurance Program
SIC	Standard Industrial Classification
UCHSC	University of Colorado Health Sciences Center
WC	Workers' Compensation

Abstract

Problem
To identify and examine several approaches to injury surveillance on a commercial construction site.

Approach
A prospective study of the hazards and injuries associated with construction on a large commercial construction project — a two-building biomedical research complex — was designed both to examine aspects of the epidemiology of construction injury and to develop and evaluate new methods for acquiring information about exposures and factors contributing to construction injury.

1. Safety professionals prospectively interviewed all consenting injured workers, using a worker interview form developed for the study. The form included free text descriptions of the injury circumstances, as well as standard questions asked about all injuries and specific questions developed for the most common types of injuries among workers. Ninety percent of workers injured during our time on site were interviewed. Once the interview was completed, the safety professional who conducted the interview circled all factors shown in an adapted version of Haddon's Matrix that contributed to the injury. The factors so identified were compared with factors identified from the free text description by a trained layperson and with factors identified by the layperson based on injury descriptions from Workers' Compensation claims.

2. Two types of site assessments were used to collect information about hazards on this site. First, the owner mandated a periodic full site walk around by a representative of the safety staff in order to identify, ameliorate, and track hazards. In addition, as part of the research project, we developed a task-specific hazard identification procedure to identify hazards associated with particular tasks, note the degree of protection afforded the workers, and make comments. A total of 105 walk throughs and 49 task-based walk-throughs were performed, approximately two per week.

3. To understand best safety practices, eight focus groups were held with a total of 62 participants, and key informant interviews were conducted with nineteen people representing a variety of roles in the overall project. These data were analyzed using QSR N5(6), a qualitative analysis program, to identify issues and themes related to elements of the safety program, employee group, and exposures.

Highlights/Significant Findings
1. The accuracy and completeness of gathering information about the conditions and factors contributing to injury depends on the source of data and the training of the person identifying and coding the data. Trained safety professionals using interview data gather more complete and accurate information about factors contributing to injury than either a trained layperson or workers' compensation files. Further exploration of how to collect such information in an economic way is suggested.

2. Walking through construction sites to assess injury hazards is problematic; depending on construction schedules to locate areas in which work is occurring may not be the best way to find

workers and hazards. There may be other ways to accomplish hazard surveillance, but they should be tested. Any such test should include every-day surveillance of every part of the construction site.

3. Management (general contractor) emphasis on safety through enforced policies that apply to all contractors and workers on site can result in a safe construction site. The manner in which policies are stated, reinforced and enforced is likely to affect their success.

Translation of Findings

The first two significant findings above are indicators of further study and suggest that the interventions we investigated are not ready for translation into safety practice. The third finding suggests best practices for general contractors (GC) for injury prevention. It was impossible to decompose the best practices employed by this GC to determine which specific practices influenced safety, but the package of prevention efforts described below appeared to result in an exceptionally safe construction site. Adoption of these practices would require GC emphasis on safety, followed up with enforcement and frequent review of site safety—a relatively inexpensive effort, but one that requires regular evaluation of injuries and safety practices on site.

Outcomes and Relevance

Recently, there has been much interest in finding the best ways to catalogue and analyze the factors that contribute to injury (Bentley, 2006, Bondy, 2005, Lincoln, 2004). We compared coding of injury information collected by two different means as well as coding of such information by two different coders with different levels of training from the same source. We found that both the source of information and the training of the coder are important in identifying conditions and factors leading to injury. A safety professional is more likely than is a trained layperson to recognize factors that could lead to injury; interviews are likely to elicit more numerous factors than are workers' compensation reports. These finding are based on a small number of injuries and interviews. Ours was a small-scale project that should be expanded upon with a larger database to determine whether our findings hold up. If they do, the implications for preventing injury are important, because meaningful prevention depends on the accuracy and completeness of the data available to identify factors that contribute to injury.

Surveillance of construction sites by walking through them and noting hazards is fraught with difficulty, if the site we examined is typical. Once the building was enclosed, it was not possible to identify areas of the site where work was occurring based on the work schedule. Often, the inspectors had to search for workers. Moreover, none of the injuries occurred near areas that were examined for hazards. Our conclusion, described in more detail below, was that it might be useful to perform these hazard surveillance activities if the inspector walked through every part of the building site every day. This would be a full-time job for a single person, and it isn't clear that it will yield much useful information. One thing is clear, a once-a-week walk-through is not enough.

The exceptionally low injury rate we observed at the Fitzsimons research complex construction project has a number of implications for prevention of construction injuries. First, the project demonstrates that safety can be a management and worker priority on complex construction sites, and efforts to reduce serious events, in particular, can be effective.

Highlights/Significant Findings

1. The accuracy and completeness of gathering information about the conditions and factors contributing to injury depends on the source of data and the training of the person identifying and coding the data. Trained safety professionals using interview data gather more complete and accurate information about factors contributing to injury than either a trained layperson or workers' compensation files. Further exploration of how to collect such information in an economic way is suggested.

2. Walking through construction sites to assess injury hazards is problematic; depending on construction schedules to locate areas in which work is occurring may not be the best way to find workers and hazards. There may be other ways to accomplish hazard surveillance, but they should be tested. Any such test should include every-day surveillance of every part of the construction site.

3. Management (general contractor) emphasis on safety through enforced policies that apply to all contractors and workers on site can result in a safe construction site. The manner in which policies are stated, reinforced and enforced is likely to affect their success.

Translation of Findings

This project's principal focus was testing injury surveillance methods for their usefulness in identifying hazards and providing enough information about them to inform development of injury prevention programs. First, we developed an instrument for interviewing injured workers about the nature of their injury, their activities at the time of injury and other circumstances surrounding their injuries. We then compared the information gathered in this way with information appearing on workers' compensation injury reports. We also compared coding and identification of factors contributing to injury from worker interviews, for two different coders, a safety professional and a trained layperson. We found sharp differences in both comparisons, especially with respect to the number of factors recognized as contributing to injury. We also found some differences in content. Given previous research into this area and the view that thorough assessment of the factors leading to injury is an important avenue for developing prevention measures, it is important that assessment methods be practical for those interested in pursuing them. Clearly, the presence of injury factors is more fully recognized by a safety professional than a lay coder. But the methods we have tested here are expensive, particularly with the participation of a safety professional in the process. We recommend that less expensive ways of assessing contributing factors be tested: intensive training by safety professionals of WC insurance company staff who read and enter injury reports, redesign of injury reports to more fully capture circumstances surrounding injury, and more extensive training of those who complete reports or investigate injury events.

The methods we originally proposed for identifying worksite hazards, i.e., use by safety professionals of a standardized hazard identification instrument to catalogue existing hazards and assess the degree to which they were protected against on a once-a-week walk-through schedule, were not adequate for the purpose we envisioned. We developed a hazard identification instrument that, after several rounds of testing, worked well in accomplishing its purpose. But a once-a-week walk-through of the site by safety professionals did not appear to be enough to identify hazards, in part because, once a building is enclosed, individual construction activities are rapidly completed, and hazards change. (In practice, safety professionals walked through the site an average of twice a week.) Moreover, we planned to use the construction schedule to tell us where work was being performed so that we could assess hazards in those areas. The work schedule was rarely accurate in identifying the place in which work was occurring and/or the type of work occurring. Also, since injuries on the site were relatively rare events, we were not able to find an injury occurring where or at the time when hazard identification took place. We believe that the type of hazard assessment we envisioned is extremely difficult. While performing the assessment itself is straightforward (although inter-rater reliability may be a problem), the frequency with which it should be done is not known. Moreover, the area of the site to be covered in order to do a thorough job of assessment is not known. Should a test of a similar method of hazard assessment be contemplated by researchers, we would suggest that safety professionals walk through the entire site every day to overcome some of the problems we identified in our approach.

Because the site we were working on was very safe—an overall injury rate of 11 per 200,000 hours of work and only 1 per 200,000 in lost-work-time injuries—we were unable to perform the originally planned rate-based analysis because of small numbers and resultant unstable injury rates. We were, however, able to thoroughly assess the safety practices of the general contractor and subcontractors on this site. We did this through a combination of focus groups and interviews. Our conclusions were that top-down emphasis on safety, fully expressed safety policies, and policy enforcement were important to the safety of the site. We also found, somewhat surprisingly, that a commonly acknowledged sequence for changing behavior, a linear pathway from knowledge of risk, to attitude change, to practice, that is included in the Health Belief Model (Strecher, 1997) and the Social Cognitive Model (Baranowski, 1997) was not always the path taken by workers on this site. We found elements of both of these models of behavior on this construction site, but they did not always operate in a linear fashion. In fact, this was a much more circular process. For example, behavior was sometimes driven by an enforced policy, with attitudes changing as habits were developed. Instead of the sequence of knowledge, attitude, practice, the process was sometimes practice, attitude, knowledge or practice, knowledge, attitude.

While we believe that the findings with respect to safety practices on this construction site are very informative, we had no way to decompose them into their individual elements and assess which of these were effective and which were not. To translate our findings into practice, the entire safety package seen on this project would have to be adopted. While finding the individual practices most likely to be effective is desirable, it is unlikely that it would be possible, given the nature of the construction industry, differences between types of projects, and different management styles and priorities.

Outcomes and Relevance

Recently, there has been much interest in finding the best ways to catalogue and analyze the factors that contribute to injury (Bentley et al., 2006, Bondy et al., 2005, Lincoln et al., 2004). To further knowledge in this area, we compared coding of injury information from the same source collected by two different means as well as coding of such information by two different coders with different levels of training. We found that both the source of information and the training of the coder are important in identifying conditions and factors leading to injury. A safety professional is more likely than is a trained layperson to recognize factors that could lead to injury; interviews are likely to elicit more numerous factors than are workers' compensation reports. These findings are based on a small number of injuries and interviews. Implications of these findings are that some sources of data on injury etiology are more reliable than others. Ours was a small-scale project that should be expanded upon with a larger database to determine whether our findings hold up. If they do, the implications for preventing injury are important, because meaningful prevention depends on the accuracy and completeness of the data available to identify factors that contribute to injury.

Surveillance of construction sites by walking through them and noting hazards is fraught with difficulty, if the site we examined is typical. Once the building was enclosed, it was not possible to identify areas of the site where work was occurring based on the work schedule. Often, the inspectors had to search for workers. Moreover, none of the injuries occurred near areas that were examined for hazards. Our conclusion, described in more detail below, was that it might be useful to perform these hazard surveillance activities if the inspector walked through every part of the building site every day. This would be a full-time job for a single person, and it isn't clear that it will yield much useful information. Again, it may be useful to evaluate the effectiveness of the type of hazard surveillance we used in a situation in which it is possible to visit every point at which work is occurring every day. One thing is clear, a once- (or twice) a-week walk-through is not enough.

The exceptionally low injury rate we observed at the Fitzsimons research complex construction project has a number of implications for prevention of construction injuries. First, the project demonstrates that safety can be a management and worker priority on complex construction sites, and efforts to reduce serious events, in particular, can be effective. There are specific tasks that must be performed and behaviors that must be practiced for construction workers to be safe. For example, poor housekeeping is responsible for many construction injuries, but it often not attended to adequately. There was ongoing attention to housekeeping on this site, and it was viewed as a shared responsibility. In our qualitative research, we found that sometimes workers complained about being expected to clean up, but they also reported that they appreciated the clean site, found it a safer environment than most projects in which to work as well as a more enjoyable one.

Other safety issues are often approached through training of workers. Despite the rhetoric on 'empowerment through training' there are examples where training falls short of empowerment. Apprentice carpenters report knowledge of fall protection/prevention but fail to use equipment and practices they have been taught in school because they are not the norm on the sites where they work (Lipscomb, 2003; Evanoff, 2006).

There is a growing body of literature documenting the failure of OSHA logs to capture the burden of workplace injury and illness due to the failure of employers to record as well as the failure of workers to report (Rosenman, 2006; Shannon, 2003; Pransky, 1999); this is not limited to construction workers.

On this project, one of the most enlightening descriptions of the essentials of a good safety program came from a safety coordinator for the general contractor (GC) on this project who listed the following elements --communication, cooperation, and trust. Without these in place other efforts, including planning, training, mandated policies, injury surveillance, and even provision of occupational health services, can fall short.

There was a top down commitment to safety that was communicated clearly and diffused throughout the site. There was also a very clear mandate that injuries that occurred were to be reported. Incentives were given for safety performance, not under-reporting.

The widespread accountability for safety on site was likely responsible for a change in behavior sometimes seen prior to a change in attitude and would indicate that expressed policy backed up by enforcement can change workers' behavior. We do not mean to give the impression that things always worked well on site or that policy was always attended to. There were tensions at times among the array of safety people on site. But, the process was always viewed as an iterative one, and we believe this was key to the safety of the site. It was important that the project start on the right foot, so to speak, but attention to safety was an ongoing process.

The definitions of safety culture and safety climate remain a source of controversy (Guldenmund, 2000). However, regardless of semantics, many of our observations are consistent with principles that others have described as key for an environment that fosters workplace safety (Hale, 2000). These include:

- a commitment to safety as a process that starts at the top;
- the sanctioning and rewarding of safe behaviors even if they cost time, money, and resources;
- continuous reflection on how the organization is going to manage risk ('if you think you have the perfect safety program, you do not');
- resources to manage risk (people, equipment, procedures) including assurance of competence of people for required responsibilities;
- "social and organizational mechanisms for structuring and limiting blame, so that uncertainty about it will not limit reporting and learning" (Hale, 2000) from events that do occur, including looking beyond individual behavior for solutions;
- open communication that includes talking openly about failures that are experienced; and
- "caring trust" among parties that each will do their work, but "that each needs a watchful eye and helping hand to cope with the inevitable slips and blunders which can always be made" (Hale, 2000).

