Journal of Safety Research 40 (2009) 53–61

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

“Safety is everyone's job:” The key to safety on a large university construction site[☆]

Mary Anne McDonald [a,*,1], Hester J. Lipscomb [b], Jessica Bondy [c], Judith Glazner [c]

[a] Division of Community Health, Department of Community and Family Medicine, Duke University Medical Center, Durham, N.C., USA
[b] Division of Occupational and Environmental Medicine, Department of Community and Family Medicine, Duke University Medical Center, Durham, N.C., USA
[c] Department of Preventive Medicine and Biometrics, University of Colorado Health Sciences Center, Denver, Colorado, USA

ARTICLE INFO

Article history:
Received 12 March 2008
Received in revised form 22 August 2008
Accepted 10 December 2008
Available online 8 February 2009

Keywords:
Occupational injury
Construction
Safety
Safety climate
Qualitative methods

ABSTRACT

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

1. Problem

The construction industry is among the most hazardous, as measured by work-related mortality, injury rates, and workers' compensation payments (Culver, Marshall, & Connolly, 1993; Glazner et al., 1998; Kisner & Fosbroke, 1994; Lipscomb, Kalat, & Dement, 1996; Ringen, Seegal, & Englund, 1995; U.S. Department of Labor, 2000). Workers are exposed to hazards in this industry that are difficult to quantify for reasons closely associated with the way construction work is performed. Not only does the work location for any group of workers often change, but each work site evolves as construction proceeds, changing the hazards workers face week by week and sometimes even day to day. Different trade groups work as a building project moves from site development to completion, and they often overlap in time and physical proximity. Even worker's compensation (WC) data on construction injuries are difficult to assemble, since the multiple contractors on any single site often have different insurance carriers. When these data are available, compensation records do not provide information on the size and characteristics of the population at risk, making it impossible to define overall injury rates.

We had the opportunity to prospectively study injuries and hazard control on a large commercial construction project owned by the University of Colorado Health Sciences Center (UCHSC). The WC insurance arrangement for this project, a Rolling Owner-Controlled Insurance Program (ROCIP), provided a single carrier for all contractors on site, obviating the need to collect injury data from multiple carriers. We report on the injury experience on that site, including injury and payment rates and document the onsite safety program, using detailed qualitative data collected for that purpose. We were interested in documenting the processes used to control risk on this large construction site, including defining key elements of the safety program from the perspectives of owner, manager (general contractor), sub-contractors, and workers.

2. Materials and methods

2.1. Description of the construction project

This biomedical research complex (RC-1) was constructed on the 160-acre Anschutz Medical Campus in Aurora, Colorado, a city adjacent to Denver, between January 2001 and March 2004. The site preparation included excavation of utilities at the decommissioned Fitzsimons Army Medical Center before construction of two 9-story adjoining towers. The project included a mix of office and laboratory space, auditoriums, and specialty areas such as animal handling facilities and magnetic resonance imaging pits, as well as parking areas and landscaping of surrounding grounds. One hundred contractors were involved in the project, including the general contractor (GC). The building's square footage was 628,423, and its total cost was $215,857,284.

[☆] This work was funded through a grant from the National Institute for Occupational Safety and Health (RO1 OH007633) to the University of Colorado Health Sciences Center (J. E. Glazner, PI).
* Corresponding author.
E-mail address: maryanne.mcdonald@duke.edu (M.A. McDonald).
[1] Mary Anne McDonald received partial support from an NIH-Clinical Translational Science Award #U54 RR023469-01.

0022-4375/$ – see front matter © 2009 National Safety Council and Elsevier Ltd. All rights reserved.
doi:10.1016/j.jsr.2008.12.005

2.2. Identification of injuries

The ROCIP for this construction project was controlled by the University of Colorado, which provided access to WC data through its insurance broker and project insurer. The workers' compensation data included very short text fields that typically described the body part injured, the nature of injury (sprain, cut, fracture), and proximate cause (fall, materials handling). In addition, data on actual WC payments were available for injuries resulting in medical care costs and/or indemnity payments.

2.3. Time at risk

The GC calculated injury rates using the gross hours worked reported by each contractor as the estimate of time at risk. Workers' compensation payments per $100 payroll were also calculated using payroll data.

2.4. Qualitative data

We used qualitative research methods to learn about the site's safety program; specifically we conducted taped interviews and focus group discussions and observed activities on-site, which we documented with field notes. We were interested in documenting the processes used to control risk, including defining key elements of the safety program from the perspectives of owner, GC, sub-contractors, and workers. This methodology enabled us to "study things in their natural setting, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them" (Denzin & Lincoln, 1994). Qualitative methods enabled us to document the 'emic,' or 'insiders,' perspectives on safety (Creswell, 1998; Fetterman, 1998; Hammersley & Atkinson, 1995).

2.5. Focus groups

The on-site ROCIP safety manager recruited focus group participants by posting flyers announcing meeting times and places 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 on the construction site. We audio-taped each session and later transcribed it verbatim. Group sessions began at the end of the work day, lasted 1 to 2 hours, and participants received dinner and a $25 incentive. Two of the eight focus groups were conducted by a native Spanish speaker for workers who spoke only Spanish. These two focus groups were transcribed in Spanish and translated into English by a native Spanish speaker.

