Validation of Self-Reported Occupational Exposures in Meatpacking Workers

Lina Lander, ScD,[1,2] Gary Sorock, PhD,[3,4] Terry L. Stentz, PhD, MPH,[5] Ellen A. Eisen, ScD,[1,6] Murray Mittleman, MD, DrPH,[1,7] Russ Hauser, MD, ScD,[1] and Melissa J. Perry, ScD, MHS[1]*

Objective *The ability of workers to accurately recall exposures that occur on the day of their injury is considered a potential limitation of case-crossover studies. This study assessed validity of occupational exposures reported by uninjured workers at a Midwestern meatpacking plant.*

Methods *One hundred thirty-six workers were observed for 60 min while working and then interviewed within 8 days (median 3 days) about exposures during the observation period. The level of agreement between self-reports and direct observations was assessed using kappas and intraclass correlation coefficients.*

Results *Excellent agreement was found between observed and reported work location ($\kappa = 0.97$, 95% CI: 0.92–1.0), task ($\kappa = 0.83$, 95% CI: 0.76–0.91) and tools used ($\kappa = 0.88$, 95% CI: 0.81–0.95). Personal protective equipment varied by work type and location, and agreement between observed and reported usage varied from excellent to poor for various items. Excellent agreement was found for tool sharpening ($\kappa = 0.89$, 95% CI: 0.82–0.97); good agreement for occurrence of break during the observation period ($\kappa = 0.60$, 95% CI: 0.45–0.74); and poor agreement for equipment malfunction, line stoppages, being tired, unusual task, unusual work method, being distracted, rushing, slipping, or falling.*

Conclusions *Agreement between observed and reported occupational exposures varied widely. Self-reported exposures are utilized in many occupational studies, and future exposure validity assessment studies should continue to improve retrospective study methods. Valid exposures will allow researchers to better understand injury etiology and ultimately prevent injuries from occurring.* Am. J. Ind. Med. 52:707–715, 2009. © *2009 Wiley-Liss, Inc.*

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INTRODUCTION

The case-crossover study design is an increasingly popular means to investigate transient, short-term changes in the risk of an acute-onset disease or injury following brief exposures to potentially causal factors [Maclure, 1991; Maclure and Mittleman, 2000]. The main question of interest in case-crossover studies in the occupational setting is "Was the worker doing anything unusual just before the injury event [Maclure, 1991]?" The study design controls for between-subject variability by comparing exposures during case and control time periods within the same subject [Lusk et al., 1995; Redelmeier and Tibshirani, 1997; Checkoway et al., 2007]. Successful applications of case-crossover

[1]Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts
[2]Department of Epidemiology, University of Nebraska Medical Center, Omaha, Nebraska
[3]Geriatric Research Services, Glyndon, Maryland
[4]Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland
[5]College of Engineering, University of Nebraska-Lincoln, Lincoln, Nebraska
[6]School of Public Health, University of California, Berkeley, California
[7]Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts
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*Correspondence to: Melissa J. Perry, Department of Environmental Health, Harvard School of Public Health, 665 Huntington Avenue, Building 1 Room 1411, Boston, MA 02115. E-mail: mperry@hsph.harvard.edu

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methodology include studies of transient risk factors for myocardial infarction [Mittleman et al., 1993], acute outcomes related to air pollution [Villeneuve et al., 2007; Jalaludin et al., 2008], and acute hand injuries [Sorock et al., 2001, 2002, 2004a,b].

Case-crossover studies of injured workers rely on the accurate recall of exposures that occurred at a particular time, such as minutes before the injury and at earlier control times when an injury did not occur. Self-reported exposures such as rushing, being distracted, or using a malfunctioning tool must be reliable and valid to produce unbiased injury estimates [Cozby, 1985]. Acute traumatic events, however, may influence recall and reporting of exposures in the hazard and control periods [Maclure, 1991; Moller et al., 2004]. Previous work has suggested that, within 4 days [Lombardi et al., 2002] or 7 days [Chow et al., 2007] following the first interview with injured workers, the recall of transient exposures in a second interview was moderately to highly reliable. Independent verification of self-reported exposures in injured workers is the best measure of validation but has been difficult to achieve. Recording of transient exposures of large numbers of workers prior to an injury would be prohibitively expensive and intrusive. The Chow et al. [2007] study found a moderate agreement between self-reported and coworker-reported exposures to malfunctioning equipment or materials before the injury ($\kappa = 0.56$, 95% confidence interval (CI): 0.20–0.91).