Scientific Report

Background:

Construction risk and challenges to study

The construction industry is among the most hazardous of all industries, as measured by work-related mortality, injury rates and workers' compensation payments (Kisner and Fosbroke, 1994; Culver et al., 1993, Ringen and Seegal, 1995; Bureau of Labor Statistics, 2000). The hazards associated with construction injury are difficult to identify, for a number of reasons closely associated with the way construction work is performed. Not only does the work location for any group of workers often change, but any single work location evolves constantly as construction proceeds, changing the hazards workers face week by week. Even compensation data on construction injuries are difficult to assemble, since the multiple contractors on any single site often have different workers' compensation carriers. Much of the data usually collected on a construction project is collected for purposes other than research, purposes such as insurance claims payment or determination of legal liability; such data may not be adequate for the purpose of epidemiologic investigation that leads to concrete prevention recommendations.

Despite considerable effort and progress, occupational health surveillance remains fragmented in the United States. A number of different surveillance methods have been used, ranging from case-based approaches such as the Sentinel Event Notification system for Occupational Risk (SENSOR) and Fatality Assessment Control and Evaluation (FACE), both NIOSH-sponsored endeavors, to rate-based approaches such as the surveys conducted by the Bureau of Labor Statistics that use aggregate assessments of time at risk.

Accurate national and state-wide surveillance data can be very useful, but more targeted surveillance methods that can be used by companies, unions, insurers and industries are also needed. An international epidemiology workshop in 1996 included these recommendations for work-related injury surveillance systems: " 1) more widespread inclusion of narrative text in databases, analyses of which can be a valuable supplement to coded data; 2) increased use of data set linkage to combine injury information and work-history data; and 3) the development of comprehensive company-wide surveillance systems to expedite the use of epidemiologic data for occupational injury prevention activities" (Sorock et al.,1997). These recommendations may be particularly relevant in construction. Injury and hazard surveillance can be very challenging for this industry and quite different from surveillance in manufacturing settings where there is a defined and easily enumerated workforce with relatively static work conditions and exposures. A number of investigators have used workers' compensation data for occupational injury surveillance (Webster and Snook, 1997; Park et al., 1992), and we have previously described a cohort approach to occupational injury surveillance using combined data sources to identify personal time at risk and work injury events (Lipscomb et al., 1996). This technique provides information on large cohorts of workers and allows rate calculations to be made to help define risk based on hours of work. Because of difficulties in obtaining data to define a cohort and their hours worked, the need to allow adequate time for cases to be entered into a database such as that of a state compensation system, and the time required for merging these complex databases, these data are often not available until several years after events occurred. Moreover, analyses of workers' compensation data do not usually provide adequate information to support making specific prevention recommendations (Lipscomb et al., 1999; Lipscomb et al., 2000).

We had an opportunity to prospectively study the hazards and injuries associated with construction on a large commercial construction project owned by the University of Colorado Health Sciences Center (UCHSC)—a two-building biomedical research complex (RC-1) on the newly acquired Fitzsimons Medical Campus. The workers' compensation (WC) insurance arrangement for this project, a Rolling Owner-Controlled Insurance Program (ROCIP), provided for a single WC carrier for all contractors on site, obviating the need to collect injury data from a large number of carriers. The ROCIP is controlled by the owner, the University of Colorado, which provided us access to WC data through its insurance broker and project insurer.

Specific Aims:

- Define and track a dynamic cohort of commercial construction workers and their work exposures, including time at risk, at an ongoing commercial construction project.

- Develop methods to conduct active surveillance on a commercial construction site to include the prospective reporting and standard investigation of injuries.

- Record the changing hazards on commercial construction sites through weekly project walk-throughs and written and photographic documentation, as well as regular focus groups with workers, contractors and safety personnel. Items to be recorded will include factors related to work organization, such as staging of materials, work schedules, presence of multiple trade groups working simultaneously on site, language and cultural barriers, and known hazards such as work occurring at heights, manual materials handling, use of power equipment, and so forth.

- Analyze workers' compensation data, including payments for medical care, indemnity, and impairment, to assess severity of injury.

- Conduct rate-based and case-based analyses to determine relationships between injury rates and risk factors, including exposures. These will include, but not be limited to, analyses by mechanism of injury, trade, work domain or stage of construction, number of different trade groups on site, amount of overtime work, and exposure to documented hazards.
  Addition to this specific aim: Compare identification of factors contributing to injury : (1) between two coders, one a safety professional and one a trained layperson, both of whom determined factors from completed interviews with injured workers and (2) by a single coder from two sources: worker interview and workers' compensation reports for the workers who were interviewed.

- Test hypotheses about worker-specific risk factors and usefulness of the work hazard measures we will employ.

- Assess the usefulness of the combination of active and passive surveillance methods we develop as well as the usefulness of each of the methods separately.

- Describe best practices on an unusually safe construction site. (This aim was added after the project was underway.)

Several things hampered our ability to achieve all of our specific aims. First, and probably unavoidably, negotiating permission to perform the study with both the owner, the University of Colorado Health Sciences Center, and the general contractor, Hensel-Phelps, was time-consuming and continued into the period during which construction of the research complex began. We felt that it was important that this be complete before submitting our grant proposal. Once the proposal was submitted, NIOSH review was time-consuming, probably also unavoidable. But once the study was approved, we received funding nearly 3 months after the start date. We prepared as best we could during this delay but, of course, we were limited by the fact that funding was not in place. By the time funding had arrived and we were able to begin work in earnest, construction of the research complex buildings was well past site preparation, and in fact, the foundation was in place and steel framing nearly complete.

In addition to these delays in getting our research team onto the site and actively conducting surveillance, the number of injuries occurring during construction was much lower than we had anticipated—about one-fifth the number projected. While this was obviously extremely positive from the point of view of safety and of the workers and contractors, it did not allow for the rate-based analyses we had proposed. The number of injuries was simply too small to allow for stability in the rates we might calculate. As we realized that this was an unusually safe construction site, we added a specific aim to assess and describe the safety practices of both the owner (University) and the general contractor (Hensel-Phelps) in order to develop a best practices analysis.

Procedures and Methods

Cohort Identification and Time at Risk (Specific Aim 1)

In order to fulfill one of our aims, to assess time at risk we obtained aggregate payroll amounts for each of 97 contractors on site by month. We had expected to get weekly reports of certified payroll for individual workers. "Certified payroll" means that each worker is listed, along with his/her job classification, the number of hours worked each day, and the pay earned. We found that the certified payroll reports at this site numbered in the tens of thousands; the different companies used different report formats; and they reported different items. Moreover, most reports did not identify overtime hours. Since companies differed in their specification of work week and overtime, e.g., the regular work week for some contractors consisted of four 10-hour days, while for others it was five 8-hour days, there was no way to determine overtime hours from these reports. We did ask owner representatives about whether they were aware of overtime work. Their perception was that overtime was not common until the last few months of the project, but they had no way to document that. In any case, it was clear that we were overoptimistic in our assessment that we would be able to collate and analyze such a large volume of data. The general contractor had collected gross hours worked, however, and we were able to use this for our estimate of time at risk.

Reporting and investigation of injuries (Specific Aim 2)

All injuries, regardless of whether they seemed minor, were reported. When a worker was injured, (s)he was required to go to a single designated medical provider, unless the injury was an emergency. The safety office was supposed to be contacted as soon as an injury occurred. At this point, a safety professional would go to the site of the injury, collect information about it, and assure that a workers' compensation claim was filed and that the contractor began an investigation of its own. In reality, however, the safety office was not always contacted immediately; sometimes it was hours after the injury occurred before the safety program was notified and sometimes it was the next day. More serious injuries were likely to be reported immediately, however.

We collected detailed information about injuries using the existing safety infrastructure. The safety personnel who would ordinarily respond to a reported injury collected, in addition to the information they usually collect, specific information necessary to the proposed study. Based on our experience with written reports of construction injury at Denver International Airport (DIA), we determined that a prospective study in which a trained investigator asked standardized questions at the time of injury would yield more complete and consistent, and probably more accurate, information regarding the factors contributing to injury. This approach avoids the problem of workers or witnesses forgetting certain attributes of the injury, the work site or other factors that are sometimes neglected in the standard written injury reports now used.

An early task in this project was the development of this worker interview form. Our previous experience identified gaps in the information available from workers' compensation data as well as in injury investigation forms that were used at DIA, underscoring the need to test questions and review possible ambiguous responses. In the form we developed, both coded and free text descriptions of the injury circumstances were recorded. Information collected on each injury included a brief text description of the circumstances surrounding the injury, site conditions, stage of construction, contributing factors, involvement of other workers and their trades, proximity of workers in different chains of command, tools and materials involved, among other items. Specific questions were developed for the most common types of injuries among workers, including overexertion injuries, falls and injuries resulting from the worker being struck. Investigators were prompted to complete relevant sections in a manner analogous to computerized work-related exposure assessments developed by the National Cancer Institute for other occupational epidemiology studies (Stewart, 1994). All questionnaires were available in English and Spanish. The tools were pre-tested initially in mock investigations and then in injury investigations on site. After testing, the tools were modified before final use. Once the interview form was finalized, safety managers at the Fitzsimons construction site interviewed those injured workers who agreed to be interviewed. An outcome of the delay in getting on site is that fewer than half of all injured workers were interviewed. A copy of the interview form appears in the Appendix.

The investigators were trained to approach the investigation of these injuries from the conceptual model of Haddon's Matrix (Robertson, 1992). This heuristic model guides attention to human, environmental, and organizational factors that may have contributed to an injury at pre-event, event, and post-event stages. It also focuses attention on multiple paths where energy transfer could be altered to prevent or decrease injury (Hagberg et al., 1997). Once the interview was completed, the safety professional who conducted the interview circled all factors shown in our adapted Haddon's Matrix that contributed to the injury. He was not constrained by the factors shown in the matrix and could add factors identified in the interview. Then, for each contributing factor, he wrote a brief explanation of the rationale for including that factor.

If the injury rates we had found at DIA and among Washington carpenters had held true, there would have been approximately 525 injuries for investigation and analysis. In contrast, we observed a total of 109 injuries of which only 11 resulted in lost time. The small number of injuries occurring at this project may have resulted not only from the organized project safety infrastructure, but also from the fact that there was one general contractor (as compared with numerous prime contractors at DIA) with its own well developed safety program that involved all major subcontractors. Also, according to the project owner, the general contractor has a reputation for considering safety to be very important and being diligent in maintaining a safe work site.

The small number of injuries occurring at this project also limited planned hypothesis testing but provided an opportunity for us to learn more about site safety and document best practices. We also felt that the planned case-based surveillance analyses would still be enlightening and could provide an opportunity to explore site safety in more depth as described below.

Hazard surveillance and documentation of best practices (Specific Aim 3 and added Aim 8)

Hazard surveillance on this site was designed to be accomplished in large part through the use of a combination of semi-quantitative and qualitative methods. The goal was to collect task-based hazard information as well as information on more global hazards associated with work on this large construction project. The scheduling software used for project management (RC1) was to be used to identify specific tasks underway and the exact location of the work (3rd floor North tower, for example) as the project progressed. The information about the location of work was to be used to target our planned walk-through hazard surveillance.

Focus groups were planned to explore issues related to work organization as well as direct physical exposures at different stages of construction. Because of our late access to the site we were unable to utilize planned methods to assess exposure prospectively. In light of the low rates of injury when we accessed the site, much of the focus shifted to understanding the safety environment on site, the control of hazards and the documentation of best practices.

<u>Guided Site Walk-Throughs</u>

Two types of site assessments were used to collect information about hazards on this site. The first began as part of the ROCIP safety efforts and involved a periodic full site walk around by a representative of the safety staff. This was designed to identify both hazards that might be task specific (such as work at height; crane operations etc) and those that might have more general effects (like housekeeping, lighting in stairwells, guardrails, trip hazards, slip hazards).

In addition, as part of the research project, we developed a task-specific hazard identification procedure. We had hoped that the process would allow us to add documentation to work scheduling that would identify potential hazards associated with each task, in addition to identifying how the hazards were controlled on this site and how they might be still better protected against. The task-based assessment focused on the following specific hazards: slip/trip hazards, fall hazard from > 6 feet, fall hazard from < 6 feet, contact with electrical distribution, use of electrical equipment or tools, mechanical impact hazards, vehicles, cut/impale hazards, manual materials handling, work requiring awkward postures, trenching/excavation, steel erection, leading edge work, and weather that created a task hazard. The person doing the assessment was to identify hazards associated with the task they were observing, note the degree of protection afforded the workers, and make comments. [See form and guidelines in Appendix.] We recognized that it was not feasible to conduct task-based assessments for every task. We hoped through weekly assessments to gain a representative appraisal of hazards encountered by workers.

<u>Focus groups</u>

The on-site ROCIP safety manager recruited focus group participants with posted flyers announcing the groups and through direct communication with workers and supervisors. To make it convenient for workers, we held the focus groups at the ROCIP office conference room. Groups began at the end of the work day and participants received a $25 incentive. Two focus groups were conducted by a native Spanish speaker for workers who spoke only Spanish. These focus groups were transcribed in Spanish and translated into English by a native Spanish speaker.