Participants were asked to keep the focus group discussions confidential and not to reveal the names of other group members or the content discussed in the group. To reduce the risk of the loss of confidentiality, participants used numbers instead of names to identify themselves.

2.6. Key informant interviews

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 ($N=19$). These interviews provided the opportunity to ask one or two individuals at a time about their perceptions of safety and the safety programs on the site. These individual interviews enabled us to gather detailed information on company safety policy and implementation, management and owner safety concerns, the range of motivations for supporting safety programs, project history, and other issues.

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 one hour and were audio-taped and transcribed verbatim. Informants did not receive incentives.

2.7. Structure of interviews and focus groups

For both interviews and focus groups we used semi-structured discussion guides. 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 & Huberman).

Topics covered in the interviews and focus groups included: safety training received on and off the site; participants' understanding of the roles of different safety personnel; the development and maintenance of the safety climate of the site; cooperation to ensure safety; the effect on safety and communication issues of workers who did not speak English; housekeeping policies and compliance; and workers' and management's views 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 in which they were raised. Questions included: What is safety like on this site? How is this site different from other sites you've worked on? What do you do if you have safety concerns? Do other trades get in your way or create hazards for you? Tell me about those hazards and how you deal with them. Tell us about the ROCIP safety orientation, what kind of information did you get? How was it useful? Or was it useful?

2.8. Additional types of observations

In addition to using the above methods, we had access to other qualitative information that provided insight into safety. We made direct observations: for example, we observed the ROCIP worker orientation program that is part of the badging process for the site for both English-speaking and Spanish-speaking workers. We sat in on several monthly safety meetings held with those involved in the ROCIP, including the owner (the university), representatives from the GC and major subcontractors, safety personnel, and the insurance carrier. These meetings provided a regular forum to discuss upcoming work plans and associated safety issues, worker injuries including circumstances of injury and return to work, and other issues. We received formal minutes of the monthly meetings. We also observed site walk-throughs made by ROCIP safety personnel on eight occasions, including two accompanied by safety representatives from sub-contractors. We wrote field notes on these observations, providing another source of information to compare with what participants, workers, and safety staff told us in focus groups and interviews.

All procedures were approved by the Colorado Multiple Institutional Review Board.

2.9. Analyses

2.9.1. Injuries, injury and payment rates

Because injuries were described in the workers' compensation records by body part injured, as well as nature and proximate cause of injury, it was possible to break down the percent of injuries by these characteristics. 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. Overall workers' compensation payment rates were calculated per $100 payroll. Confidence intervals were calculated assuming a Poisson distribution (Haenszel, Loveland, & Sirken, 1962).

Table 1
Body part injured, nature and mechanism of injuries incurred, construction of UCHSC's Research Complex 1, 2001-2004

	Frequency of injury (%)
Body part injured	
Lower extremity	27 (24.8)
Hand and/or fingers	23 (21.1)
Back	17 (15.6)
Eye	14 (12.8)
Arm and shoulder	7 (6.4)
Trunk	6 (5.5)
Head/face/mouth	3 (2.8)
Bodily system	3 (2.8)
Unknown (not described)	9 (8.3)
Total	*109 (100.0)*
Nature of injury	
Sprain/strain	40 (36.7)
Contusion	16 (14.7)
Cut	16 (14.7)
Foreign body	14 (12.8)
Fracture	2 (1.8)
Abrasion/scrape	2 (1.8)
Puncture	2 (1.8)
Illness	2 (1.8)
Allergic reaction	1 (0.9)
Burn	1 (0.9)
Broken tooth	1 (0.9)
Hernia	1 (0.9)
Repetitive motion	1 (0.9)
Unknown (not reported)	10 (9.2)
Total	*109 (100.0)*
Cause of injury	
Struck by or against	42 (38.5)
Overexertion/bodily motion	26 (27.9)
Fall	10 (9.2)
Repetitive motion	6 (5.5)
Stepped on	5 (4.6)
Trip/slip	3 (2.8)
Exposures (dust, fumes)	2 (1.8)
Welding	1 (0.9)
Splash	1 (0.9)
Unknown	2 (1.8)
Total	*109 (100.0)*

2.9.2. Analyses of qualitative data

We used a qualitative software package (QSR N5™)(QSR International Pty Ltd., 2003) to analyze the narrative documents, which included transcripts from interviews and focus groups, notes from walk throughs, meetings, and other observations. The discussion guides used in focus groups and interviews provided the basic coding categories, and we reviewed these narrative data to identify issues or themes that our preliminary code structure did not include. Examples of codes used included: use of overtime; implementation of safety programs; orientation policy; Spanish-English communication; and safety culture on site. We defined each code and used a text analysis approach to assign codes to passages of the narrative data. We categorized employees as management/administrative, professional safety staff, general contractor employees, and sub-contractor employees so we could investigate variation among employees by role and affiliation. The categories were not mutually exclusive (e.g., a person could be on the professional safety staff and be an employee of the GC). We assigned codes to focus groups based on the predominant type of employee participating. With this qualitative software, we were able to compare the views of different employee groups on aspects of safety on site and the examples they used to support their points. For example, we could identify possible differences between GC employees and sub-contractor employees and compare the safety rhetoric of managers with that of workers.