The validity of exposure information in the hazard and control periods is considered a potential limitation in case-crossover studies [Cozby, 1985; Maclure, 1991; Sorock et al., 2002, 2004a]. While several studies have validated exposures in various settings [Oh et al., 2004; Anveden et al., 2006], exposure recall in a hazardous, high-paced, and repetitive work environment such as meatpacking may be especially challenging. This industry remains one of the largest employers in the United States, with 503,000 workers employed in 2006 [Bureau of Labor Statistics, 2006]. The incidence rate of non-fatal injuries and illnesses in meatpacking was 9.1 per 100 full-time workers, more than double the incidence rate in U.S. private industry (4.4 non-fatal injuries and illnesses per 100 full-time workers in 2006) [Bureau of Labor Statistics, 2006].

In this study, we evaluated the agreement of observed work location, work task, tool use, personal protective equipment (PPE) use, and other potential risk factors with self-reported exposures in a volunteer, uninjured sample of meatpacking workers.

MATERIALS AND METHODS

Study Population

This study was conducted in a Midwestern meatpacking plant specializing in pork processing. The plant employed about 1,400 workers and had an on-site occupational health and safety clinic staffed by nurses. Operations were co~nducted in two shifts: the first shift was from 6 a.m. to 4 p.m., the second shift was from 3 p.m. to 11 p.m., and major cleaning occurred from 11 p.m. to 4 a.m. Most slaughter and cutting operations occurred during the first shift. Production was physically divided into two sides. ''Hot'' side operations included slaughter, evisceration, and preparation for overnight refrigeration. ''Cold'' side operations processed refrigerated carcasses including cutting, fabricating, and packing. Approximately 10,000 hogs were processed daily.

Recruitment

Participation requirements included speaking English or Spanish, being observed for 60 min while working, and participating in a 20-min phone interview within a few days following the observation. Of the 1,995 workers in the plant, approximately 700 spoke English or Spanish and were eligible to participate. In the study's first phase, workers were observed while they worked for 60 min, and in the second phase, workers were interviewed over the phone about their exposures and behaviors during the observation time. Workers were approached in the plant cafeteria or hallway, informed of the study requirements, and invited to participate. Phone interview details were not discussed at the time of recruitment; instead, workers were informed that researchers require better understanding of tools and work processes in meatpacking to improve working conditions. Flyers describing study details, participation requirements, and assurance of confidentiality were provided in English or Spanish, depending on workers' preference. Contact information and work area location were obtained from workers who agreed to participate.

Observation

Operational definitions were used to facilitate the observation and identification of tasks performed, tools used, and transient risk factors (Table I), and exposure logs were used to systematically record exposures. Logs were reviewed for completion following each observation period, and inconsistencies were clarified immediately. The assistance of line supervisors in identifying a safe observation place for researchers and identifying workers agreeing to participate was crucial in making data collection in this environment possible.

Five observers were trained to complete exposure logs. Training consisted of detailed explanation of exposure definitions, examples of various tools and behaviors, a plant tour, and trial observation. Initially, all five observers independently evaluated exposures of one randomly selected worker for 60 min. Logs were reviewed and inconsistencies in exposure assessment were discussed. If necessary,

TABLE I. Definitions of Workers' Exposures Used to Complete Exposure Logs

Term	Definition
Department	
Hot side	Slaughter, eviscerate, prepare carcasses for overnight refrigeration
Cold side	Cut, fabricate, package
Main task performed	
Cut, trim	Basic dissection of cleaned, chilled carcass into individual pieces of meat into specific customer requirements or for use in further processing
Move, sort, arrange product	Pick up, shove, pull, or move product
Package product	Box, tub, package product for market/storage
Remove bone	Perform large action or multiple labor intensive cuts to remove bones
Make, load, move boxes	Fold cardboard to create boxes, line with plastic, transfer
Weigh product, boxes	Move product/boxes on/off scale, add/remove product if needed
Clean, quality assurance	Clean-up equipment/floor, inspect
Move combos, pallets (mule)	Operate fork lift, pallet jack, mule
Tool	
Knife	Perform cutting/trimming operations using straight, curved, semicircular, ring, or whizard knives
Hands (no tools)[a]	Perform tasks without tools: package/move product/boxes
Saw (split, table)	Use floor-mounted equipment such as table saw or split saw
Hook	Use hand-held meat hook to stabilize/move product
Other: shovel, fork, rod	Use other hand-held tools to transport product
Forklift/mule	Use forklift/mule to transport boxes, tubs, pallets
Transient risk factors	
Sharpen knife/tool	Use ergo steel or a mousetrap to sharpen knife/tool
Break	Go to/return from two 15 min breaks or one 30 min lunch break
Equipment malfunction	Machinery not working normally
Line stop	Conveyor/line not moving
Tired	Yawning or stretching while working
Unusual task	Unjamming equipment/line
Unusual method/task	Equipment drop/switch
Slip	Slipping on the floor, not falling
Fall	Falling on the floor
Distracted	Talking to a coworker/supervisor/looking around
Rushing	Processing more product units than department median (50th percentile)
PPE	Personal protective equipment including gloves apron, coat, eye protection, head protection, and boots