We asked participants to keep the focus group discussion confidential and not reveal the names of other group members or content discussed in the group. To reduce the risk of the loss of confidentiality, participants used numbers instead of names. Before the focus group began, all participants signed a consent form approved by the University of Colorado Health Sciences Center Institutional Review Board.

Key informant interviews

Although not planned as part of the original project design, we also decided to collect information through a series of key informant interviews with owners, insurers, representatives of the General Contractor (GC), sub-contractors and workers. As opposed to the collective nature of information gleaned in the focus groups, these provided the opportunity to ask one or two individuals at a time about their perceptions of safety on site.

We interviewed individuals involved with project administration at the University and ROCIP, representatives of the GC, safety staff hired through the ROCIP, safety personnel of major sub-contractors, senior level foremen and one worker (N=19). Individual interviews enabled us to gather detailed information on company safety policy and implementation, management safety concerns, the range of motivations for supporting safety programs, project history and other issues. These interviews provided another means of corroborating data.

For convenience and privacy these interviews were typically conducted in private offices or conference rooms. To preserve confidentiality we refer to our respondents by broad job title only. Interviews lasted an average of an hour and were audio-taped and transcribed verbatim. Informants did not receive any incentive.

Structure of interviews and focus groups

For both interviews and focus groups we used semi-structured discussion guides. Areas covered included: safety training received on and off the site; understanding of the roles of different safety personnel; how the safety culture of the site was developed and maintained; how and if people worked together to ensure safety; issues of communication due to workers speaking different languages (usually Spanish) and the effect on safety; housekeeping; and workers' and management's view of random drug testing as a means of ensuring worker safety. This was a guide, not a questionnaire, and we allowed participants to discuss topics in the order they were raised: we did not attempt to impose the order of the discussion guide.

We developed an outline of topics we wanted to explore to improve our understanding of safety on the site. This approach is termed "prestructured case" by Miles and Huberman (1994). Unlike a grounded theory approach, where the aim is to develop theories from the data and test them using the constant comparison method, the pre-structured case can be used when researchers have a conceptual framework, the questions are reasonably well defined, and the sampling plan established (Miles and Huberman, 1994).

Other qualitative data

In addition to the above methods, a number of observations were made on site. For example, we observed the ROCIP worker orientation program for English speaking and for Spanish speaking workers that is part of the badging process for the site. We sat in on several monthly safety meetings held with a variety of parties involved in the ROCIP including the owner (in this case the university), representatives from the GC and major sub contractors, safety personnel, insurance carriers, etc. These meetings provided a regular forum to discuss upcoming work plans and associated safety issues, worker injuries including circumstances and return to work, and a variety of other issues on the site. When we were not present, minutes of the monthly meetings were made available to us. We also were able to observe site walk-throughs on six occasions and two safety walks with safety representatives from sub-contractors on site at the time. All of these observations provided corroboration of what participants say they do and what takes place on the worksite. Combined with the interviews and focus groups, the observations provided a means of checking the accuracy of our data and collection methods.

Analyses of qualitative data streams
We entered the data into QSR N5(6), a qualitative analysis program. The discussion guides provided the basic coding categories, and we reviewed the data to identify other issues or themes that our preliminary code structure did not include. We defined each code and used a text analysis approach to assign codes to passages, called text units, of the interviews and focus groups. We categorized employees as Management/Administrative, Professional Safety Staff, General Contractor employees and sub-contractor employees so we could investigate variation by employee role and affiliation. The categories were not mutually exclusive. For example, a person could be on the Professional Safety Staff and be an employee of the GC. We assigned codes to focus groups by which type of employee predominated. With N5, we were able to compare different employee groups with respect to how they acted on safety policy and possible differences between GC employees and sub-contractor employees. We could also compare the rhetoric on safety from managers with that of workers.. Finally, we used the Haddon Matrix as a conceptual framework to describe varied elements of the safety program on this site.

Analyze workers' compensation data, including payments for medical care, indemnity, and impairment, to assess severity of injury.
Conduct rate-based and case-based analyses to determine relationships between injury rates and risk factors, including exposures. These will include, but not be limited to, analyses by mechanism of injury, trade, work domain or stage of construction, number of different trade groups on site, amount of overtime work, and exposure to documented hazards. (Specific Aims 4 and 5)
Added to this Specific Aim: Compare factors identified as contributing to injury: (1) between two coders, one a safety professional and one a trained layperson, both of whom determined factors from completed interviews with injured workers and (2) by a single coder from two sources: worker interview and workers' compensation reports for the workers who were interviewed.

Rate-based Analyses. Only aggregate data on hours by contractor by month were available through records, so personal event histories could not be created for our rate-based analyses. However, in light of the low number of events, it is unlikely that we would have been able to utilize more detailed event histories for robust multivariate analyses, had they been available. Overall rates and lost time injury rates, defined as any work time lost in excess of three work shifts, were calculated per 200,000 hours worked; confidence intervals were calculated assuming a Poisson distribution. These rates were compared with rates estimated in the building of the Denver International Airport (1990-1994) (Glazner et al. 1998) and Bureau of Labor Statistics data for SIC codes 15, 16, and 17 (2002). [See Tables below]

Comparisons of coders and data sources.

We made an addition to specific aim 5 when we observed that the worker interviews were yielding much more information than we had noted in our analysis of factors contributing to injury based on injury reports in our studies of DIA. Other researchers in this area (Lincoln et al., 2004, Bentley et al., 2006) had identified factors contributing to injury based on detailed interviews. They did not, however, compare the information they gathered with information that could be gathered retrospectively based on injury reports. Such a comparison would be helpful in guiding injury researchers with respect to the adequacy of different methods.

To accomplish this, we manually compared the factors noted in Haddon's matrix by the safety professional who interviewed injured workers with those retrospectively identified by a trained layperson who based factor identification on the information contained in the interviews. We also compared factors identified by the layperson from the interviews with those she identified from workers' compensation reports for the same injury.

Hypothesis Testing (Specific Aim 6)

We described several hypotheses we planned to test in order to explore the usefulness of both the information available from construction sites and the surveillance tools we used. Because we expected to have information about worker-specific time on site from certified payroll, we planned to explore associations that have heretofore been difficult to analyze in construction injury studies. The hypotheses for which we expected to have adequate numbers or data to support analysis are described below.

Hypothesis 1: A high hazard index score (indicating a high level of hazard) determined by the site hazard index (determined by the site walk-through) is associated with high overall injury rates and with high rates of falls.

Injuries on this site were rare and were not concentrated in any particular stage of construction. We were therefore unable to calculate stable rates.

Hypothesis 2. Injury rates are higher for workers who are working proximate to other workers from a different contractor (i.e., in a different chain of command) than for those who are not.

The small number of injuries does not allow us to test this hypothesis. Other-worker involvement was noted in only 13 injuries, and information about exposures to this condition was not available.

Hypothesis 3. Overtime work of more than 20 percent is associated with higher injury rates.

In earlier work, we found high proportions of *contract-level* overtime work (20% or greater) to be associated with high injury rates relative to contracts with less than 20 percent overtime work (Lowery et al., 1998). But we were unable to investigate whether workers who work large amounts of overtime are themselves at greater risk of being involved in an injury. A finding of such a relationship would have important implications for responses to budget and time pressure on construction projects. Unfortunately, as described above, the payroll information collected on this site did not identify overtime work. So while we collected this information in our interviews of injured workers, the fact that we did not have overtime information on the entire worker population made this hypothesis impossible to test. (Only 5 workers indicated working overtime during the week prior to the injury, and only one reported working overtime on the date of injury.) It is worth noting that the owner and general contractor designed the schedule to minimize the need for overtime work.

Hypothesis 4: Spanish-speaking workers are subject to higher injury rates than are other workers.

We expected this construction project to attract a work force with a large proportion of Latino workers, many of whom speak only Spanish or mostly Spanish. This subgroup may be at greater risk of injury than other workers, for several reasons, including speaking a different language than their supervisors and therefore having difficulty understanding warnings about risks, or being assigned more hazardous work. Our only measure of this was the number of workers who attended Spanish-language safety training sessions. (Attendance at safety training was required before a worker could receive a badge to work on the site; all workers therefore attended training.) While we know the number and proportion of workers attending the Spanish-language classes—1175, or 26.8% of all workers—we were not able to calculate hours on site because of the impossibility not only of assembling detailed payroll data, as described in an early section of this report, but of matching the names of workers attending Spanish-language training with workers in the payroll files. In addition, all of the injured workers interviewed spoke English; we would therefore have had no numerator for addressing this hypothesis because workers' compensation claim data, which were available for all injured workers, do not reliably identify workers as Spanish speaking.

Results

- ***Specific Aim 1. Define and track a dynamic cohort of commercial construction workers and their work exposures, including time at risk, at an ongoing commercial construction project.***

Time at risk for all workers was approximately 1.98 million person hours, based on data supplied by the general contractor. We were unable to calculate time at risk for subgroups as a result of our inability to collect data from the thousands of certified payroll files.

- ***Specific Aim 2. Develop methods to conduct active surveillance on a commercial construction site to include the prospective reporting and standard investigation of injuries.***

This was a methodological aim. Its accomplishment is described in the procedures and methods section above. The surveillance tools we developed, a hazard assessment and an injured worker interview, appear in the Appendix.

- ***Specific Aim 3. Record the changing hazards on commercial construction sites***

through weekly project walk-throughs and written and photographic documentation, as well as regular focus groups with workers, contractors and safety personnel. Items to be recorded will include factors related to work organization, such as staging of materials, work schedules, presence of multiple trade groups working simultaneously on site, language and cultural barriers, and known hazards such as work occurring at heights, manual materials handling, use of power equipment, and so forth.

Site walk-throughs

Over the course of the project we had information from 105 site walks between May of 2003 and May of 2004, when the building was complete, but they were not collected in the same format. Review of these walk-arounds reveals the very fluid nature of construction hazards, but they provided little in the way of data that could easily be used in a quantitative manner. These walk-throughs were part of the existing safety structure and the format used changed over the course of the project.

Direct participant observation of the process by members of the research team (MAM and HJL) did reveal useful qualitative information, however. The person assessing the site, in our observation, made attempts to correct problems as they were identified. Sometimes this involved a direct action on the part of the safety person such as removing frayed extension cords from the workplace or talking with workers about ladder safety. At other times the sub-contractor responsible was notified of things that needed attention such as the addition of a guardrail to prevent struck-by events to workers below a scaffold. Notes from walk to walk were used to look for accountability in making changes.

Task-based assessments

The RC1 (software) schedule had already been modified considerably by the time we were able to access the site. Despite attempts to update the schedule from time to time, we did not find it to be a reliable source of information on what tasks would actually be found to be underway on site. Although a total of 49 task-based assessments were done between May and October, 2003, much time was wasted by investigators trying to find the exact location of each task. To try to minimize the time required just to locate task sites for the assessments, we later instructed investigators to complete task-assessments for whatever work they found. What we had thought would be a predictable method of tracking work never amounted to that.

Focus groups and key informant interviews

A series of eight focus groups were held with a total of 62 participants. The make-up of each of the groups is presented in the table below.

Focus Group	Number of participants	Participants' trades	Employer: GC or sub or both	Language
1	13	Union electricians, union pipe fitters, GC laborers	both	English 2 more comfortable speaking Spanish
2	8	GC laborers	GC	English

3	4	Carpenters, laborer, GC intern	both	English
4	6	3 carpenters, 1 laborer, 2 GC interns	both	English
5	9	Laborers	both	Spanish
6	7	3 electrical foremen, 2 carpenter foremen, 1 field engineer, 1 sheet metal foreman	subs	English
7	10	6 tile setters, 4 union electricians	subs	English
8	5	4 Tile setters, 1 laborer	sub	Spanish

We often found that participants raised issues we had in our focus group guide before they were asked specifically. This reassured us that we had captured important domains in planning.

Key informant interviews were conducted with nineteen different people representing a variety of roles in the overall project. A summary of interviews and types of participants is below.

Key Informant Interviews
1. Project Manager, sub-contractor
2. Safety Supervisor, sub-contractor
3. Project Manager, sub-contractor
4. University representative (owner)
5. ROCIP, Safety Supervisor
6. ROCIP, Safety Supervisor
7. Site Supervisor, sub-contractor
8[1]. Project manager & Site superintendent for GC
9. GC area superintendent
10. GC Safety Engineer
11. GC Safety Supervisor
12. Safety Supervisor, sub-contractor
13. Safety Supervisor, sub-contractor
14. Broker manager on site
15. Insurance safety representative
16. Broker for ROCIP
17 Tile and stone worker [2]
18. Safety consultant – for oversight

In the interviews and focus groups the message consistently was that 'safety is everyone's job'. There was agreement that establishing a site-wide safety culture had to begin with commitment from the highest level. The GC received widespread acknowledgment for putting a strong emphasis on safety and backing this up with supplying appropriate tools, realistic scheduling, training and information. Its staff was held accountable for safety and this accountability

[1] There were 2 people in this interview.
[2] This worker was interviewed because he turned up for a focus group and no one else showed up.

extended to very clear expectations that all injuries be reported. Supervisors and workers at times received incentives for safety, but it was also clear that the incentives were for running a safe site, not for under-reporting of injuries. Safety on the site was process oriented, iterative and infused into the workplace. Because of this integrated approach to safety, it is difficult to separately categorize practices as establishing, diffusing, or maintaining a safety culture; many practices may serve all three purposes.