Finally, we used a modification of Haddon's Matrix as a conceptual framework to describe and categorize the varied elements of the safety program (Haddon, 1968, 1972; Robertson, 1992). The matrix was designed to draw attention to human, environmental, and organizational factors that may contribute to injury at pre-event, event, and post-event stages (Robertson, 1992). We did not distinguish the 'Event' from the 'Pre-event' stage because we had difficulty clearly delineating these stages, as have others (Bondy, Lipscomb, Guarini, & Glazner, 2005). We did include post-event measures designed to lessen severity or repercussions of injury after the energy transfer resulting in injury had occurred.

3. Results

3.1. Injuries, time at risk and rates

A total of 109 injuries were reported for the construction of RC-1, most commonly involving the lower extremities (25%) followed by the hand or fingers (21%), the back (16%), and the eye (13%). Over a third of these injuries were described as sprain or strains, followed by contusions (15%), cuts (15%), and foreign bodies (in the eye; 13%). Over half resulted from being struck by or against something or overexertion (lifting, pushing, carrying). Falls accounted for only 9% of injuries (Table 1); only 5 (5%) involved a fall from height.

Time at risk for all workers totaled 1.98 million person-hours, based on data supplied by the general contractor, representing an overall injury rate of 11.0 per 200,000 hours worked. The medical care payment rate at this construction site was $0.45 per $100 payroll (Table 2). Medical care payments totaled $194,963, or an average of $1,789 per injury. Most (87; 80%) injuries required less than $1,000 in medical care, but eight injuries were treated at costs of over $5,000, including two over $15,000. 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, resulted in a medical cost payment of $39,757and total costs of $294,208.

There were 11 (10%) lost-work-time injuries (Table 2). Total indemnity payments for these injuries amounted to $288,201, for an indemnity payment rate of $0.66 per $100 payroll. Indemnity payments ranged from $808 to $185,000. Four injuries required over $10,000 in indemnity payments. "Other" expenses accounted for $0.19 per $100 payroll.

3.2. Qualitative data

3.2.1. Focus groups and key informant interviews

Eight focus groups were held with a total of 62 participants; Table 3 shows the make-up of each group. These sessions were conducted in June, July, and August of 2003. Often participants raised issues

Table 2
Injury and workers' compensation payment rates, construction of University of Colorado Health Sciences Research Complex 1, 2001-2004

	Injury Rate[1] (95% Confidence Interval)
Total Injury Rate (n = 109)	11.0 (9.0,13.4)
Lost-work-time Injury Rate (n = 11)	1.0 (0.5, 1.8)
	Payment Rate[2] (95% Confidence Interval)
Total[3] Workers' Compensation Payment Rate (total payments = **$563,226**)	$1.30 ($1.06, $1.59)
Medical Care Payment Rate (payments = $194,963)	$0.45 ($0.36, $0.54)
Indemnity Payment Rate (payments = $288,201)	$0.66 ($0.53, $0.80)

[1] Injury rates are per 200,000 hours worked.
[2] Payment rate is per $100 of payroll.
[3] Total payments include medical, indemnity, and impairment.

Table 3
Summary of focus group participants, construction of UCHSC's Research Complex 1, 2001-2004

Focus group	Number of participants	Participants' trades	Employer: GC or sub-contractors	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	Sub-contractors	English
7	10	6 tile setters, 4 union electricians	Sub-contractors	English
8	5	4 Tile setters, 1 laborer	Sub-contractors	Spanish

included in our focus group discussion guide before we introduced these issues, verifying that we had captured important domains when designing the guide.

Key informant interviews were conducted with 19 people representing a variety of roles in the project. Table 4 summarizes the types of participants.

3.2.2. Safety Program in the Conceptual Framework of Haddon's matrix

In Table 5, some of the elements of the site safety program are depicted in the conceptual framework of Haddon's Matrix. While a comprehensive presentation is beyond the scope of this paper, these examples demonstrate how the safety program reached all domains in Haddon's matrix. It is of particular note that most of these items, including those classified as ‘Host' or worker factors, are driven by broad organizational factors.

The university's decision to work under a ROCIP, in which the owner is responsible for the safety of all workers regardless of their employer, appeared to establish the basis for the project's safety infrastructure. This contrasts with the more common arrangement in the construction industry in which each contractor and sub-contractor is responsible for its own insurance coverage and management of the injuries of its workers. According to interviews with representatives of the owner, management, insurance, and the safety staff this decision influenced the choice of a general contractor with a well-respected safety record. The same insurer was responsible not only for workers' compensation claims, but all insurance on site including liability and faulty-construction claims that may be made after completion of the building. To support a safe site, the insurer made safety classes and training sessions (depicted in the matrix as Pre-event Host Factors), such as OSHA's 10-hour certification, specialized safety, equipment and regulation training classes, available at no cost to workers as long as their individual employers allowed them time to attend. The project timeline and schedule took into account where different groups would be working in order to avoid possible dangers and inconvenience created by people working too close to one another. In focus groups workers told us they appreciated, and used, the training opportunities and appreciated that the project ran smoothly.