[a]Contained occasional usage of scissors.

exposure definitions were clarified and additional training provided. This process was repeated three times until consistent exposure assessment was reached by all observers. Following the training period, direct observation by one observer was considered a gold standard for assessment of one worker's occupational exposures.

A total of 161 workers were observed in various departments. Observations were conducted at different times, Monday to Friday, over an 8-week period. The observation day and time were not announced in advance, and the observation area was randomly selected. There was one observer for each worker. The observer unobtrusively observed one worker for 10 min prior to recording exposures. This period allowed the worker to become comfortable with being observed and the researcher to familiarize him/herself with the worker's tasks and tools and with the surrounding environment. Start and finish times for each continuous exposure and the exact time of occurrence for each dichotomous exposure variable were recorded. For example, "Worker A used straight knife from 8:05 a.m. until 9:05 a.m., the knife dropped at 8:53 a.m."

Phone Interview

Informed consent was obtained over the phone prior to conducting an interview. A structured questionnaire was administered over the telephone within 1–8 days of the observation, depending on the worker's availability. One hundred thirty-six workers (84%) were reached within the 8-day window of the observation period for the phone interview. Workers were asked to think back to the earlier observation period and report tasks performed; tools and/or equipment used; tool sharpening; count of product processed; number of workers on the line; PPE used; line stoppages; dropped tools or equipment; unusual events such as switching tools, unjamming the product line, and equipment malfunction; slips/trips/falls; being tired; and possible distractions such as talking with coworkers, looking around, and loud noises. In addition, workers were asked about exact occurrence time for dichotomous exposures and start and finish times for continuous exposures. Specific definitions used to record exposures by observers were provided only if workers asked for more information about the meaning of a particular exposure. Following interview completion, workers were compensated for participating in the study ($25).

Statistical Methods

Self-reported questionnaire answers were cross-tabulated with corresponding observation records to assess the level of agreement between self-reports and direct observations [Lombardi et al., 2002]. The level of concordance between self-reports and direct observations was assessed by the kappa statistics and 95% CIs [Fleiss, 1981]. A kappa below 0.4 represents poor agreement, between 0.4 and 0.75 represents intermediate to good agreement, and greater than 0.75 represents excellent agreement beyond chance [Landis and Koch, 1977]. These analyses were performed in SAS, version 9.1. Intraclass correlation coefficients (ICCs) were calculated in SPSS to evaluate the level of agreement between observed and reported duration of equipment malfunction, tool usage, task, line stoppage, and counts of product handled [Shrout and Fleiss, 1979]. The ICC is the proportion of total variance accounted for by between-subject variance of exposures. Stratified analyses were used to evaluate the effects of gender, work shift, and race (Hispanic vs. non-Hispanic) on the recall of transient risk factors. The study was approved by the Institutional Review Board of the University of Nebraska-Lincoln.

RESULTS

Of the 700 eligible workers, approximately 350 were approached and invited to participate until a list of 170 interested workers (49%) was generated. Reasons for refusing to participate included lack of interest and time. The majority of workers, however, did not state their reasons for refusal. We attempted to include at least five workers in all departments to get a representative sample of the plant population. We observed and then attempted to interview 161 workers. Twenty-five (16%) were unreachable within the 8-day window of the observation period for the phone interview, yielding a final study sample size of 136 workers (84%).

