ORIGINAL ARTICLE

Transient risk factors for acute traumatic hand injuries: a case-crossover study in Hong Kong

C Y Chow, H Lee, J Lau, I T S Yu

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See end of article for authors' affiliations

Correspondence to:
Dr I T S Yu, Department of
Community and Family
Medicine, 4th Floor, School
of Public Health, Prince of
Wales Hospital, Shatin,
Hong Kong SAR, China;
iyu@cuhk.edu.hk

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Objectives: To identify the remediable transient risk factors of occupational hand injuries in Hong Kong in order to guide the development of prevention strategies.

Methods: The case-crossover study design was adopted. Study subjects were workers with acute hand injuries presenting to the government Occupational Medicine Unit for compensation claims within 90 days from the date of injury. Detailed information on exposures to specific transient factors during the 60 minutes prior to the occurrence of the injury, during the same time interval on the day prior to the injury, as well as the usual exposure during the past work-month was obtained through telephone interviews. Both matched-pair interval approach and usual frequency approach were adopted to assess the associations between transient exposures in the workplace and the short-term risk of sustaining a hand injury.

Results: A total of 196 injured workers were interviewed. The results of the matched-pair interval analysis matched well with the results obtained using the usual frequency analysis. Seven significant transient risk factors were identified: using malfunctioning equipment/materials, using a different work method, performing an unusual work task, working overtime, feeling ill, being distracted and rushing, with odds ratios ranging from 10.5 to 26.0 in the matched-pair interval analysis and relative risks ranging between 8.0 and 28.3 with the usual frequency analysis. Wearing gloves was found to have an insignificant protective effect on the occurrence of hand injury in both analyses.

Conclusions: Using the case-crossover study design for acute occupational hand injuries, seven transient risk factors that were mostly modifiable were identified. It is suggested that workers and their employers should increase their awareness of these risk factors, and efforts should be made to avoid exposures to these factors by means of engineering and administrative controls supplemented by safety education and training.

The hands are known to be the most commonly injured body parts in traumatic occupational injuries.¹ The incidence rate of occupational traumatic hand injuries varies across different industries, ranging from 4 to 11 per 100 workers per year.² Very few papers have been published so far on the acute transient risk factors of occupational hand injuries; they have mostly arisen from studies conducted by the same group of researchers in the northeastern United States.^{3–5}

In Hong Kong, a major metropolis in Southern China with receding industrial activities, occupational traumatic hand injury is still one of the leading work-related injuries.⁶ Although the number of occupational traumatic hand injuries, which peaked in 1988, has been declining over the years, the current local incidence is still comparable to overseas figures. Despite the magnitude of occupational hand injuries in Hong Kong, little research has been done to investigate the associated transient risk factors. Most of the past studies were hospital-based case series and were conducted years ago when industrial activities were prevalent.^{7–8} The current study was undertaken to identify the remediable transient risk factors of occupational hand injuries in Hong Kong in order to guide the development of prevention strategies.

METHODS

An interview-based, case-crossover study was designed to assess the transient risk factors for acute occupational hand injuries. The case-crossover study design was introduced in 1991 to evaluate the effect of a brief exposure on the acute onset of an outcome.⁹ Its key feature is to allow cases to serve as their own controls by comparing the exposures during the hazard period to those during the control period. This design

has been shown to be the most suitable method in studying the effect of transient factors in causing an acute event, including acute occupational traumatic injuries.

Study subjects were recruited from the Occupational Medicine Unit (OMU) of the Labour Department in Hong Kong in November 2002. All employers in Hong Kong are required to report to the Commissioner for Labour any non-fatal work injuries within 14 days.¹⁰ The OMU will then interview the injured workers for clearance of sick leave and

Table 1 Occupational background of the subjects and the types of injuries

	No	%
Job categories		
Construction site worker	43	22.3
Machine operator/maintenance worker	38	19.8
Cook	28	14.6
Clerical and sales	25	13.0
Services	17	8.9
Cleaner	15	7.8
Professional	5	2.6
Others	21	10.9
Types of injuries		
Laceration	85	44.3
Contusion	59	30.7
Puncture	23	12
Abrasion	7	3.6
Fracture	18	9.4

preliminary assessment for compensation. Permission to conduct the study at the OMU was obtained from the Occupational Health Services of the Labour Department.