Some important aspects of the safety program on this site are not apparent in Haddon's matrix. For instance, insurance safety professionals told us that they intentionally tried to clearly define policies and procedures at the outset so these policies could be supported and enforced consistently by management. They thought, as did the University representatives, that the beginning of the ROCIP process was crucial in establishing a safe site. Consequently, at the beginning of the project, the ROCIP and GC set up regular safety meetings that established the importance of safety and enabled consistent follow-up on safety issues. The meetings provided time to review progress, provide updates for safety personnel and managers on upcoming plans (including potentially dangerous procedures or conditions), review reports of injuries, and also raise accountability issues. Workers, safety professionals, and managers saw the required orientation to site policies, the safety meetings, the badging of all workers, and sub-contractor safety walks as contributing to the site's safety culture.

In the interviews and focus groups we consistently heard that ‘*safety is everyone's job*.’ There was consensus that establishing continuous site-wide safety had to begin with commitment from the highest level. The GC was widely acknowledged for strongly emphasizing safety and for supporting safety by supplying appropriate tools, realistic scheduling, training, and information. Workers described safety as the norm on this site with everyone as a participant, and they contrasted it to other sites on which they had worked:

> *Everyone is held accountable for safety and 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. It just makes it a lot easier for people to come together and be safe when everybody's part of it.*

The GC's supervisors were held accountable for safety by their managers and by the GC's expectations. Participants in interviews and focus groups understood the policy requiring that all injuries, regardless of severity, had to be reported. Supervisors and workers at times received incentives for safety, particularly prevention of serious injuries. However, it was clear that incentives were for operating a safe site, not for under-reporting of injuries; managers

Table 4
Summary of key informant interviews, construction of UCHSC's Research Complex 1, 2001-2004

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

[1] This worker was interviewed because he was the only worker who attended a focus group session.

Table 5
Safety program elements organized around Haddon's matrix, construction of UCHSC's Research Complex 1, 2001-04

PHASE	HOST Workers on site	AGENT/VEHICLE *Tools, trash, equipment, hazardous chemicals, dust, electricity*	PHYSICAL ENVIRONMENT Construction site	SOCIAL ENVIRONMENT *Workplace norms, policies, rules*
PRE EVENT Before workers are involved in an accident	*Workers oriented to site including ROCIP safety orientation *Regular tool box talks *Hazard analyses surrounding specific topics/tasks * Opportunities for training – through insurance academy, OSHA 10 taught on site, etc. *Workers wear badges to prevent unauthorized individuals on site *PPE expectations communicated. *Random drug and alcohol tests. *Work scheduling to provide crews with ample room to work and time to complete tasks.	*Regular housekeeping efforts to clear site of debris *Site regularly inspected by safety staff for violations or potential problems. *Appropriate equipment and tools available *Limited exposure to hazardous chemicals and dusts *All containers accurately labeled. *All chemicals with MSDS available. *Use of appropriate scaffolds, ladders handrails	* Planning of project * Experience modification considered when contracts awarded. * Safety personnel on site and identifiable *Site regularly inspected by safety staff focused on rapid correction of problems *Housekeeping efforts ongoing to reduce debris. *Appropriate equipment and tools available. * Temporary handrails, lighting * Slip resistant coverings on unfinished flooring	*Orientation to safety practices *Workers trained in safety (fall prevention, etc.) *Wearing of badges to ensure only authorized personnel are on site. *Safety incentives for safety – not under-reporting * OSHA's rules viewed as basic requirements, not standard *PPE use enforced – eye protection, hardhats, boots, fall protection *Trash clean-up emphasized *ROCIP Safety Director with strong safety enforcement powers. *Electrical boxes clearly labeled and secured. *Regular safety meetings on site * Pre-hire and random drug testing *Any contractor whose mod rating fell below the site's acceptable level terminated and removed.
POST EVENT After worker is injured	* Procedure established for first-aid on site and for rapid communication of injury * Procedures in place for immediate non-emergent care with occupational medicine provider * Procedures in place for emergent care if needed * Policies established for modified (light) duty work for those who are injured	Injury investigated by ROCIP Safety staff to identify points of intervention so similar injuries can be prevented in the future – tools, equipment that need modification or replacement, etc.	Injury investigated by ROCIP Safety staff so similar injuries can be prevented in the future by site modification	*Plan for medical treatment and monitoring of injuries *Plan for modified (light) duty work for those who are injured *Easy to report worker injuries so worker can receive medical care *Enforcement of rule that all injuries must be reported when they happen *Injury investigations with the objective of identifying the primary cause and correcting it *Discussion of injury with worker and sub contractor

understood that they would be held accountable for any non-reporting. As one manager explained:

If you don't have a ROCIP program, I think people are less likely to report an injury. We used to just put people in the office and say, "We'll call in first aid and just work [on the injury] in the office," and then it's not a doctor's case [for reporting purposes]. Whereas in a ROCIP you're more likely to say, "Hey, the owner's paying for it, we'll just send him to the doctor." So they're [small injuries] more likely to be reported and treated when you do have a ROCIP program.