Staff were viewed as an integral part of the safety program. The GC employed a full time professional safety manager responsible for only this site, and ROCIP had a safety professional dedicated to the site as well. Each trade foreman wore a bright green vest to announce that he or she could be asked about safety. Major sub-contractors —electricians, carpenters, metal workers – also employed someone dedicated to safety. These safety workers covered a large territory and generally came to the Fitzsimons site once or twice a week depending on the number of their workers on the site. They could also be contacted by cell phone. They performed site walks with the ROCIP safety personnel periodically.

When we interviewed members of the professional safety staff, they presented themselves as helping workers to stay safe, not as safety policemen. The majority of workers shared this view; we heard few adversarial references to safety staff. Workers noted that they felt management listened to them when they made suggestions about safety or identified a potential hazard. An electrician foreman stated:

> *Even from the older journeymen who are out there, right down to the youngest apprentice, I think that they feel that they can go talk to somebody in a yellow vest and they'll get action, whether it's just over the radio, to get the right person out there--*
>
> *Because us, as supervisors, we wear the yellow vests, and ninety percent of us have the radios the Nextel, where I could call the other craft and say, "Hey, there's a problem here," and it gets taken care of right away, instead of that apprentice not knowing what to do or who to talk to, the journeymen, same thing.*

Workers said that they felt supported by their foremen when they had to take extra time to do a job safely or had a question about appropriate safe practices. A union-electrician with 30 years of experience told us:

> *I think management on this job has made it clear, "Hey, we don't want you to hurt yourself. If you need help with something, go get help, and we're not going to hassle you if we find you walking around looking for somebody to help you. If we ask you, 'What are you doing,' 'Well, I'm going to get help for this task.'" They're not going to hassle you about it. And I think everybody's pretty much comfortable that they really mean that. And that's one of the things that contributes to this job being safer.*

The GC had safety policies which were enforced throughout the site by foremen, managers, and professional safety staff and even workers. Because of consistent enforcement, workers conformed—or they left the site. Regardless of individual workers' attitude or knowledge concerning the safety practice, the GC's rules and policies created an environment where everyone had to comply with existing safety rules. The majority of safety practices were not individual decisions, rather they were mandated. This set the stage for safety practices to exist first with changes in attitude and behavior occurring later.

Workers described safety as the norm on this site and everyone was a participant:

> *Because everybody is held accountable for safety. And if you're not, if you're not abiding by the safety rules, it's not something that somebody can just go, "Hey, forget about it." You're held accountable for your actions. You'll have ROCIP, or you'll have [GC] safety person out here. And no one wants to see anyone get hurt. And it just makes it a lot easier for people to come together and be safe when everybody's a part of it.*

Another aspect of the overall safety management was provision of occupational medicine services through a Concentra provider that was close to the site. A system was well-established for communication through an automatic email system. The ROCIP site received notification when a worker was seen, the date of service, who their employer was, the time of the visit, when they signed in, when they were checked in, and when they checked out. The ROCIP safety office was notified as to whether the injury was OSHA recordable, and the type of visit—meaning whether it was a new injury or a follow-up visit. The office also received a diagnosis, which included an ICD-9 code to one decimal place, with a description. There was also notification on this form about whether work activities were modified and whether the worker was to return for a follow-up visit. The employer is notified about restricted activities, anticipated date of maximum medical improvement. This information was also given to the worker by the Concentra provider. These reports came to the ROCIP office within one day. One of the physicians from Concentra often sat in on the ROCIP safety meetings as long as workers being discussed had not contacted an attorney regarding any litigation for the injury.

Concentra also worked with ROCIP staff to provide a modified work-duty program. A Concentra representative with an ergonomics background reviewed the work done by contractors on-site and created a matrix that could be used to identify tasks that people with work restrictions could do for each contractor. This allowed the provider at Concentra to refer to the matrix and give examples of work that person could do with restrictions. Although most of the larger contractors had modified work-duty plans spelled out in advance in terms of what people could do when they needed restricted duty, this process allowed smaller contractors on the site to create modified work-duty programs that they could take to other sites with them.

<u>One insurance company was responsible</u> for not only workers' compensation claims but all insurance on site including faulty construction claims that may come after the building is constructed. Workers on sites covered by the carrier were eligible for all of the insurance company classes/training at no cost, as long as their contractor would allow them the time.

The insurance safety person viewed the very beginning of the ROCIP process as crucial; he felt it was essential that things start off well. Policies and procedures need to be clearly spelled out, enforced and supported by management from the very start. He said this did occur on this site, and it was clear that management and the university owner were supporting the safety infra-structure. Regular, ongoing safety meetings were described as important in setting tone, and following up on issues. Sub-contractor safety walks were felt to be time well spent.

<u>Safety Program in the Conceptual Framework of Haddon's matrix</u>
We framed much of our research approach, particularly the case-based investigation of injuries, within Haddon's Matrix (Robertson, 1992). We previously found this framework useful in

identifying factors that contribute to construction injuries (Bondy et al; Glazner at al; Lipscomb et al). The matrix guides attention to human, environmental, and organizational factors that may contribute to injury at pre-event, event, and post-event stages. Below we illustrate how elements of this comprehensive safety program spanned across Haddon's Matrix. As we categorized elements of the safety program in this framework, we also were struck by the circular nature of the overall safety infrastructure on this site. Specific activities designed to protect workers, when communicated widely, became part of the overall social environment, as did enforced policies. We have not distinguished the 'Event' from the 'Pre-event' stage because we had difficulty clearly delineating these stages, as have others (Bondy, 2005).

Exhibit 1. Haddon's Matrix Modified for Use in Interviews of Injured workers on the Fitzsimons Research Complex Construction Site

	Pre-event	Event	Post event
Human	Lack of training Age Fatigue Co-worker's behavior Worker's behavior	Fatigue Heavy objects or task Failed to ask for help Co-worker's behavior Worker's behavior	Age Co-worker's behavior
Object	Equipment Materials	Equipment Tools PPE	Equipment (rescue equipment failed) PPE (if PPE actually caused injury)
Environmental	Weather conditions Lighting	Weather Debris Lighting	Weather Debris Lighting
Organizational	Availability of training Availability of equipment Materials staging; storage Speed of work Failure to train personnel (in rescue procedures)	PPE -availability; norm to use Lack of available help Time pressures Housekeeping problems	Lack of rescue plan

We provide here additional representative examples from interviews and focus groups to illustrate a number of important concepts relevant to safety on this construction site. Dissenting views are presented when they were present.

Representative quotations on creating and maintaining a safety culture

Issue	Quotations
Advance scheduling	If you've got safety in mind when you're building a schedule, you can tell it in the field. Manager for GC.
	We try to minimize our own stacking of trades, and try to keep that under a tight rein. In talking about accidents-a lot of times you'll see trades, and you'll see more accidents on other jobs when they've created a lot of stacking of trades. And everybody gets nervous, and thinks that they're going to get it done faster with putting everybody in the same box together, and pretty soon alls you have is just a messy sandbox. That creates a lot of havoc. Those are big issues for us. (Proj-Manager-large-sub)
	For something this big it's run pretty smooth, as far as us getting in there and doing what we have to do. Because a lot of the times we're always waiting. Being the finishing crew, you're always waiting on somebody. Or you're waiting on somebody, then you get in there and have to hurry because somebody's waiting on you, so, you know. (Laughs) And so far on this job, stress is low, really down. (finish worker, sub contractor)
Initial Orientation by ROCIP	It's real clear-cut. They spelled out pretty exactly what you wanted to do. So there's no question. They made it real blunt, and they didn't sugar-coat it as to what they wanted and this is what we need to do. So they did a pretty good job. It's pretty efficient. (carpenter for sub-contractor)
	Most of the time within the first day or first two days that you're here, you're in this room for ROCIP training. I think that's a good beginning. The gentlemen that do the class in that are really good--I mean, they've been around for a long time-and it carries out into the field. You know, because they're there, and they let you know that they're there. [Someone agrees] If you see something out there that's not taken care of, say, by the general [contractor] or our boss, go see them. And I've done that. (Foremen and Supervisors)
	I think also this particular site, even before you can land on that, put a foot on it, you have to take a little training course, and they kind of show you some stuff, which is really good for the kids that are starting out. So being introduced saying, "If you want safety first-" it's putting something right into the head. So I think that's kind of made the site pretty good that way, because you're starting right off the bat with safety. (union electricians and pipefitters)

	Dissent: Could be a little bit more in-depth. It was just a guy standing in front of a camera talking to you. It was a video, and there was no examples of anything, and all we heard was stories coming from this guy. You really didn't even know what he was talking about. I think you [needed] a lot more visual way of showing some examples. (worker for sub-contractor)
Creating a safety culture	I believe that really the safety culture on this job site comes predominantly from the leadership on the job site, in conjunction with the fact that, as our employees come out of school and are raised within the organization, we preach safety over and over again. (GC Project manager)
	So I mentioned to the yellow vest for the carpenters, and he said, "Oh, sorry. I'll fix that right away." It's not like, "Oh, go mind your own business" or something. Everybody's looking after everybody else, basically. (Electrician, foreman)
	It's largely a function of the contractor who's running the project. You can have safety people crawling out every window, but if you don't have a good culture with your contractor and their supervisors, you're not going to have as good a success, because it has to be the culture. And so the material we start with has a lot to do with the success of the project. (Laughs) They have different approaches, different caliber of safety program and how they implement it. (ROCIP insurance representative)
	And when it starts at the top-you know, if you're going to be supported by your managers-well, it's great. I hear other companies, I hear of them, that are not supportive at the top. And you know, when they're not, it's impossible to push safety. (GC superintendent)
	My boss has to tell me that his interest is my safety, because then it makes me concentrate a lot more on that, because I couldn't really care if the guy in the green vest's-he can't, he's not going to fire me. He might kick me off the job, but I know that my company's going to send me to another job. So the fact that my company is interested in safety makes it a lot easier to follow the rules, and maybe I do waste fifteen minutes trying to find something to make sure I'm safe. That makes it a lot easier to accept, if I know that my boss is ok with it. (sheet metal worker for large sub contractor)
	And when the top guy on the job site, running the work out there, is making those statements [about the importance of safety], it makes it much easier for the superintendents who work for [GC Project Superintendent] to be able to do that, for the foremen to be able to do that. And I believe that really the safety culture on this job site comes predominantly from the leadership on the job site, in conjunction with the fact that, as our employees come out of school and are raised within the organization, we preach safety over and over again. (GC Project Manager)

Acceptance of safety as a priority	And when it starts at the top, if you're going to be supported by your managers-well, it's great. I hear other companies that are not supportive at the top. And you know, when they're not, it's impossible to push safety. (GC area safety supervisor) But really the owner is a big one, because without the owner's support, these kinds of projects, the safety people who are on site, don't have the same authority. And so the owner has been a really strong presence, as far as giving us authority and backing us up and being available if we have questions. (Insurance official)
	That's just the way it's structured. Because everybody is held accountable for safety. And if you're not-like you said-if you're not abiding by the safety rules, it's not something that somebody can just go, "Hey, forget about it." It's-(laughs)-you're held accountable for your actions. You'll have ROCIP, you know, or you'll have Hensel-Phelps safety person out here. And no one wants to see anyone get hurt. And it just makes it a lot easier for people to come together and be safe when everybody's a part of it.
	Financially, companies can not put me at risk, or they lose. Back when they could put me at risk, they made more money, because I was doing it quicker, but I was also doing it unsafe. They were pushing me to get on the top of that six-foot ladder, and now the totally different attitude from the companies, from the top of the companies, that, "Hey, now we need to make these guys safe. We need to train them and INSIST that they are safe." Because if you're not safe, they'll let you go.(Electrician foreman, large sub-contractor, 25 yrs experience)
	I think management on this job has made it clear, "Hey, we don't want you to hurt yourself. If you need help with something, go get help, and we're not going to hassle you if we find you walking around looking for somebody to help you. If we ask you, 'What are you doing,' 'Well, I'm going to get help for this task.'" They're not going to hassle you about it. And I think everybody's pretty much comfortable that they really mean that. You know, and that's one of the things that contribute to this job being safer. (union electricians and pipe fitters)
Safety meetings & Job Task Analysis	We have safety meetings every week. You have to have a procedure written before you can do any task. Any hazard to that particular project and you have to turn this procedure in before you start work on that project. And it's good. You write down all the things you do so that an accident doesn't happen. (Site Supervisor for large Sub.,p.14, Manage +imple)
	In fact, our company today talked about heat problems and heat illnesses, and what to-how to keep yourself from becoming a target of that. We basically have a lot of on-the-job training, dealing with certain tools, if you haven't used it before, or even if you have. The proper way to use any equipment on the job site. Our own company takes care of that. We learn a lot of that just from being around other trades, seeing the way people operate tools, and sometimes how to not operate tools properly.(trim carpenter, sub contractor)

	Our foremen are supposed to do a job-hazard analysis before every different task. You know, say we're going to do some pre-casts. You have to sit down with your crew and say, "All right, this is what we're going to be doing. Here's the things to watch out for," before every different type of job. You're supposed to sit down with your crew, go over the hazards of every task we'll be doing. (field engineer for large sub contractor)
Training offered on site and off site	The beginning of every month, we have a safety meeting with the whole company. We all come out, out front out here, and the safety guys, they'll each have a turn to speak and tell us a little bit about what they've been seeing and noticing about the safety, as far as us wearing proper eyewear, etc. (worker for small sub-contractor)
	Pretty much everybody goes through our Level One [training], and then after a certain time when somebody's moving up, then they'll go into a ten-hour OSHA. It's a ten-hour class, and some people don't want to be looking out for other people, but we try to encourage everybody to look out for everybody. Basically what we say is safety's part of everybody's [job], not just the safety directors. (Safety professional of large subcontractor)
	We have a safety guy that works out of our main office in Henderson that gives classes. If someone sees a need for a class, he recommends it. They'll make a list and see if there's enough people, and they'll give it. We've had trench classes-and anything, basically, first-aid related or construction-related. (electrician, large sub contractor)
	We have a pretty extensive forklift training class up at [community college). (foreman for sub) We went through that. The last time you guys had it, they invited the other trades. I went through it, because I was going to be training new guys on forklifts, and that's a great class. (foreman for sub)
	As far as safety training, for the whole site, other than our once-a-month all-hands safety meeting, where we go through current safety issues and reinforce what some of the rules are-for example, we're turning the building up to permanent power, so you need to have GFI-protected receptacles in there, we've got to have the pigtails-we'll reinforce some of those things, do some of that training job-site-wide. As far as internally, we do quite a bit more of that. We will do our on-site, you know, toolbox meetings, which there'll be training there. At our staff meetings (HP safety person) will generally go through two or three things, just, "By the way, remember, when you look at scaffolding you've got to look at this and this and this." We also do a staff training session on the job site here, with just our staff, our salaried staff members, every other week, and that varies in focus from a technical topic to sometimes administrative topic to a safety topic. And so we've done, over the last year, I would imagine, oh, half a dozen to ten safety topics. So that's on-site safety training that's above and beyond Hensel-Phelps's corporate required safety training, which is, for a salaried staff member, you have to take four classes a year in addition to a series of mandatory classes. Like I have to take a fork-lift class, a scaffolding class, a rigging class, things like that.