Study participants were 38 years of age on average, 55% were male, and the majority of participants were Hispanic (77%) (Table II). The average job experience was 3 years (median 1.6 years, range: 3 days to 25 years). Observations were conducted mainly during the first shift (84%) on all workdays: Monday (10%), Tuesday (10%), Wednesday (15%), Thursday (25%), and Friday (41%). The median time between observation and interview was 3 days (range 0–8 days), and the interviews lasted approximately 20 min.

The level of concordance between self-reports and direct observations assessed by the kappa values is presented in Table III. Excellent agreement was found between observed and reported work location, hot side versus cold side ($\kappa = 0.97$, 95% CI: 0.92–1.0). The majority of workers

TABLE II. Characteristics of the Workers Observed at the Meatpacking Plant (n = 136)

Characteristic	n (%)
Age	
Mean (SD), (years)	38.1 (10.0)
Range	20–63
Gender	
Male	75 (55.2)
Female	61 (44.9)
Race	
Hispanic	104 (76.5)
Caucasian, non-Hispanic	25 (18.4)
Black, non-Hispanic	4 (2.9)
Other, unspecified	3 (2.2)
Education	
High school education or higher	75 (55.1)
Mean (SD), (years)	8.8 (4.2)
Median	9.0
Range	0–19
Job experience	
Mean (SD), (months)	38.1 (56)
Median	19.0
Range	0.1–300
Work restrictions	
Permanent	8 (5.9)
Temporary	7 (5.1)
Shift worked	
First	114 (83.8)
Second	22 (16.2)
Sharp objects used	
Mean (SD), (hr/day)	4.9 (3.6)
Range	0–10.5

TABLE III. Comparisons Between Direct Observation and Self-Reports of Department, Task Performed, and Tools Used by Meatpacking Workers (n = 136)

Variable	Observed	Reported	Kappa (95% CI)
Department			0.97 (0.92–1.0)
Hot side	22 (16.2)	21 (15.4)	
Cold side	114 (83.8)	115 (84.6)	
Main task performed			0.83 (0.76–0.91)
Cut, trim	58 (42.6)	55 (40.4)	
Move, sort, arrange product	35 (25.7)	30 (22.1)	
Package product	9 (6.6)	14 (10.3)	
Remove bone	9 (6.6)	12 (8.8)	
Make, load, move boxes	10 (7.4)	8 (5.9)	
Weigh product, boxes	6 (4.4)	5 (3.7)	
Clean, quality assurance	5 (3.7)	7 (5.2)	
Move combos, pallets (mule)	4 (2.9)	5 (3.7)	
Tool			0.88 (0.81–0.95)
Knife	64 (47.1)	66 (48.5)	
Hands (no tools)[a]	53 (39.0)	50 (36.8)	
Saw (split, table)	4 (2.9)	3 (2.2)	
Hook	8 (5.9)	9 (6.6)	
Other: shovel, fork, rod	4 (2.9)	4 (2.9)	
Forklift/mule	3 (2.2)	4 (2.9)	

[a]Contained occasional usage of scissors.

observed on the cold side were in the cut department (20, 15%). Therefore, when asked about tasks performed, almost half of the participants reported cutting or trimming as their main tasks, followed by moving, sorting, or arranging product. There was excellent agreement between observed and reported task ($\kappa = 0.83$, 95% CI: 0.76–0.91). Tasks were accomplished using a wide variety of tools. The majority of observed workers used knives, including straight (27%), curved (4 in. long) (9%), whizard (7%), semicircular (2%), and ring (2%), followed by hands only or occasional scissors (39%). Workers who did not use tools were involved in moving, sorting, weighing, arranging, or packaging product. Excellent agreement was found between observed and reported tool use ($\kappa = 0.88$, 95% CI: 0.81–0.95).

PPE usage varied by work type and location. All workers had hard hats, and all workers except for one were observed using hearing protection (Table IV). Intermediate to good agreement was found for full rubber suits, which protect workers from getting wet ($\kappa = 0.65$, 95% CI: 0.36–0.93), and for plastic belly guards ($\kappa = 0.64$, 95% CI: 0.46–0.82). Arm protection varied by area, and the majority of workers wore either hard plastic arm guards or plastic sleeve protectors. There was moderate to excellent agreement between observed and reported arm protection, with the highest agreement for plastic arm guard for the left hand ($\kappa = 0.81$, 95% CI: 0.70–0.91). Hand protection varied by side of production, with workers on the cold side wearing more layers of clothing and gloves for warmth. There was excellent agreement for metal mesh glove for the left hand ($\kappa = 0.77$, 95% CI: 0.66–0.88) and poor agreement for the right hand ($\kappa = 0.13$, 95% CI: -0.03 to 0.30). Moderate agreement was found between observed and reported usage of reusable and disposable gloves. Finally, excellent agreement was found for footwear for both rubber and leather boots ($\kappa = 0.89$, 95% CI: 0.81–0.98).