It became clear to us that safety on the site was process-oriented, iterative, and infused into the workplace. Because of this integrated approach, it is difficult to separately categorize particular safety practices as establishing, diffusing, or maintaining a safety climate; many may serve all three purposes.

Workers and management viewed the safety staff as an important, visible part of the safety program. This explanation for the safe site, given by a laborer, was typical:

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–that's his job– to go walk around and check everybody.

The GC and ROCIP employed full-time professional safety managers responsible for only this site. Major sub-contractors — electricians, carpenters, metal workers – also employed dedicated safety staff. These latter 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 there. They could also be contacted by cell phone and periodically accompanied the ROCIP safety personnel on site walks. In addition to dedicated safety staff, foremen also had safety responsibilities. Each trade foreman wore a bright green vest to announce that he or she could be asked about safety.

The professional safety staff we interviewed presented themselves as helping workers to stay safe. 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 [green] vest and they'll get action, whether it's just over the radio, to get the right person out there. Because as supervisors, we wear the [green] vests, and ninety percent of us have the radios, 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.

Regardless of individual workers' attitudes or knowledge concerning safety practices, the GC's rules and policies created an environment where everyone had to comply with existing safety rules (Table 6). Because of consistent enforcement, it was clear that workers conformed—or they had to leave the site. For example, on one site walkthrough, ROCIP safety staff asked a scaffolding crew to put up a toe board to prevent materials from falling below. The crew explained the area below was taped off to keep workers from walking or standing below the scaffold. The policy was reiterated politely but firmly as a command, not a request, and the safety staff member checked for compliance at the end of his walk-through.

Safety was not based on simply "being careful," but on specific, consistent guidelines about how the work was to be done. This put in place safety practices that could elicit later changes in individual attitude and knowledge. These representative quotations illustrate the process of safety practices existing first, followed by changes in attitude.

It took about eight months to make sure that I didn't take my safety glasses off. It 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.

They [GC] 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 it just fits in [and you do what is policy].

For example, there was a clear plan for regular housekeeping. Each trade group was responsible for the cleanup of their work area, and there was a crew with representatives from each contractor who was responsible for weekly overall cleanup. While workers complained about this responsibility they also acknowledged their appreciation of working on a clean site.

Injury reporting and investigation were another aspect of overall safety management. The ROCIP safety personnel met with each injured person, when possible, and his or her supervisor to review the circumstances surrounding the injury. The focus of these investigations was not punitive, but rather on the prevention of future injuries. Safety personnel listed items that needed attention and outlined an action plan for managers, foremen, and workers in order to prevent future injuries. Sometimes these plans required securing appropriate tools or equipment; sometimes they involved scheduling a tool box talk or other training.

A clinic located close to the site provided all occupational medicine services. During orientation workers learned that they were required to use this clinic and how to report injuries and secure services. Rather than resenting being sent to a designated provider, most of the workers we spoke with appreciated this arrangement since an injured person could be seen quickly and then returned to the job if appropriate.

ROCIP safety staff and the medical provider communicated through a well established email system. When a worker was seen by the medical provider, ROCIP safety staff were automatically notified of the date and time of the visit, the worker's employer, if the injury was OSHA-recordable, and whether it was a new injury or a follow-up visit. The e-mail included notification of any need to modify work activities and whether the worker should return for a follow-up visit. The provider notified the employer and the worker about restricted activities and the anticipated date of maximum medical improvement. These reports were sent to the ROCIP office within one day of the injury.

Medical staff worked with ROCIP staff to provide a modified work-duty program. A clinic representative with an ergonomics background reviewed the work done by contractors on site; a matrix was created that could be used to identify tasks that people with work restrictions could do for each contractor. This allowed the medical staff to refer to the matrix and give contractors examples of appropriate work for a person with restrictions. Although most of the larger contractors had modified work-duty plans in place, this process allowed smaller contractors to create modified work-duty programs for their Fitzsimons workers, as well as for their workers at other sites.

4. Discussion

4.1. Injury rates

Through access to WC records and work hours we were able to describe injury and payment rates for injuries experienced on this large construction project. Based on previous work capturing injuries and hours worked for defined groups of workers, we had expected over 500 injuries on this site for investigation and analysis (Glazner et al., 1998; Lipscomb et al., 1996), many more than actually occurred. Access to the physical work site and to personnel enabled us to use interviews, focus groups, and site observations to assess and describe the safety practices from the perspective of multiple parties including: (a) the owner (University), (b) the general contractor, (c) subcontractors, (d) safety personnel representing each of these entities, and (e) workers.