Consistent enforcement of safety policy	But most of the safety, once you get on the job, the equipment is furnished here. It's up to people like me to enforce it. And you have to. You just have to wear them (safety glasses). It's enforced by the people on the site. (Site supervisor for large Sub.)
	I think it's the safety director on the job site. I think this is the first job that I've seen a safety director. And you know, I've been around a lot of jobs. This is the one where the safety director is actually going that's his job, to go walk around and check everybody. (laborer)
	We have quarterly meetings, it's a big safety meeting for the whole company and our division. And they reflect on injuries that have happened, and try to relate to you how to prevent different accidents, the same accident just kind of happens. Somebody hurts their back, and then the next thing you know there's like three others across country that pulled a muscle in their backs. Or a cut on the hand, somebody kept cutting their hand with the utility knives, so they got us these special gloves, like thirty-dollar-a-pair gloves that you couldn't cut (laughs). (Carpenter supervisor, 18 years experience)
Safety staff approach to safety as non-punitive	Our safety people all get together in one group and walk the whole site, and they look at everybody else's work. And it's not like they get angry at another trade, because, "Oh yeah, the site's dirty," and all this kind of stuff. They say, "Hey, we're running into some housekeeping problems on this particular-- So how do we get this taken care of? What's the best way to do this?" So, in that context, people are more cooperative. (Safety professional, contract company)
	He's not out to get me. He's out there helping me. (electrician foreman)
	Like a lot of people think we're like police guys, out there to give tickets-and as far as me, I'm not looking out to give tickets. I'm more there to train them, and explain to them why, you know. If I see somebody on the scaffold that hasn't locked the wheels, or has something wrong, instead of going, "Lock your wheels," or "Put a safety rail on it," "OK, come down. Tell me what's wrong with this, and why you got to put it." (Safety professional)
	Dissent: I think that having people there, the more people there, the better. You see somebody in a green vest, like they were saying, "I bust my ass [laughter from group] and I try not to get caught for some of the things that I don't do right." If I am doing something, and I see a green vest, it makes me think twice about what I'm doing. (worker for large sub, 2 years experience)
Power of safety staff to enforce policy	In the last couple years, we've totally been given the authority to run these guys off if we have to. You got to document it and you've got to make sure that he's accused correctly, and be fair. But if there are guys who aren't wearing the safety glasses, and it's the whole crew, and it's because the superintendent for that crew doesn't give a s***, the whole crew could be gone. (GC, field superintendent)

	I don't think that it's unusual for a safety person to have the power and the authority to RECOMMEND disciplinary action. It might be a little bit unusual to see it actually happen, to the point of being terminated. Usually if I recommend somebody have disciplinary action over a safety issue, at least there's a discussion with the individual. But yeah, if somebody were to put other workers in imminent danger, or create a safety hazard, yeah. Definitely it's talked about. And we have terminated people for that reason. (Safety Professional for large sub contractor)
Importance of housekeeping, clean as you go	Every trade, everybody, had to furnish people every Friday for a clean-up crew. They were real, REAL adamant about clean-up. They would go through the whole building every Friday, because in construction you get such a mess. Such a mess. Everybody has to furnish people depending on how big a crew we have. And probably trash and debris is the biggest cause of accidents, death. (large sub site supervisor)
Minimal overtime	Just in case of emergency, or something that had to be done, when we had to do it, when the other trades weren't there. Or an emergency come up. That's the only overtime. (electrician foreman, 42 years experience)
	Small amounts of it (overtime) don't affect it (safety) a whole lot. If you get to be in where I've been on jobs that are seven twelves [7 days at 12 hours per day], or seven fourteens [7 days at 14 hours per day] or whatever, then, yes, safety becomes a problem. (worker for sub-contractor)
	Fatigue, accidents, everything. Overtime, your body isn't made to work sixty, seventy hours a week. But normally I think that a two-shift system is a lot safer, more productive, than overtime work. Overtime work is hazardous. People are only about half awake after a month. (Site supervisor for major sub contractor)

Incentives from GC and sub contractors for safe work	Our particular company was giving a couple of incentives for coming up with innovative ways for doing things, so a couple of the guys from our actual company have been awarded prizes for that. So that's pretty good. (finish carpenter for sub contractor) I think we're doing like a quarterly thing where if nobody gets injured they'll get like a twenty-five-dollar Home Depot card or something like that. It helps us to keep safety in their focus and everything. I would hope it does. I mean, it shows that the management's willing to pay to keep everybody safe. (Carpenter sub-contractor foreman, 27 years experience) [GC] they give you safety incentives. You receive tokens, and you can either change them in for cash if you want, or prizes from a list. (GC, laborer) [For foremen, crafts foremen and superintendents] For a hundred thousand man hours, they'll get a [GC] watch free. For two hundred thousand they get a 750-dollars gift certificate or something like that. And three hundred thousand, they get four thousand dollars, and four hundred thousand man hours they'll get ten thousand dollars. (GC project superintendent)
	Now, we will do things on jobs, where we try to talk to his subs and we get them involved, and we've done safe craftsmen awards. What it is, then you're selected by your peers, they do like a "Safe Craftsman of the Month." And then they can give out awards for that. It just depends on the job and who's involved in it, because some people (sub contractors) don't want to participate. But it's getting better, because more and more people are having structured safety programs.

Representative quotations on random drug testing

Issue	Quotations
For random drug testing	Well, it makes you feel good, that you don't have to have any kind of self-doubt about somebody dropping something on you, or trying to hurt you, you know? It gives you good peace of mind, that you're with a bunch of people that are actually straight. (Laughter)
	I think, the trends of drug use, you might start out only using outside of work, or outside of school or whatever, but at some point those boundaries blur. And for all of us working on a site like this, we all depend on everyone else to keep us safe. [1 agrees] So for me, I don't want to be working next to someone who's on coke, you know? Because that puts me and everyone else around them in danger. So I think that's really important. And you know, with the insurance that's also a huge thing that, if somebody gets hurt on an accident when they're high, there's very minimal coverage extended to them. Minimal protection.
	It does. I mean, everyone would agree. It really makes a person be on their Ps and Qs. it definitely helps it out, because there'll be guys that show up at these jobs I've been on, three sheets to the wind, and you're like, "You need to go home, because you're going to hurt me."
	Sub contractor manager: I think drug-testing is great. I've done a lot of jobs over the years, and I've had a lot of people leave too.
	I think it's great. I think it sucks that it does infringe on your personal life, but I guess I also think that's too bad, because if you're going to be on a ladder working above my head, I definitely want you to be clean and sober.
Against random drug testing (minority view)	I think it's more of an invasion of privacy, myself. I'm not too big on them. But I don't discourage them, you know what I mean? I can go either way with it. I think then you have a probable cause [after an injury]. Like I said, probably cause I don't have a problem with, but just to start picking people out and somewhat accusing them of doing something, or trying to-I don't know, I just think it's-I don't know, I'm not real big on it. But I deal with it, obviously. I don't personally do drugs myself.

Representative quotations on diffusion of safety culture, making safety the norm

Issue	Quotations
Diffusion of safety culture among workers	If you see something wrong, you've got to go address that with the person, and nine times out often they will thank you for pointing out the error of their ways. They know that you're looking out for their best interest. (GC project manager) p 4
	I think it's more of just watching out for one another. Like, me, I was up on a ladder. I went out, I looked out for myself and asked a friend to come and hold the ladder. But if I see a guy on a ladder, I might come by and say, "Hey, let me hold that ladder for you." But if no one's like that, then that guy's out of luck.
	Oh yeah, we tell each other, and when we're carrying them [equipment], one guys walking by, so you know there's a guy on the other side telling him, "Watch it, there's a pipe behind you, so don't step on it." You know, they're always telling each other something, make sure we don't trip and fall. (carpenter)

Representative quotations illustrating the iterative process of workers practicing safe work habits.

Issue	Quotations
Practicing safe work habits-	FG-Intern-3-Carpenters-2-laborers-7-16-03 This one's-yeah, they hold zero tolerance, I've noticed. More so here than on other job sites. I think you get used to it after a while. I think when you first start, it seems difficult, but after a few weeks and stuff it just fits in. I think it's really effective, because of the way that it's carried out. And you obviously meet some resistance from individuals, but I think as a whole, people are willing to comply because they know that the rules are for their own benefit.
	FG-Foremen-&-Supervisors-8-14-03 Like if I was to try to correct old Number 1 over there, "Hey, get your safety glasses on," he would say "Oh f---you, to heck with it." That's not the way it is out here now. If somebody asked me to put my safety glasses on, our attitude out here is, "Hey, thanks. I appreciate it. I totally spaced it out." Or, "Hey, I didn't see that hazard. Thank you."
	And the cooperation here, like Number 6 was saying, you know, if you see something that's not safe, you mention to him about your safety glasses. And Number 5 mentioned the GFCI. Today I just had an occasion. They had-say it was being used wrong. So I mentioned to the yellow vest for the carpenters, and he said, "Oh, sorry. I'll fix that right away." It's not like, "Oh, go mind your own business" or something. Everybody's looking after everybody else, basically.
	I think it's more of just watching out for one another. Like, me, I was up on a ladder. I went out, I looked out for myself and asked a friend to come and hold the ladder. But if I see a guy on a ladder, I might come by and say, "Hey, let me hold that ladder for you." But if no one's like that, then that guy's out of luck.
	And then it's after two or three times in to the eye doctor to get stuff pulled out, it's like, "Wear a pair of safety glasses, would you?" [Safety glasses are] Not standard everywhere. It's like a screwdriver. It's part of your tools. It's just like your tool pouch, your safety glasses, your hard hat, your work boots. It's one of your tools. It's not safety equipment anymore. It's mandatory. (foreman for sub contractor)
	Well, it took about eight months to make sure that I didn't take my safety glasses off. I took me eight months to create that habit. [Laughter] I may take off my hardhat, but I'll leave my safety glasses on all the time. (union electricians and pipe fitters)

STOP program	All of us that work for Hensel-Phelps are required to write STOP cards. [refers to Dupont Safety Program] It's kind of like the way the police department works. You've got a quota you've got to meet. You know? Personally I usually just write that up. But you just write a card about where it happened, what the person was doing. Part of the program is that you have to approach the person and correct the situation before you walk away. So usually that just involves "Put your glasses on," you know. And that's the end of it. Sometimes there's more serious issues, and then they keep track of those trends. Lately-and we've talked about this at the safety meetings-personal protective equipment has been a real problem. Safety glasses in particular. So if we start to see a trend in a negative direction, they'll bring it up at the safety meetings to all the trades. And you know, like with the eye protection, our superintendent's gotten to the point where they're getting ready to go to a zero-tolerance, where you could actually be kicked off the job site for not wearing it. So they'll kind of warn them ahead of time if they see a trend that might lead to that. Yeah. I guess it's something a lot of you wouldn't see, because all that they see is one of us walking up to them and saying, "Hey, you're not wearing safety glasses. Can you put them on?" And then when we get back to the office we'll write it down, you know. 5: Did you say you actually hand the person a card? 6: No. No no no. HL: You hand the GC a card that says- 6: Yeah. We turn it in to our safety glasses. 5: Oh, ok. HL: "Somebody didn't have safety glasses," so they're able to track how many times you're seeing that sort of thing.
Does safety pay for itself?	Oh yeah. It definitely does, because if you're able to set up a job-especially if it's repeated-once you start doing it the way it should be done the first time, for say, doing a wall, or setting up the scaffold-no matter if it takes you this long to do it, to get that ready, but it takes you less time to do the work that you actually need to do. And once you've picked up the groove and you already know the system, you get ready one after the other, and you can do it safely, and you do it more efficiently. So just because of that, picking up the efficiency on the safety side by preparing and planning properly, it pays for itself right there. It's immediate, almost. So yeah, it definitely pays for itself. (GC Safety Professional)
	We furnish the gloves and we furnish the glasses, as the contractor, because it's just in your benefit. You have accidents, your rate [MOD] goes down, you can't even bid jobs. You know, you have to set a standard. And then hard hats. (Safety Supervisor, large subcontractor)

- ***Specific Aim 4. Analyze workers' compensation data, including payments for medical care and indemnity payments to assess severity of injury.***
- ***Specific Aim 5. Conduct rate-based and case-based analyses to determine relationships between injury rates and risk factors, including exposures. These will include, but not be limited to, analyses by mechanism of injury, trade, work domain or stage of construction, number of different trade groups on site, amount of overtime work and exposure to documented hazards.***
- ***Addition to Specific Aim 5. Compare factors identified as contributing to injury: (1) between two coders, one a safety professional and one a trained layperson, both of whom determined factors from completed interviews with injured workers and (2) by a single coder from two sources: worker interview and workers' compensation reports for the workers who were interviewed.***

Rate-based Analyses.