Table V summarizes observed and self-reported exposure to transient risk factors for occupational injury. Excellent agreement was found for tool sharpening ($\kappa = 0.89$, 95% CI: 0.82–0.97), and good agreement was found for occurrence of break during the observation period ($\kappa = 0.60$, 95% CI: 0.45–0.74). Recall of equipment malfunction; line stoppages; being tired; unusual task; unusual work method; being distracted; and rushing, slipping, or falling had poor agreement with observation findings. Kappas ranged from 0.2 for equipment malfunction to 0.03 for being distracted. Separate analyses according to the number of days between observation and interview (≤ 2 vs. >2 days) yielded similar results. In addition, there was some evidence of effect modification by gender, shift, and race (results not presented). These results, however, were constrained by the small number of reports.

The level of agreement between observed and reported duration of exposure was evaluated using ICC and 95% CI (Table VI). There was excellent agreement between observed

TABLE IV. Observed and Reported Personal Protective Equipment Usage and the Corresponding Kappa Statistics (n = 136)

Personal protective equipment	Observed	Reported	Kappa statistic	95% CI for kappa
Hardhat	136	136	1.0	N/A[a]
Hearing protection	135	136	1.0	N/A[a]
Safety goggles/face shield	9	12	0.43	0.16–0.71
Torso				
Rubber suit	8	7	0.65	0.36–0.93
Plastic belly guard	22	21	0.64	0.46–0.82
Apron—plastic	105	87	0.53	0.38–0.68
Arm				
Plastic arm guard (R)	4	5	0.66	0.29–1.0
Plastic arm guard (L)	49	47	0.81	0.70–0.91
Plastic sleeve (R)	68	62	0.59	0.45–0.73
Plastic sleeve (L)	70	60	0.60	0.46–0.73
Hand				
Metal/whizard (R)	5	27	0.13	−0.03–0.30
Metal/whizard (L)	43	58	0.77	0.66–0.88
Reusable (R)	39	47	0.53	0.38–0.68
Reusable (L)	35	46	0.57	0.42–0.72
Disposable (R)	92	88	0.55	0.41–0.70
Disposable (L)	83	89	0.48	0.33–0.63
Cotton/anti-cut (R)	64	107	0.16	0.03–0.29
Cotton/anti-cut (L)	72	112	0.21	0.07–0.34
Feet				
Rubber boots	97	99	0.89	0.81–0.98
Leather/safety boots	39	37	0.89	0.80–0.98

R, right hand/arm; L, left hand/arm; CI, confidence interval.
[a]Could not be calculated because of perfect agreement.

and reported duration of equipment malfunction, tool usage, and task performed (ICC ranged from 0.78 to 0.99). Excellent agreement was also found between observed and reported counts of product processed (ICC 0.93, 95% CI: 0.90–0.95). Agreement between observed and reported duration of line stoppage, however, was poor (ICC 0.04, 95% CI: −0.84 to 0.50).

DISCUSSION

As case-crossover study design becomes increasingly popular in occupational epidemiology, validity of exposure recall remains to be addressed [Maclure, 1991; Sorock et al., 2001, 2002, 2004a,b]. The ability of workers to recall the frequency and duration of exposures that occur on the injury day is considered a potential limitation of case-crossover studies [Cozby, 1985]. Several studies attempted to validate exposures using direct observation. For example, one study reported strong correlation between self-reported and observed exposures to chemicals ($r_s = 0.73$), gloves ($r_s = 0.72$), water ($r_s = 0.68$), and food ($r_s = 0.67$) in a study of exposures while wearing gloves in the laboratory setting [Anveden et al., 2006]. In another study, researchers observed 1,036 postal service employees to validate self-reported usage of sun protective clothing and found good to excellent agreement ($\kappa = 0.51$–0.83) for various items of clothing such as hat, long-sleeved shirt, pants, and sunglasses [Oh et al., 2004].