The overall injury rate of 11 per 200,000 hours worked was 36% higher than that reported by the Bureau of Labor Statistics (BLS) for the construction industry in the same time period (U.S. Department of Labor, 2003). Our findings should be viewed in light of the limitations of the BLS injury reporting system including the growing documentation of under-counting of work-related injuries and illnesses in this national surveillance system (Rosenman et al., 2006) as well as reports of undercounting specific to construction (Center to Protect Workers' Rights, 1998; Glazner et al., 1998; Leigh, Marcin, & Miller, 2004; Lipscomb et al., 1996). Previously, we estimated that BLS missed approximately two-thirds of injuries from small construction companies and two-thirds of injuries that do not require the worker to miss more than three work shifts (Glazner et al., 1998). Consistent with our belief that this was an unusually safe site, the lost time injury rate that we observed (1.0/200,000 hours) was considerably lower than reported by BLS for the construction industry in 2002 (2.8/200,000 hours; Lipscomb, Li, & Dement, 2003).

The distribution of injuries is also of note. Back injuries are responsible for a considerable burden of injury and costs in the construction trades, typically accounting for 20%-25% of all injuries (Center to Protect Workers' Rights, 1998; Lipscomb et al., 1996). While a back injury was the most costly single injury on the Fitzsimons site, back injuries accounted for less than 16% of all injuries. Likewise serious falls from height were controlled.

4.2. Safety practices

Reporting all injuries, even minor ones, was an important element of the ROCIP safety program. Our qualitative data showed that all categories of workers, skilled and unskilled, English and Spanish speakers, union and non-union, and different trade groups, knew that they must report all injuries and understood the reasons for it. The GC offered incentives to both rank-and-file workers and supervisors for good safety performance. Yet in focus groups and interviews we heard that the goal was a safe work site, not the under-reporting of injuries, and that supervisors were penalized for not reporting. We believe this injury-reporting policy contributed to building a true commitment to safety instead of encouraging under-reporting to get incentives. It may also be responsible for the capture of a large number of relatively minor injury events.

We previously found the Haddon Matrix framework to be useful in identifying factors that contribute to construction injuries (Bondy et al., 2005; Glazner, Bondy, Lezotte, Lipscomb, & Guarini, 2005; Glazner et al., 1998; Lipscomb et al., 2003). As we categorized elements of the safety program in the Haddon framework, we were struck by the iterative, circular nature of the overall safety process on this site. Safety was not viewed as an add-on, but rather as part of the overall management plan.

Working with the Haddon matrix revealed how few of the overall safety efforts focused on individual worker behaviors. Specific activities designed to protect workers, when communicated widely, became part of the overall social environment, as did enforced policies. There were constant built-in reminders of safety, such as the vests that identified safety resource people, but focus on individual behaviors made up a very small proportion of the overall safety efforts. Instead, the emphasis was on creating a safe working environment that reduced worker exposure to unsafe conditions. Concern with safety was evident in many, if not all, activities, including the awarding

Table 6
Risk control processes implemented by organization. Bold type indicates activities common to two or more organizations

Organization	Risk control activities
Owner (The University)	• Choose to use ROCIP insurance program making owner responsible for safety of all workers regardless of their employer • Work timeline and schedule designed to consider impact on safety • Accepted bids only from companies which had low experience modification ratings, indicating a record of safety. • **Authority to remove workers who demonstrated unsafe work practices**. • **Cooperatively at start of project set up regular safety meetings; forum to review injuries, lost work time, current construction activities and plans for hazard control; meetings included representatives from the University, the General Contractor and ROCIP as well as sub-contractors common to all parties**
Insurance Company (ROCIP) controlled by owner	• **Safety managers on site** • **Existing comprehensive safety program** • **Authority to remove workers or sub contractors who demonstrate unsafe work practices** • Random drug testing • Encouraged employees to take safety classes and earn certifications on work time (OSHA 10 Hour, for example). • Safety managers document and investigate each injury with the goal of preventing future injuries • Orientation program for all workers before they begin to work on the site • ID Badges issued to all workers, required for entrance to the work site • Nearby clinic provided all occupational health services and has automated communication system
Manager General Contractor (GC)	• **Existing comprehensive safety program brought to site; included safety managers on site, safety rules and practices which exceeded OSHA standards** • **Enforcement of safety rules**. • **Authority to remove workers who demonstrated unsafe work practices**. • Managers and supervisors responsible and held accountable for reporting all injuries. • Safety managers made regular site walk throughs to check safety practices, equipment and compliance with safety regulations
Major sub-contractors	• **Regional safety supervisors available for consultation and on-site visits and walk-throughs** • **Supervisors met with ROCIP safety staff and injured workers to explore factors contributing to injury** • **Enforcement of safety rules**. • Provided appropriate tools and equipment to work safely; responsible for task specific training of own workers

of the GC's contract, the planning of the project timeline, the hiring of sub-contractors with low experience modification ratings, planning for orientation and ongoing training opportunities, plans for hazard identification and abatement, and the rapid provision of medical care in case of injury. When injuries occurred, rather than blame the victim, the ROCIP safety staff investigated the event in order to identify procedures, tools, and staff that might prevent a similar event.