The table below presents overall injury rates and workers' compensation payment rates for this project and the DIA Project. The general contractor provided the injury rate data for the site. As mentioned above, we were unable to use the thousands of certified payroll files. To check the accuracy of the GC's data, we estimated hours worked by dividing total payroll for each company by the Davis-Bacon wage of the predominate trade for that company. A weakness of this method is that, while laborers are employed by many construction firms, this category of work is not identified as the principal type of work for any company. This leads to an undercount of hours worked on the site, since they are paid at a lower rate than trades. Our calculations of the likely denominator based on Davis-Bacon wages resulted in a somewhat lower number of hours than were calculated by the general contractor, exactly what would be expected, since the general contractor has information about total hours worked, including laborers. We therefore felt comfortable that the GC's estimate of hours worked was reasonable.

Not only were injury rates lower at this site than at the DIA site, but they were also less expensive. The injury rate at the Fitzsimons complex was one-third that of the DIA project while the payment rate was one seventh that of DIA.

Injury rates per 200,000 person hours and workers' compensation claims payment rates per $100 payroll, construction of Denver International Airport and UCHSC's Research Complex 1

	Denver International Airport (1990-1994)	UCHSC Research Complex 1 (2001-2004)
Total Injury Rate	32.7	11.0 (9.0,13.4)
Lost-work-time Injury rate	6.8	1.0 (0.5, 1.8)
Total Workers' Compensation Payment Rate	$7.06	$0.92 (0.75, 1.10)

The table that follows presents the total injury rates and lost work time rates for the DIA project and the Fitzsimons site (RC1) as well as BLS data for the construction industry (SIC codes 15, 16, 17) for relevant years. Even on the current site we identified injury rates higher than BLS for overall injury rates.

Total and Lost-Work-Time Injury rates per 200,000 person hours, Construction of Denver International Airport and UCHSC's Research Complex 1, Compared with Bureau of Labor Statistics Injury Rates for Comparable Years				
	DIA (1990-1994)	BLS (1992)	RC-1 (2001-04)	BLS (2002)
Total Injury Rate	32.7	13.1	11.0	7.1
LWT Injury Rate	6.8	7.2	1.0	2.8

We believe, as other investigators have reported, that there is a large undercount of injuries in construction in the BLS data, especially for small companies and for injuries that do not require the worker to miss more than three shifts—we estimated that BLS missed approximately two-thirds of all such injuries in 1992 (Glazner et al., 1998). The lost time injury rate at this site was about one-third that shown in BLS reports.

The medical care payment rate at this construction site was \$0.40 per \$100 payroll. Medical care payments totaled \$172,886, or an average of \$1586 per injury. Most (87) injuries required less than \$1000 in medical care, but eight injuries were treated at costs of over \$5,000, including two over \$15,000.

There were eleven lost-work-time injuries. Total indemnity payments for these injuries amounted to \$134,499, for an indemnity payment rate of \$0.31 per \$100 payroll. Indemnity payments ranged from \$808 to \$38,171. Four injuries required over \$10,000 in indemnity payments. "Other" expenses and reserves accounted for \$0.21 per \$100 payroll.

The vast majority of injuries were not severe, as indicated by the workers' compensation costs associated with them. Payments of more than \$10,000 in *total* costs were made for eight injuries. One of these, a back injury, is expected to require nearly \$130,000 in total payments. Total payments for other injuries in this category were for less than \$50,000.

Comparison between different types of coders and different data sources with respect to identification of risk factors.

These are the results of the analyses we proposed in the addition to specific aim 5, in which we compare coding of contributing factors along two dimensions. The first comparison examined the factors contributing to injury that were identified by two different people--a safety professional and a trained layperson—using data from detailed interviews with injured workers. Both used Haddon's matrix to classify factors.

A striking finding was that the safety professional identified more than twice as many factors in 40 interviews as did the layperson: 239 vs 114. There may be several reasons for this. A safety professional is more likely than a non-professional to recognize factors that lead to injury and may also understand better when hazards are present. (S)he may also understand construction work processes better than a layperson without construction experience. Moreover, the safety professional conducted the interview and identified factors immediately after the interview was completed, so the factors may reflect information that the safety professional heard, but did not record on the form.

Upon examining factor identification in detail, we found that not only did the safety professional identify more factors, he identified factors somewhat different from those found by the lay coder. To determine the level of agreement in coding between the two, we examined individual codes for interviews. The degree of agreement varied among categories, but was weak in nearly all. Among the general categories, human, object, environmental and organizational, agreement ranged from 19.5% for object factors to 58.1% for human factors. Using the safety professional's coding as the gold standard (because he was more likely to discern situations and activities that were unsafe and because he completed the Haddon matrix on completion of the interviews, with the information from the interview fresh in his mind), it appears that a trained coder who is not a safety professional and codes retrospectively misses a number of factors that may have contributed to injury.

We also compared the identification of factors contributing to injury from two sources: the injured worker interview and WC reports. The trained layperson identified factors from both sources.. Over twice as many factors were identified from the interviews as from the WC reports. Coding from WC descriptions resulted in only 54 factors being identified. Many factor categories had no entries from this data source.

Specific Aim 6. Test hypotheses about worker-specific risk factors and usefulness of the work hazard measures we employ.

As explained above in "Procedures and Methods," we were unable to test any hypotheses due to small sample size.

Evaluation of feasibility for other commercial projects (Specific Aim 7)

On this construction project, much of the surveillance infrastructure was part of the ongoing safety program on site, and in that regard, it is feasible for other construction sites. However, it was in place for proactive intervention purposes and not as a research tool. The project provides an excellent example of how surveillance methods can be used for primary prevention. For example, ongoing hazard surveillance was part of the construction project. A team of safety personnel were on site, hired as part of the ROCIP. Their jobs included regular hazard surveillance and investigation of injuries as they occurred.

A number of the components in place were found to be more useful than those we sought to impose for research purposes. This may have been because the personnel involved viewed their efforts as critical safety elements and not as a research protocol.

Hazard surveillance occurred through regular site walk-throughs as well as through planning for known hazards associated with given construction tasks. The walk-throughs were used to: 1) identify hazards, 2) ameliorate hazards that could be dealt with on the spot, 3) identify and notify appropriate parties for more complex issues, and 4) to assess correction of previously identified concerns. This appeared to be an important part of the effective safety program on this site. The continuous process also made the hazard surveillance less useful for predicting risk of injury events, in large part because hazards were corrected as soon as they were identified.

Injury events were investigated systematically as they occurred on site as well. The investigation involved the injured worker and supervisor, and the process was focused on preventing a subsequent occurrence. These meetings did not appear to be punitive; rather they resulted in action items to be attended to that could prevent other injuries. The goal of the interviews was to more fully understand the circumstances surrounding injuries and to agree on solutions going forward.

A unique aspect of this project was the clear understanding, on the part of workers at all levels that injuries were to be reported – regardless of how minor. While incentives were offered to rank-and-file workers as well as supervisors for safety performance, it was very evident that the goal was a safe work site, not under-reporting of injuries. Attesting to that goal, supervisors were penalized for not reporting injuries. The result, we truly believe, was not under-reporting to get incentives, but a true commitment to safety as a priority. This message was clear from all levels of workers from the top down, English and Spanish speakers, and across trade groups, based on our qualitative data.

Development of a realistic Job Exposure Matrix that could be used for research purposes was problematic. Task-based hazards could be more clearly identified based on knowledge of activity and planning specific to the site, but this still fails to identify risks that are not directly related to given tasks, but rather to the overall work – delivery of materials, walkways, slippery surfaces throughout – where workers must travel but are not necessarily working

The ROCIP approach, in which the owner bears responsibility and realizes the financial benefits of running a safe site, has built-in incentives for safety that extend beyond hazard and injury surveillance to health services issues – fast treatment of injured workers, ongoing management of their injuries, and rapid return to gainful work.

Discussion

This research project was designed to test methods for prospective surveillance on an ongoing construction worksite. While we were delayed in getting onto the site, for reasons detailed in the background section, we were able to test most of our methods adequately. The fact that this was an unusually safe worksite allowed us to document best safety practices for a large commercial construction project, an analysis we had not contemplated in our original proposal.

With respect to the surveillance procedures we tested, we found mixed results. Our comparison of two different coders with different levels of knowledge of construction safety and their identification of factors contributing to injury provides more information than heretofore available about the relative virtues of different approaches (Bondy et al., 2005, Lincoln et al., 2004, Bentley et al., 2006) to collecting data on construction risk factors. The comparison of the information available from two different sources of data, worker interview and workers' compensation reports, likewise shed light on the usefulness of those two data sources. It was not surprising that worker interviews yielded more information about the injury event than did the workers' compensation reports. We also found that the level of safety knowledge of the coder was important in eliciting a relatively complete list of risk factors. Assuming that the safety professional who completed Haddon's matrix provided the 'gold standard,' we found that the trained lay coder identified only half of the potential risk factors. Moreover, the lay coder sometimes identified different factors than did the safety professional. In addition, the workers' compensation data provided enough information to identify only about half the number of factors identified by the lay coder and only one-fourth of the number identified by the safety professional.

This has implications for accurately assessing the factors contributing to injury with an eye to planning safety interventions and injury prevention. Our findings with respect to the background and training of coders as well as different sources of information indicate that, if at all possible, trained safety professionals should conduct interviews with injured workers, using a framework such as Haddon's Matrix to elicit maximum information about contributing factors. If the only source of data is workers' compensation reports, it is likely that many risk factors will be missed. A review of the agreement between the two data sources (interview and WC reports) revealed that the primary difference between them was not disagreement about factors when factors were noted by both datasets, but that the coding based on WC reports missed a number of factors entirely. We think it possible that the brevity of the WC reports and the level of training of those who file and compile them may result not so much in misunderstanding of contributing factors, but in not always recognizing them.

This research does not suggest that injury reports should not be used when they are the only source of information about injuries, but it does indicate that they are weaker than interviews in terms of specifying all contributing factors. Interviews of injured workers, such as those performed by Lincoln et al. (2004) and Bentley et al. (2006) are likely to be superior to analysis of injury reports in identifying factors contributing to injury. Interviewing workers, especially if the interviews are conducted by safety professionals, is expensive and probably beyond the means of individuals contractors. It is possible that large workers' compensation insurers could fund such an enterprise, but it would be useful to test various permutations of interviewing by various types of personnel, training those who complete injury reports to be more exhaustive in their descriptions, improving injury reporting forms and requirements, interviewing a sample of injured workers, or interviewing workers whose injuries, whether severe or not, have been identified as being in a class characterized by high cost and severity. Such research could aid in developing efficient methods for identifying the points of intervention most likely to result in fewer injuries.

With respect to our qualitative research into the safety culture, we found some indication that the nature of behavior on this construction site did not necessarily follow the often depicted linear pathway from knowledge of risk, to attitude change, to practice that is included in The Health Belief Model (Strecher, 1997) and the Social Cognitive Model (Baranowski, 1997). We found elements of both of these models of behavior on this construction site, but they did not always operate in a linear fashion. In fact, it was a much more circular process. For example, behavior was sometimes driven by an enforced policy with attitudes changing as habits were developed. Instead of the sequence of knowledge, attitude, practice, the process was sometimes practice, attitude, knowledge or practice, knowledge, attitude. For example, we saw examples where it appeared that the process began with practice, which is typically described as the end outcome. We believe this has significant implications for safety on worksites and points out the potential utility of clear policy development, communication, and enforcement. This top-down or 'functionalist' approach to culture in the workplace (Glendon and Stanton, 2000) has been described, and sometimes criticized, as predicated on management's desire to change culture to meet their objective (Hale, 2000). However, through this project we saw some utility in that approach and also observed that it was not inconsistent with the desires of the workforce. It was abundantly clear that workers liked working in a clean, safe environment.

Strengths and limitations

Limitations

The process we originally outlined for this research project could theoretically have identified a number of relationships between hazards and injury in commercial construction. A highly organized safety effort was incorporated into the construction project from early planning to completion, making the link between hazards and injury less direct. We were welcomed on site – perhaps because of this; it is likely more challenging for field researchers to gain open access to sites being run with less safety oversight.

A major limitation of this project was our inability to identify which precise elements or critical group of activities were needed for maintaining site safety. The number of safety personnel was described to us as perhaps more than needed with the term "luxury safety". We were surprised, and gratified, by the low number and rate of serious injuries on this site. We gained access to the site after the project and the safety structure were well incorporated into the project, and it appeared that the safety efforts were effective. These things influenced our decision to focus much of our effort on qualitative data collection that would help us understand what safety practices were in place, how they were perceived by the workforce and by management, and how consistently they were integrated into work practice. While we gained considerable knowledge about the safety program and culture on the site, we cannot discern which individual elements were essential.

We had a limited window of time on the site and were not able to observe the entire construction process as we had hoped. The process for site walk-throughs changed with changes in safety personnel, even before we were onsite. This made the data more difficult to use for research purposes.