Recall of exposures that occur in a hazardous, high-paced, and repetitive work environment such as meatpacking may be especially challenging. Although workers in this plant rotated to different departments and jobs depending on the plant's needs, they accurately recalled production side, main task, and tools used during the observation time (Table III). Agreement between observed and self-reported exposure to transient risk factors for occupational injuries varied from excellent for tool sharpening to poor for equipment malfunction; line stoppages; being tired; unusual

TABLE V. Observed and Self-Reported Exposure to Risk Factors for Occupational Injuries and the Corresponding Kappa Statistics for Meatpacking Workers Interviewed Within 8 Days of the Observation Period (n = 136)*

Transient risk factor		**Exposure agreement**		
Observed	**Reported (if different)**	**Observed**	**Reported**	**Kappa statistic (95% CI)**
Sharpen knife/tool		57	54	0.89 (0.82–0.97)
Break		44	23	0.60 (0.45–0.74)
Equipment malfunction		7	30	0.20 (0.03–0.38)
Line stop		55	49	0.19 (0.02–0.36)
Yawn/stretch	Tired	42	48	0.17 (0.001–0.34)
Unjamming	Unusual task	13	6	0.16 (−0.09–0.41)
Equipment drop/switch	Unusual method/task	37	10	0.06 (−0.08–0.20)
Slip		2	12	0.12 (−0.12–0.36)
Noise	Distracted	12	71	0.08 (−0.01–0.17)
Talk/look around	Distracted	113	71	0.03 (−0.10–0.16)
Product processed	Rushing	68	43	−0.04 (−0.20–0.12)

*For example, 113 workers (out of 136 workers) were observed talking or looking around during the observation period, but only 71 recalled and reported doing this behavior during the telephone interview. A single episode of talking or looking around during an observation period was classified the same as multiple episodes of talking or looking around during the observation period.

task; unusual work method; being distracted and rushing, slipping, or falling (Table V). Such poor agreement may be attributed to two main reasons: Either workers had poor recall of transient exposures during specific time periods, or the methods used in our study were not optimal to accurately capture exposures to transient risk factors. In the first instance, the repetitive nature of meatpacking work may make remembering transient exposures challenging. In the second instance, the slight environmental change, such as the presence of an observer, could not be compared to the emotional trauma associated with being injured. The emotional response associated with injury may in turn anchor the memory of events immediately preceding injury time. Such anchoring is less likely to occur following observation time. Future validation studies may consider providing workers with an anchoring event, such as a supervisor speaking to a worker, to simulate injury circumstances.

Recall of exposure duration also varied (Table VI). There was excellent recall of the duration of equipment malfunction, tool usage, task performed (ICC ranged from 0.78 to 0.99), and counts of product processed (ICC 0.93, 95% CI: 0.90–0.95). Although many workers did not remember being exposed to malfunctioning equipment, those who did (n = 5) were able to recall duration of exposure (ICC 0.998, 95% CI: 0.99–1.0). Only 38 workers reported duration of line stoppages, and the agreement between observed and reported duration of line stoppages was poor (ICC 0.04, 95% CI: −0.84 to 0.50) (Table VI). It is possible that definitions of line stoppages were unclear to participants and observers, and normal pauses in operations may have been counted as line stoppages by observers. The discrepancies in the validity of exposure duration may also be attributed to frequency of exposures. The amount of product processed remains relatively stable over the course of the day

TABLE VI. Observed and Reported Duration of Exposure to Potential Risk Factors for Occupational Injuries and the Corresponding Intraclass Correlation Coefficient (ICC) (n = 136)

		Duration of exposure (min), mean (SD)		
Potential risk factor	**n[a]**	**Observed**	**Reported**	**ICC (95% CI)**
Equipment malfunction	5	15.5 (23.4)	56.3 (133.7)	0.998 (0.99–1.0)
Product processed (count/hr)	115	952.6 (3,484.2)	982.7 (4,448.0)	0.93 (0.90–0.95)
Any tools used	135	55.4 (11.3)	56.7 (9.6)	0.85 (0.80–0.90)
Task	136	52.8 (14.7)	54.4 (13.2)	0.78 (0.70–0.85)
Line stoppage	38	2.4 (3.0)	8.5 (13.0)	0.04 (−0.84–0.50)

[a]Number of observation used in analysis was fewer than 136 due to missing duration of exposure data.

and thus lends itself to recall better than less frequent events such as line stoppages.