The Health Belief Model from social psychology (Strecher & Rosenstock, 1997) and the Social Cognitive Model from psychology (Baranowski, Perry, & Parcel, 1997) depict a pathway from knowledge of risk, to attitude change, to practice. This commonly described linear progression does not portray the nature and evolution of workers' safety behaviors on this site. We observed elements of both of these behavior models, but also saw that improved safety behavior began with practice, which is typically described as the end outcome. For example, behavior was sometimes driven by a consistently enforced policy, and attitudes changed as safety behaviors became habit. We believe this has significant implications for development of safety programs on worksites and demonstrates the utility of clear policy development, communication, and enforcement.

4.3. Strengths and limitations

There are limitations to qualitative data, just as there are in all research efforts. We cannot guarantee that the findings we report are representative of all workers on site. The data were collected over a three month period and do not cover the full course of the project. We strove to reach a broad mix of workers including union and non-union workers representing a variety of different trade groups and job tenures, as well as Spanish-speaking workers.

The selection process relied on the workers voluntarily staying after work to participate in the focus group. Workers who were not able to stay or who were not interested in discussing their work did not attend. This recruitment process may have made our sample of workers heavy with those who were invested in the work they did and wanted to talk about it. We may have missed workers who were dissatisfied with the administration of the site or who were not interested in participating in a discussion or being part of a research project. However, the consistency of the data reassures us that what we collected provided a realistic appraisal of the overall safety program even though we were not able to observe the initial stages of construction and may have missed some types of workers.

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

Qualitative research findings can be difficult to transfer to other situations because they are generally context- and subject-specific (Janesick, 1994; Patton, 2002; Ulin, Robinson, & Tolley, 2005). In this case, some applications of the safety program were site specific, but many of the broad elements are transferable. The General Contractor established clear and consistent safety policies *and* practices. The fact that sub-contractors reported this was the standard for this GC is an indication that these policies and practices do transfer from site to site.

4.4. Conclusion and implications for industry

While the definitions of safety culture and safety climate remain a source of controversy (Guldenmund, 2000), many of our observations on this site are consistent with principles that others have described as key for fostering an environment of workplace safety (Hale, 2000). These include: a commitment to safety as a process that starts at the top; continuous reflection on how the organization is going to manage risk; adequate resources to manage risk (people, equipment, procedures, time); reinforcement of safe behaviors including assurance of worker and management competence; and mechanisms for limiting blame so that “uncertainty about it will not limit reporting and learning” (Hale) from events that do occur. The latter include talking openly about mishaps and looking beyond individual worker behaviors for solutions.

The research community has largely neglected the careful evaluation of how the organization of construction projects, including ownership, contracting/subcontracting relationships, and project insurance (including WC and liability insurance), influences worksite safety and health practices. Our work suggests that such evaluations would allow owners and contractors to determine whether shifting their risk management emphasis from individual worker behavior to organization-level factors, such as creating a safety culture, providing ample opportunity for safety training, and consistently enforcing and reinforcing safety rules, would benefit their organizations. Such evaluation also has the potential to reveal how the incentives and disincentives for safety vary based on these organizational arrangements, as well as how they affect injury rates.

Acknowledgements

We would like to thank Mike Barden, Manager, Building Projects, at the University of Colorado Health Sciences Center for his support of this work. He negotiated the research team's access to the construction site and facilitated our research. We acknowledge the role of Hensel-Phelps Construction Company in allowing us access to their worksite and workers. We also thank Skip Guiarini, President, OMI Incorporated, and Jim Romero from the ROCIP safety program for their assistance in understanding the ROCIP's role and safety practices. Lastly, we want to thank the interview and focus group participants for sharing their insights with us.

References

Baranowski, T., Perry, C. L., & Parcel, G. S. (1997). Social Cognitive Theory. In K. Glanz F. M. Lewis & B. K. Rimer (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice* (pp. 153−178)., 2nd ed. San Francisco, CA: Jossey-Bass Inc.

Bondy, J., Lipscomb, H. J., Guarini, K., & Glazner, J. (2005). Methods for using narrative text from injury reports to identify factors contributing to construction injury. *American Journal of Industrial Medicine*, *48*(5), 373−380.

Center to Protect Workers' Rights (Ed.). (1998). *The Construction Chart Book: The US Construction Industry and Its Workers*, 2nd ed. Washington DC: Author.

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design.* Thousand Oaks, CA: Sage Publications Inc.

Culver, C., Marshall, M., & Connolly, C. (1993). Analysis of Construction Accidents: The Workers' Compensation Database. *Professional Safety*, *38*(3), 22−28.

Denzin, N. K. & Lincoln, Y. S. (Eds.). (1994). *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage Publications.

Fetterman, D. M. (1998). , Second ed. *Ethnography: Step by Step*, *Vol. 17*. Thousand Oaks, CA: Sage Publications Inc.