Despite almost weekly task-based assessments we did not capture information on the majority of tasks required to construct a complex such as this one. The two investigators conducting the task-based assessments openly acknowledged their different appraisals of what is realistic in controlling risk and this likely colored their appraisals. In retrospect we should have been more diligent about quality control in these efforts. We grossly underestimated the complexity of having task-based assessors find specific activities in the places and at the times when they were projected to occur. Even our attempts to have them capture whatever tasks were being done was not satisfactory. Our impression, based on looking for correspondence between injuries and hazards identified during walk-throughs, is that walk-throughs would have to be performed every day throughout the entire building and that every task in every location would have to be assessed to identify exposures throughout the site. This may be a good idea, but our findings do not allow us to make a recommendation to do this.

Strengths

Despite some of the problems carrying out our original study plan, the qualitative data we collected proved very useful in helping us understand the dynamics of the safety program on this site from the perspectives of a wide variety of key players, from workers to owners. Because qualitative research is often specific to the site or subjects about whom research is being done

(Ulin, 2005; Janesik, 1994), findings can be difficult to transfer to other situations. In this case, specific applications of the safety program were site specific, but many of the broad elements are transferable. One case in point is the clear and consistent policies and practices of the General Contractor. Sub-contractors reported that these were the standard for this GC, clearly indicating that they transfer from site to site. The consistent "top down" approach to safety was not questioned by anyone with whom we talked on site.

With qualitative methods, data collection is complete when little different or contradictory information emerges (Patton, 2002; Morse, 1994). This is termed data saturation and indicates that the range of available data has been plumbed. We reached this point after conducting around 75% of the interviews and focus groups, but since we had already committed to the remaining interviews and focus groups we continued to collect data. This confirmed we had reached data saturation, as no new or contradictory information emerged.

Despite difficulties encountered in this project there are a number of implications for prevention of construction injuries. First, we found that safety can be a priority on complex construction sites and that efforts to reduce serious events, in particular, can be effective.

We observed that there are specific safety-related tasks that must be performed and behaviors that must be practiced for construction workers to be safe. For example, poor housekeeping is responsible for many construction injuries, but it often is not attended to adequately. There was ongoing attention to housekeeping on this site and it was viewed as a shared responsibility. Sometimes workers complained about being expected to clean up, but they also reported that they appreciated the clean site, found it a safer environment in which to work as well as a more enjoyable one.

Perhaps one of the most enlightening descriptions of the essentials of a good safety program came from a safety coordinator for the GC who listed the following elements: communication, cooperation, and trust. Without these in place, other efforts, including planning, training, mandated policies, and even provision of occupational health services fall short.

There was a top down commitment to safety that was communicated clearly and diffused throughout the site. The accountability for safety on site was likely responsible for the change in behavior sometimes seen prior to a change in attitude; this would indicate that policy with enforcement can change worker behaviors. We do not mean to give the impression that things always worked well on site or that policy was always attended to. There were tensions at times among the array of safety people on site even. But, the process was always viewed as an iterative one and we believe this was key to the project's safety record. It was important that the project start on the right foot, so to speak, but attention to safety as an ongoing process was continuous.

The definitions of safety culture and safety climate remain a source of controversy (Guldenmund, 2000). However, regardless of semantics, many of our observations are consistent with principles that others have described as key for an environment that fosters workplace safety (Hale, 2000). These include:

- a commitment to safety as a process that starts at the top,

- the sanctioning and rewarding of safe behaviors even if they cost time, money, and resources,
- continuous reflection on how the organization is going to manage risk (or if you think you have the perfect safety program, you do not.),
- resources to manage risk (people, equipment, procedures) including assurance of competence of people for required responsibilities,
- "social and organizational mechanisms for structuring and limiting blame, so that uncertainty about it will not limit reporting and learning" (Hale, 2000) from events that do occur, including looking beyond individual behavior for solutions,
- open communication that includes talking openly about failures that are experienced, and
- "caring trust" among parties that each will do their work, but "that each needs a watchful eye and helping hand to cope with the inevitable slips and blunders which can always be made" (Hale, 2000).

Publications

Two manuscripts are in preparation, but no publications exist at this time.

The topics of the manuscripts are:

Surveillance in construction injury: different approaches to and sources of identifying factors contributing to construction injury.

Best injury prevention practices in construction.

Inclusion of gender and minority study subjects.

This form will follow in hard copy.

Inclusion of Children

Not applicable.

Materials available for other investigators

None available at this time.

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APPENDIX

I. Injured Worker Interview

Judith Glazner, PI
COMIRB # 02-596
July 25, 2002

Code Number: __ __ / __ __ __

Research Methods in Construction Injury

INJURY REPORT FORM

(This information can be used by the investigator to identify relevant sections of the questionnaire in advance of the interview)

1. Date injury reported to ROCIP office: ___/___/___ MM/DD/YY

2. Injured worker: ____
3. Workers' phone number: __________________

4. Date of injury: ____/_____/_____ MM/DD/YY

5. Time of injury: ______________ (24 hour clock)

6. Day of week when injured: M T W Th F Sat Sun (circle one)

6. Employer (contractor) at time of injury: _________________________________

Description of injury:

____

____

____

7. Exact location on site where event occurred:

____

____

____

To be assigned in research office

8. Assign stage of project: ____

rev4:01/09/03

Code Number: ____________________

Investigator: ______________________________

Interview with: _____ **victim**

_____ other informant

Describe: ______________________________

(co-worker, supervisor, etc.)

Interview conducted in: English Spanish (circle one)

Research Methods in Construction Injury

Injury Investigation Protocol for Worker Interviews

Note to interviewer: *Italics to be included only when interviewing a victim*

INJURY DESCRIPTION

1. I am interested in learning about an injury that occurred on: ___________________.

Tell me about how the injury happened (*and what you were doing when you got hurt*).
PROMPT After description ----> Was there anything that you think led to the injury?

Record text description.

Interviewer checklist:
Did you get: • What happened ___ • Type of injury ___ (fall, struck by, etc) • Task at time ___ • Factors leading to injury ___

2. What tools or equipment were *you using/(*or were being used by the person who got hurt) at the time of the injury? (list all)

____ None (skip to next question)

Equipment list — Any malfunction you were aware of? **If Yes, describe***

____________________ No Yes —> ______________________________
____
Brand: ______________________________
Age: ______________________________
Last maintenance: ______________________________

____________________ No Yes —> ______________________________
____
Brand: ______________________________
Age: ______________________________
Last maintenance: ______________________________

(*Describe what happened. Record details of equipment including brand name if known, age of tool, maintenance of tool)

Has anyone ever shown you how to use this tool?
No ___
Yes ___
If yes, who was this? ______________________________

Did they show you specifically ow to use the tool safely?
Yes ___
No ___

3. Did tools or equipment contribute to the injury in any way other than malfunctioning?
(For example: tripped over, lost balance because of tool, weight of tool, etc)
No ___
Yes___
If yes, what tool or equipment was that? ______________________________
Were safety guards or devices present?
Yes ___
No ___
Describe: ______________________________

Were they used?
Yes ___
No ___
Describe: ______________________________

4. What materials were you using at the time of the injury?

____

____

5. Was more than one person (*you*) injured?
   No ____
   Yes____

6. Was the injury the result of working near another worker or the result of another worker's behavior?
   No _____
   Yes ____
   If YES, what were they doing (if more than one additional person was involved record what each was doing)

   ____

   ____

   ____

   ____

   What trade (s) were they? (carpenter, plumber, electrician, mason, etc.) ____________________

Most common injury mechanisms expected: ----> If none of these SKIP TO PAGE 13 'JOB SITE'

Eye injury: **Go to eye injury section, next page**

Struck by: Go to page 6

Includes injuries from being struck by or against something:

- Struck by tools or materials
- Struck against
- Caught against or between
- Caught by

Overexertion: **Go to page 7**

Includes injuries from handling materials, moving body, cumulative trauma or repetitive activity

- Lifting
- Carrying
- Pushing/pulling
- Repetitive activity
- Moving leading to pain
- Just started hurting

Falls: **Go to page 9**

Includes any injury from a fall; does NOT have to have been from a height.

- Fall from same level; slip/trip with fall
- Fall from height
- Fall associated with work surface collapse

Slip/trip **Go to page 12**

Includes injuries that occurred from slipping or tripping but **without falling**.

EYE INJURIES

7. Were *you/* (was the injured person) wearing eye protection?
   _____ No
   _____ Yes
   If yes, what type of eye protection were you using?
   Regular glasses ___
   Safety glasses with side pieces____
   Safety glasses without side pieces____
   Goggles____
   Face shield ____
   Other ____
   Describe: ____
   If you were wearing eye protection, please describe how you were injured:____________
   ____

8. Were you working overhead when you injured your eye?
   _____ No
   _____ Yes

9. Have you ever been instructed in the proper use of eye protection, including how to choose the appropriate protection?
   ______ No
   ______ Yes

SKIP TO PAGE 13 'JOB SITE'

Specific information to collect for all 'STRUCK BY OR CAUGHT BY/BETWEEN' injuries

---

10. What struck you (*the injured person*) ? ______________________________
    What do you think this object weighed?
    Estimated size or weight of object ________________ (pounds)
    How far had the object traveled?
    Distance object had traveled ________________ (feet)

11. What caused the object or material to strike *you*/ the worker?

____

12. For **injuries from saws**
    Was the injury caused by kickback of the material being cut?
    ____ Yes
    ____ No

    Did the saw have a guard in place?
    ____ Yes ----- Was it used? Yes___
    No ___
    ____ No

    Did the saw have or an anti-kickback mechanism?
    ____ Yes ----- Was it used? Yes___
    No ___
    ____ No

SKIP TO PAGE 13 'JOB SITE'

Specific information to collect for all 'OVEREXERTION/BODILY MOTION' injuries

13. Tell me more about the exact task *you were doing/* that was being done when you got hurt.

Activity? (Describe)

Lifting what? ______________________________

From where had you lifted the object?
(from ground, from rack 18" off ground, get distance from ground)

____

How were you holding the object?
(one hand vs two hands; position of hands – in front of body, to side)

____

Carrying what? ______________________________

How were you holding the object?
(one hand vs two hands; position of hands – in front of body, to side)

____

What about: from where had you picked up the object?
(from ground, from rack 18" off ground, get distance from ground)

____

Pushing what ?______________________________

On what surface (flooring, ground outside, gravel?) ______________________________

Using assistive device?

No _____

Yes _____

If YES, what type of device? (hand truck, cart, etc.)

____

Pulling what?______________________________

On what surface (flooring, ground outside, gravel?) ______________________________

Using assistive device?

No _____

Yes _____

If YES, what type of device? (hand truck, cart, etc.)

____

14. What materials were involved (sheetrock, plywood sheet, rebar, etc --length, width, estimated weight)?

Material involved	Size	Estimated weight of object in pounds
______________	__________	______________

15. Were you/ (*was the worker)* doing the task alone or was any one else helping?

Doing task alone_____

Working with someone else ______

Did the other person do anything to contribute to injury?

No _____

Yes_____ If yes, describe: ______________________________

[This page only if interviewing victim]

16. Tell me how often you had done this same task?

First, how many times, or for how long, had you done that same task on the day you got hurt?
_______ (number of times) or
_______ (length of time)

How many times, or how often, had you done that same task in the last 7 days?
_______ (number) or
_______ (length of time)

17. Was the weight of the load unexpected? (heavier than you thought, co-worker dropped their load)
No _____
Yes_____

18. Were you in an awkward posture when you got hurt?
No _____
Yes_____
If yes, describe your position or posture: (bent over, twisted, reaching out)
____

19. What other tasks had you done that day before you got hurt? And how long had you done them?

Task: ______________________	Length of time: ____________
Task: ______________________	Length of time: ____________
Task: ______________________	Length of time: ____________
Task: ______________________	Length of time: ____________

SKIP TO PAGE 13 'JOB SITE'

Specific information to collect for all 'FALLS'

20. Did you fall from a height or elevation or did you fall (slip/trip) from the ground or onto your work surface – by that I mean not from a height?

    ___ fell from height or elevation **(Skip to FALLS FROM ELEVATION SECTION page 10)**

    ___ did not fall from height or elevation

21. What did you fall onto? ____________________________

22. To help us understand the amount of force involved in your fall, about how much do you weigh ? ______ pounds (or did you weigh at the time of the injury, if older injury)

23. How did you land when you fell? (on back, on hands, etc)

    ____

24. Tell me about the work surface where you were working when you fell. Was it any of the following? (check all that apply):
    - ___ dry
    - ___ wet
    - ___ frosted/ covered with snow or ice
    - ___ damaged or worn surface
    - ___ cluttered
    - ___ not secure
    - ___ other (describe): ____

25. Did any of the following event(s) happen just before you fell?
    - ___ slipped or tripped (on what): ________________________________
    - ___ lost balance
    - ___ other: (describe): ____

26. Were you working with any tools at the time of the fall?
    - ___ No
    - ___ Yes

    If YES, describe: ____

27. Were you handling or carrying any materials at time of fall?
    - ____ No
    - ____ Yes

    If YES, describe: ____

28. What kind of footwear were you wearing at the time of the fall? ______________

29. Do you think any of the following contributed to your falling?
    - ___ work surface slippery
    - ___ work surface cluttered
    - ___ visibility limited (such as by carrying sheetrock?)