Agreement between observed and reported PPE usage varied from excellent to poor for various protective items (Table IV). With temperatures of 38–42°F (3–6°C) on the cold side, several layers of clothing are needed to work comfortably. These layers of clothing and gloves concealed some of the PPE from observers and reduced agreement between observed and reported exposures such as for cotton or anti-cut gloves. The poor agreement for metal glove on the right hand ($\kappa = 0.13$, 95% CI: −0.03 to 0.30) and excellent agreement for the left hand ($\kappa = 0.77$, 95% CI: 0.66–0.88) were surprising. This discrepancy may be attributed to over-reporting or missed observed usage. Workers may be uncomfortable using their tools while wearing a metal glove and may be reluctant to report omission of the required PPE. It appeared, however, that gloves were worn in layers, and the order of layers was different for dominant versus non-dominant hands. On the dominant hand, a metal mesh glove was likely to be worn under cotton and disposable gloves and thus was less visible to observers. On the non-dominant hand, a metal mesh glove was likely to be worn over cotton and disposable gloves and thus was more visible to the observers, resulting in better agreement.

A few additional limitations are noteworthy. First, this study relied on volunteers. Workers were approached while on their breaks in the plant cafeteria or hallway and invited to participate. Generally, workers have two 15-min breaks and one 30-min lunch break. During the lunch break, workers must remove all PPE, walk to the lunch room (may take up to 5 min from distant areas in the plant), have lunch, and return in time to don PPE before the break ends and the line begins again. This set of activities requires workers to rush, and therefore, they are often not amenable to discussion about research study participation. In addition, limited lunch room space at the time of recruitment resulted in substantial crowding around lunch time. Volunteers may have been different from other workers in their motivation to improve working conditions. It is unlikely, however, that increased motivation affected workers' ability to recall occupational exposures and biased results away from the null hypothesis of no association between observed and reported exposures. In addition, some workers were unable to participate because of lack of a home phone. Other workers (26%) provided the wrong phone number or were unreachable after five attempts for interview. We do not believe that the presence (or absence) of a home phone number affected workers' recall of occupational exposures.

We attempted to reach all workers as soon as possible after the observation period. The median time between observation and interview was 3 days. While it seemed that better recall of occupational exposures would occur with shorter time between observation and interview, separate analyses according to the number of days between observation and interview (≤ 2 vs. >2 days) yielded similar results.

Task definitions were used to systematically classify and record observed behaviors. Some definitions, however, may be limited in scope for this study and future studies should consider expanding them. This may be especially true for being distracted and tired. Although researchers were trained by observing several workers and discussing completed exposure logs, misclassification of exposure was still possible. Workers might have made different task classifications than their observers, particularly for equipment malfunction and unjamming equipment (Table V). During the interview, specific definitions used to record exposures by observers were provided to workers only if they asked for more information about the meaning of specific exposures. Therefore, misclassification of reported exposures could occur. This misclassification would bias results toward the null hypothesis of no agreement between observed and reported exposures.

In addition, only English- and Spanish-speaking workers were observed and interviewed for logistical reasons. While the plant population is multicultural, English- and Spanish-speaking workers comprise the plant majority. It is also unlikely that speaking other languages would result in differential recall of occupational exposures. Study generalizability may be limited because the study was conducted in one plant with a sample size of 161. We do not believe that working in a particular plant influenced recall of occupational exposures and/or behaviors and biased study results.

This was a challenging study from a practical standpoint. Workers were reluctant to participate and provide contact information. Numerous explanations and assurances of confidentiality were provided at the time of recruitment. Identification of workers, who had agreed to participate when approached in the plant cafeteria, was difficult on the plant floor because of their changed appearance due to protective clothing, hardhat, and safety goggles. Workers' names, printed on their hardhats, were often difficult to see because of the small font and their downward gaze at the product being worked on.

CONCLUSIONS

The ability of workers to recall the frequency and duration of exposures that occur before their injury and during earlier control times is considered a potential limitation of case-crossover studies. In this group of volunteer uninjured workers, excellent to good agreement was found between observed and reported work location, tasks, and tools, as well as tool sharpening and the occurrence of break during the observation period. Poor agreement, however, was found for observed and reported equipment malfunction, line stoppages, being tired, unusual task, unusual work method, being distracted, rushing, slip, or fall.

It was assumed that these results would hold for injured workers, but they may not.