Glazner, J., Bondy, J., Lezotte, D. C., Lipscomb, H. J., & Guarini, K. (2005). Factors contributing to construction injury at Denver International Airport. *American Journal of Industrial Medicine*, *47*(1), 27−36.

Glazner, J., Borgerding, J., Lowery, J. T., Bondy, J., Mueller, K. L., & Kreiss, K. (1998). Construction injury rates may exceed national estimates: evidence from the construction of Denver International Airport. *American Journal of Industrial Medicine*, *34*(2), 105−112.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety Science*, *34*(1-3), 215−257.

Haddon, W., Jr. (1968). The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. *American Journal of Public Health and the Nation's Health*, *58*(8), 1431−1438.

Haddon, W., Jr. (1972). A logical framework for categorizing highway safety phenomena and activity. *Journal of Trauma-Injury Infection and Critical Care*, *12*(3), 193−207.

Haenszel, W., Loveland, D., & Sirken, M. (1962). Lung cancer mortality as related to residence and smoking histories. *Journal of the National Cancer Institute* (Appendix C:1000).

Hale, A. R. (2000). Culture's confusions. *Safety Science*, *34*(1-3), 1−14.

Hammersley, M., & Atkinson, P. (1995). *Ethnography: Principles in Practice*, Second ed. New York: Routledge.

Janesick, V. J. (Ed.). (1994). *The Dance of Qualitative Research Design: Metaphor, Methodolatry, and Meaning.* Thousand Oaks, CA: Sage Publications.
Kisner, S. M., & Fosbroke, D. E. (1994). Injury hazards in the construction industry. *Journal of Occupational Medicine*, *36*(2), 137−143.
Leigh, J. P., Marcin, J. P., & Miller, T. R. (2004). An estimate of the U.S. Government's undercount of nonfatal occupational injuries. *Journal of Occupational and Environmental Medicine*, *46*(1), 10−18.
Lipscomb, H. J., Kalat, J., & Dement, J. M. (1996). Workers' compensation claims of union carpenters 1989-1992: Washington State. *Applied Occupational and Environmental Hygiene*, *11*(1), 1−8 (erratum 1997).
Lipscomb, H. J., Li, L., & Dement, J. M. (2003). Falls among union carpenters. *American Journal of Industrial Medicine*, *44*(2), 148−156.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis*, Second ed. Thousand Oaks, CA: Sage Publications, Inc.
Morse, J. M. (1994). Designing Funded Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research*, 1st ed. Thousand Oaks, CA: Sage Publications Inc.
Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods*, 3rd ed. Thousand Oaks, CA: Sage Publications Inc.
QSR International Pty Ltd. (2003). *QSR N5 (Non-numerical Unstructured Data Indexing Searching and Theorizing) qualitative data analysis program (Version 5)* Melbourne, Australia: Sage Publications, Inc.
Ringen, K., Seegal, J., & Englund, A. (1995). Safety and health in the construction industry. *Annual Review of Public Health*, *16*, 165−188.
Robertson, L. (1992). *Injury Epidemiology.* Oxford University Press.
Rosenman, K. D., Kalush, A., Reilly, M. J., Gardiner, J. C., Reeves, M., Luo, Z., et al. (2006). How much work-related injury and illness is missed by the current national surveillance system? *Journal of Occupational and Environmental Medicine*, *48*(4), 357−365.
Strecher, V. J., & Rosenstock, I. M. (1997). The Health Belief Model. In K. Glanz F. M. Lewis & B. K. Rimer (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice* (pp. 41–59), second ed. San Francisco, CA: Jossey-Bass Inc.
U.S. Department of Labor. (2000). *Industry Injury and Illness Data 1999.* Retrieved from http://stats.bls.gov/iif/oshbulletin1999.htm
U.S. Department of Labor. (2003). *Workplace Injuries and Illnesses in 2002.* Retrieved from http://www.bls.gov/iif/oshwc/osh/os/osnr0018.pdf
Ulin, P. R., Robinson, E. T., & Tolley, E. E. (2005). *Qualitative Methods in Public Health: a field guide for applied research.* San Francisco: Jossey-Bass.

Mary Anne McDonald is an Assistant Professor at the Duke Center for Community Research, Division of Community Health, Duke University Medical Center, Durham, N.C., USA. At the time this work was done she was a Research Associate in the Division of Occupational and Environmental Medicine at Duke. Her research interests include culture and health, community-engaged research and health disparities.

Hester Lipscomb is a Professor of Occupational and Environmental Medicine at Duke University Medical Center, Durham, N.C., USA. She is an occupational epidemiologist with research interests in injury and musculoskeletal outcomes. She has worked with the construction trades for 15 years.

Judith Glazner is an Associate Professor in the Department of Preventive Medicine and Biometrics at the University of Colorado School of Medicine. She is an economist with particular interest in construction injury and its costs as well as cost analysis of various health care interventions.

Jessica Bondy is an Assistant Professor in the Department of Preventive Medicine and Biometrics at the University of Colorado School of Medicine. She has over twenty years of experience in applying information technology to problems of medical care, research and education.