      What limited visibility? ________________________

SKIP TO PAGE 13 'JOB SITE'

Specific information on FALLS FROM ELEVATIONS

30. What did you fall from?

___ ladder What type of ladder?: ____________________

___ scaffold What type of scaffold?: ____________________

___ vehicle or piece of equipment: Describe: ____________________

___ roof

___ ceiling joist/beam

___ floor joist/beam

___ down stairs

___ elevated work surface Describe: ____________________

___ through an opening Describe: ____________________

___ other Describe: ____________________

31. Tell me about the work surface where you were working when you fell.
Was it any of the following? (check all that apply):

___ dry

___ wet

___ frosted /covered with snow or ice

___ damaged or worn surface

___ cluttered/debris

___ guard rails up

___ leading edge marked (6 feet back from edge)

___ not secure or unsteady

___ other (describe): ____________________

32. What did you fall onto? ____________________

33. What was this surface like that you fell onto?
Was it any of the following? (check all that apply):

___ dry

___ wet

___ frosted/ covered with snow or ice

___ cluttered

___ other (describe): ____________________

34. How did you land when you fell? (on back, on hands, etc) ____________________

35. How far do you think you fell (in feet)? ________

36. To help us understand the amount of force involved in your fall, about how much do you weigh?
____ Pounds (or did you weigh if older injury)

37. Did any of the following event(s) occur just before you fell? (Check all that apply)
___ work surface collapsed
___ slipped or tripped
___ lost balance
___ other: describe ________________________________

38. Were you working with any tools at the time of the fall?
___ No
___ Yes
If YES, describe: ________________________________

39. Were you handling any materials at time of fall?
___ No
___ Yes
If YES, describe: ________________________________

40. Was there any equipment failure involved in your fall?
___ No
___ Yes

If yes, what equipment failed?
___ scaffold planking broke or collapsed
___ scaffolding collapsed
___ scaffolding tipped over
___ ladder slipped
___ ladder broke
___ fall protection failed
___ other / Describe: ________________________________

41. What condition was your footwear in? By that I mean was it wet, muddy, was the tread in good condition, etc?

____

SKIP TO PAGE 13 'JOB SITE'

Specific information on SLIPS/TRIPS (without falling)

42. Did you slip or trip on anything in particular?
_____ No _____ Yes
If yes, what did you slip or trip on? ______________________________

43. Tell me about the work surface where you were working when you fell.
Was it any of the following? (**check all that apply**):
___ dry
___ wet
___ frosted/ covered with snow or ice
___ damaged or worn surface
___ cluttered
___ not secure
___ HVAC cutouts in floor
___ other (describe): ______________________________

44. Were you working with any tools at the time of the fall?
___ No
___ Yes
If YES, describe: ______________________________

45. Were you handling or carrying any materials at time of fall?
_____ No
_____ Yes
If YES, describe: ______________________________

46. What condition was your footwear in? By that I mean was it wet, muddy, was the tread in good condition, etc?

____

47. Do you think any of the following contributed to your falling?
___ work surface slippery
___ work surface cluttered
___ visibility limited (such as by carrying sheetrock?)
What limited visibility? ______________________________

CONTINUE ON NEXT PAGE ' JOB SITE'

JOB SITE INFORMATION

I want to know exactly where you were on the site when you got hurt.

48. First, were you inside or outside the building structure?
    ___ inside building structure
    ___ outside building structure
    ___ other
    Describe: ____________________________

49. If you were inside a building, where exactly were you hurt?
    ___ South Building
    ___ North Building
    What level were you on when you got hurt? _____________
    Can you describe the area of that floor you were in? ____

50. How long had you been working on the Fitzsimons site before your injury?
    (fill in one of below)
    ____Days
    ____Weeks
    ____ Months

51. How long had you worked for your contractor, or company, when you got hurt?
    (fill in one of below)
    ____ Days
    ____ Weeks
    ____ Months
    ____ Years

52. What were your responsibilities on this job site? ____

53. On this job site whom do you ask for directions or instructions or assistance if needed?
    ____ co-worker
    ____ supervisor
    ____ foreman
    ____ other Describe:_______________________________________

54. What was the weather like the day of the injury? ____________________________________

55. Was the weather a factor in your injury in any way in your opinion?
    ___ No
    ___ Yes
    Describe how: ____

56. Were any of the following examples of personal protective equipment available to you on site?

	Available	Check if using when injured
Hard hat	_____	_____
Gloves	_____	_____
Safety glasses	_____	_____
Safety goggles	_____	_____
Face shield/welders helmet	_____	_____
Ear plugs or other hearing protection	_____	_____
Aprons or sleeves	_____	_____
Guardrails or safety railings	_____	_____
Safety belt/harness and/or lifeline	_____	_____

PERSONAL INFORMATION

57. *Interviewer, record sex of worker* *Male* _____ *Female* ____

Tell me a little bit about yourself.

58. What is your age ? _____ (years)

59. What is your native language? English Spanish Other (circle one)

60. What is the highest grade in school you completed? 1 2 3 4 5 6 7 8 9 10 11 12 12+ (circle one)

Now tell me some about your experience.

61. What is your trade? ______________________

62. How long have you been in the trade?
(Record number in only one box)

_____years _____months _____weeks _____days

63. Was the activity you were doing at the time of your injury a NEW or unfamiliar job task?
Yes____
No____

64. How much experience do you have with the specific task you were doing when injured?
(Record number in only one box)

_____years _____months _____weeks _____days

65. Was the activity you were doing at the time of the injury part of your usual job tasks?
Yes____ No____

66. Had your supervisor told you to do this task or assigned you this work?
Yes____ No____
If yes, did your supervisor train you or explain how to do the task?
Yes____ No____

67. Tell me about the hours you have worked recently:
Hours worked day of injury before got hurt _______
Hours worked in the last week _______ (meaning last 7 days, not just this work week)
Hours worked in the last month _______
Hours worked in last year _______

INJURED WORKER'S ASSESSMENT OF CAUSES OF INJURY AND WHAT COULD HAVE PREVENTED INJURY.

68. Were there any worksite conditions which you feel contributed to the injury? For example do you think any of the following contributed? (Check all that apply)

_____ Weather
_____ Slippery surfaces
_____ Lighting
_____ Housekeeping or cluttered work areas
_____ Time pressures
_____ Location or delivery of materials
_____ Storage of materials
_____ Crowded worksite
_____ Specific Objects

Describe:____

______ Others:

Describe:____

69. Any other factors that you think contributed? (Check all that apply)

_____ Co-worker's activity
_____ Speed of work
_____ Wrong tools for job
_____ Fatigue
_____ Task too heavy
_____ Lost concentration or attention
_____ Needed training

Describe what training would have been helpful:

____

_____ Needed help that was not available

Describe help that would have been useful:

____

70. What might have been different that would have prevented the injury? Thinking about someone

else in the same situation, how could this type of injury be prevented?

(If response is self-blaming such as 'be more careful' or 'lift properly,' encourage more specifics and other options that could have prevented the event)

That is all the questions I have. Is there anything else you would like to tell me about your injury? Or do you have any questions for me? (Record comments or questions)

INVESTIGATOR'S ASSESSMENT OF WHAT COULD HAVE PREVENTED INJURY OR CONTRIBUTING FACTORS

71. Using the format of Haddon's matrix, circle any factors that you feel contributed to this injury. Add any others in appropriate box that you identified and/or describe below.

	Pre-event	Event	Post event
Human	Lack of training Age Fatigue Co-worker's behavior	Fatigue Heavy objects or task Failed to ask for help Co-worker's behavior	Age Co-worker's behavior
Object	Equipment Materials	Equipment Tools PPE	Equipment (rescue equipment failed) PPE (if PPE actually caused injury)
Environmental	Weather conditions Lighting	Weather Debris Lighting	Weather Debris Lighting
Organizational	Availability of training Availability of equipment Materials staging; storage Speed of work Failure to train personnel (in rescue procedures)	PPE -availability; norm to use Lack of available help Time pressures Housekeeping problems	Lack of rescue plan

Explain your assessment of all factors you believe contributed to this injury. Do not feel constrained by the choices or categories in the box.
(Large free text field)

72. Was there any safety violation involved?

___ No
___ Yes
If yes, describe violation:

____

____

Time requirements

Date of this interview: ___/___/___ MM/DD/YY
Time required to complete interview _____ : _____ (hours: minutes)

Participation / cooperation
How well did the victim or informant seem to remember the event?
___ very well
___ fairly well, some problems
___ not very well

How cooperative was the victim or informant?
___ very cooperative
___ fairly cooperative
___ not very cooperative

How well did the victim or informant appear to understand the questions you asked?
___ very well
___ fairly well, some problems
___ not very well

Other comments of investigator about quality of interview:______________________________
____
____
____

II. TASK-BASED HAZARD AND CONTROL ASSESSMENT

Date: ______________________________ **Time:** ______**AM or PM**

Location (circle one): **South tower, North tower, North pod, Grounds/roadway, Other** (*describe)* ________________________________

TASK: Description of basic sequence required:		***Define workers involved in task:*** ***Trade:*** ***Estimated #:***
Potential hazards	Associated with this task? (circle one)	**Rate (1-5 score)** 1=fully protected; 5= no protection **and describe protection** **Do not score if hazard is not associated with this task**
Slip trip hazard: *Rough, irregular walking surface or materials/tools/debris likely to result in tripping*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Fall hazard < 6 feet: *Vertical work or work surface edge w potential for fall of 6 feet or less*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Fall hazard 6 feet or greater: *Vertical work or work surface edge with potential for fall of more than 6 feet*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Contact with electrical distribution: *Presence of any electrically charged materials, including distribution circuits, electrical cords, wires, power lines – (excludes electric-powered tools or equipment and*	YES NO	1 Fully Protected 2 3 4 5 No Protection

totally enclosed power lines such as within a wall)		
Use of electric tools/equipment: *Electric tools or equipment such as lights, saws, etc*	YES NO	1 2 3 4 5 Fully Protected ... No Protection
Mechanical impact: *Potential for impact from machines, tools, or moving objects, including objects falling from heights (excludes vehicles)*	YES NO	1 2 3 4 5 Fully Protected ... No Protection
Vehicles: *Potential for contact w vehicle, including both operator, passengers or workers in the vicinity of operation; vehicle must be present*	YES NO	1 2 3 4 5 Fully Protected ... No Protection

Potential hazards	Associated with this task? (circle one)	**Rate (1-5 score)** 1=fully protected; 5= no protection **and describe protection** **Do not score if hazard is not associated with this task**
Cut/impale hazards: *Presence of an object that could cut or impale if worker is in contact; include tools*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Manual materials handling: *Task requires moving, lifting, handling materials weighing 40 pounds or greater.*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Awkward posture: *Task requires worker to be in awkward posture to accomplish work – bent over for prolonged time, twisting, reaching*	YES NO	1 Fully Protected 2 3 4 5 No Protection
Trenching/excavation:	YES NO	1 Fully Protected 2 3 4 5 No Protection
Steel erection:	YES NO	1 Fully Protected 2 3 4 5 No Protection
Leading edge work:	YES	1 Fully 2 3 4 5 No

	NO	Protected Protection
Task safety affected by weather/ weather hazard:	YES NO	1 2 3 4 5 Fully Protected No Protection

Other comments/recommendations:

Signature: ______________________________

Instructions for: TASK-BASED HAZARD AND CONTROL ASSESSMENT

Identify tasks to be done, and where on site, from RC1 schedule.
Confirm task is occurring as scheduled.
Observe and complete assessment for each task.

The purposes of the assessment include:

1. Provide a brief description of each task based on RC1 schedule including a brief sequence of job steps.
2. Identify potential hazards associated with the task, thinking about each job step.
3. Rate the current level of protection on the site
   1= hazard is associated with the task but it is fully protected
   5=hazard is associated with the task and it is not protected at all

Do not provide a rating if the hazard is not even theoretically associated with the task.

For example, you would not rate fall hazards for tasks do not require working at height.

Documentation for purposes 1 and 2 requires that you theoretically assess hazards.
For 3 you are rating the current level of protection afforded workers on this site.

In the free text field at the end of the form, make any additional comments about the task, hazards, or protection. Include any recommendations you have for increasing protection, training that should be required, PPE needed, different or improved tools. This can be from workers' perspectives who are doing work, as well.

Also, include any observations you make that are not directly task related – like other workers or trade working nearby that might could affect safety.

Principal Investigator/Program Director (Last, First, Middle):

Inclusion Enrollment Report

This report format should NOT be used for data collection from study participants.

Study Title: Surveillance Research Methods in Construction Injury

Total Enrollment: 104 **Protocol Number:** 02-596

Grant Number: 1 R01 OH 007633

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race

Ethnic Category	Sex/Gender			
	Females	Males	Unknown or Not Reported	Total
Hispanic or Latino	1	35	0	36 **
Not Hispanic or Latino	3	65	0	68
Unknown (individuals not reporting ethnicity)	—	—	—	
Ethnic Category: Total of All Subjects*				104 *
Racial Categories				
American Indian/Alaska Native	0	0	0	
Asian	0	0	0	
Native Hawaiian or Other Pacific Islander	0	0	0	
Black or African American	0	5	0	5
White	3	60	0	63
More Than One Race				
Unknown or Not Reported	1	35	36	36
Racial Categories: Total of All Subjects*	3	65	36	104 ~~68~~ *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)

Racial Categories	Females	Males	Unknown or Not Reported	Total
American Indian or Alaska Native				
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American				
White				
More Than One Race				
Unknown or Not Reported	1	35		36
Racial Categories: Total of Hispanics or Latinos**	1	35		36 **

* These totals must agree.
** These totals must agree.