Because self-reported exposures are utilized in many occupational injury studies, future studies should continue to improve methods to evaluate exposure validity. Methodological improvements may be achieved by (1) detailing the definition of each transient risk factor in the workers' own words from focus groups and agreed-upon photographs, (2) asking workers to keep track of transient exposures at the end of each shift on a checklist themselves and compare with what was observed during that same shift, (3) interview each co-worker on either side of the injured worker about what happened at the time of injury and during control periods. Valid exposures will allow researchers to better understand injury etiology and ultimately prevent injuries from occurring.

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REFERENCES

Anveden I, Lidén C, Alderling M, Meding B. 2006. Self-reported skin exposure-validation of questions by observation. Contact Dermatitis 55:186–191.

Bureau of Labor Statistics. 2006. http://www.bls.gov/iif/oshwc/osh/os/ostb1765.pdf. Accessed November 20, 2006.

Checkoway H, Pearce N, Kreibel D. 2007. Selecting appropriate study designs to address specific research questions in occupational epidemiology. Occup Environ Med 64:633–638.

Chow CY, Lee H, Lau J, Yu ITS. 2007. Transient risk factors for acute traumatic hand injuries: a case-crossover study in Hong-Kong. Occup Environ Med 64:47–52.

Cozby PC. 1985. Chapter 9: Measurement. In: Methods in behavioral research. Third ed. Palo Alto, California: Mayfield Publishing Company.

Fleiss J. 1981. Statistical Methods for Rates and Proportions. New York: Wiley & Sons.

Jalaludin B, Khalaj B, Sheppeard V, Morgan G. 2008. Air pollution and ED visits for asthma in Australian children: a case-crossover analysis. Int Arch Occup Environ Health 81:967–974.

Landis J, Koch G. 1977. An application of the hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. Biometrics 33:363–374.

Lombardi DA, Sorock GS, Lesch MF, Hauser R, Eisen EA, Herrick RF, Mittleman MA. 2002. A reliability study of potential risk factors for acute traumatic occupational hand injuries. Am J Ind Med 42:336–343.

Lusk SL, Ronis DL, Baer LM. 1995. A comparison of multiple indicators-observations, supervisor report, and self-report as measures of workers' hearing protection use. Eval Health Prof 18:51–63.

Maclure M. 1991. The case-crossover design: a method for studying transient effects on the risk of acute events. Am J Epidemiol 133:144–153.

Maclure M, Mittleman MA. 2000. Should we use a case-crossover design? Annu Rev Public Health 21:193–221.

Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE for the Determinants of Myocardial Infarction Onset Study Investigators. 1993. Triggering of acute myocardial infarction by heavy physical exertion—Protection against triggering by regular exertion. N Engl J Med 329:1677–1683.

Moller J, Hessen-Soderman AC, Hallqvist J. 2004. Differential misclassification of exposure in case-crossover studies. Epidemiology 15:589–596.

Oh SS, Mayer JA, Lewis EC, Slymen DJ, Sallis JF, Elder JP, Eckhardt L, Achter A, Weinstock M, Eichenfield L, Pichon LC, Galindo GR. 2004. Validating outdoor workers' self-report of sun protection. Preventive Medicine 39:798–803.

Redelmeier DA, Tibshirani RJ. 1997. Association between cellular-telephone calls and motor vehicle collisions. N Engl J Med 336:453–458.

Shrout PE, Fleiss JL. 1979. Intraclass correlations: Uses in assessing rater reliability. Psychol Bull 86:420–428.

Sorock GS, Lombardi DA, Hauser RB, Eisen EA, Herrick RF, Mittleman MA. 2001. A case-crossover study of occupational traumatic hand injury: methods and initial findings. Am J Ind Med 39:171–179.

Sorock GS, Lombardi DA, Hauser RB, Eisen EA, Herrick RF, Mittleman MA. 2002. Acute traumatic occupational hand injuries: type, location, and severity. J Occup Environ Med 44:345–351.

Sorock GS, Lombardi DA, Hauser R, Eisen EA, Herrick RF, Mittleman MA. 2004a. A case-crossover study of transient risk factors for occupational acute hand injury. Occup Environ Med 61:305–311.

Sorock GS, Lombardi DA, Peng DK, Hauser R, Eisen EA, Herrick RF, Mittleman MA. 2004b. Glove use and the relative risk of acute hand injury: a case-crossover study. J Occup Environ Hyg 1:182–190.

Villeneuve PJ, Chen L, Rowe BH, Coates F. 2007. Outdoor air pollution and emergency department visits for asthma among children and adults: a case-crossover study in northern Alberta, Canada. Environ Health 6:40.