Patient selection

Study subjects were those presenting to the OMU within 90 days from the date of injury with at least one or more of the following types of injury to the fingers, hand, or wrist: laceration, contusion, puncture, abrasion or fracture. Sprain and strain injuries were excluded because of the uncertain time of onset. Needle-stick injuries were excluded because there was no need for clearance of sick leave. Informed verbal consent was obtained from the eligible subjects when they attended the OMU. Subjects who agreed to join the study provided contact telephone numbers for subsequent interviews.

Data collection

A telephone interview with each included subject was performed to obtain the necessary information by a single investigator (CYC). A patient was considered unreachable after at least three unanswered telephone calls were made. Considering the variety of working conditions and procedures in Hong Kong, a structured questionnaire was specially designed to collect the background demographic data and the detailed exposure information during the 60 minutes prior to the occurrence of the injury, during the same time interval on the day prior to the injury, as well as the usual exposure during the past work-month. The questionnaire was written in Chinese in order to avoid unnecessary semantic misunderstanding. The questionnaire was pilot tested to ensure it was understandable by the subjects. To improve the recall of the injury event, the subjects were asked an open-ended question to describe the circumstances of the accident, restate the injury time and report the work tasks during the hour just before the injury. Questions assessing exposures to specific transient risk factors during the 60-minute period (in 10-minute intervals) before the injury were asked and the answers were recorded on a work-time-before-injury log by the interviewer.¹¹ The eight transient risk factors included those studied by Sorock *et al*: using malfunctioning machine, tools, or work material; performing an unusual work task; being distracted; rushing; feeling ill; working overtime; and wearing gloves.³ Information on exposures to these factors at the same time period of the injury on the previous workday was also collected.

The subjects were also asked to estimate the usual frequency and average duration (in minutes or hours) of each episode of exposure to every potential risk factor in the past work-month. The total exposure to each transient factor was then calculated by multiplying the reported usual frequency by the corresponding average duration.

Reliability of exposures assessment

It is possible that self-report statements rather than objective records of exposures could be distorted by recall bias.^{12,13} The test-retest reliability was assessed by re-interviewing 30 subjects randomly selected within seven days after the initial interview using the sections on exposure information in the original questionnaire. Information was also collected from the workmates of these selected cases to verify the exposures to malfunctioning equipment in the same workshops on the day of the injury, one week before and one week after the incident.

Data analysis

Standard methods for stratified analyses of case-crossover studies were used.^{9,14} Eight transient risk factors associated with the occurrence of occupational hand injuries previously identified³ were evaluated. Both matched-pair interval approach and usual frequency approach were adopted to assess the associations between transient exposures in the workplace and the short-term risk of sustaining a hand injury.¹⁵ While the 10-minute period before the injury was demonstrated to work effectively as the hazard period for capturing information on exposures,³ different control periods were used in the two approaches. In the matched-pair interval analysis, a comparison was made between the exposure to each transient risk factor in the hazard period, defined as 10 minutes before the injury, and the exposure in the control period, another 10-minute period during the same time interval on the day prior to the injury. This analysis was analogous with a one-to-one matched case control study and therefore could be analysed using McNemar's test with continuity correction. The control period in the usual frequency analysis was defined as the average amount of work-time exposures in the past work-month. Relative risk estimates are based on the ratio of the observed frequency of exposure to each transient factor at the time of the injury to the expected frequency of exposure in the past work-month. The relative risk and 95% confidence intervals were estimated using the Mantel-Haenszel estimator for person-time data.¹⁶

The reliability of the self-reported exposures of each potential risk factor in the past work-month before the accident was evaluated by calculating the intra-class correlation coefficients (ICC).¹⁷ Cohen's kappa coefficient was utilised to analyse the degree of agreement between the initial and the follow-up interviews in reporting the exposures of potential risk factors at the time of the injury.¹⁸ Exposure information obtained from the follow-up interviews with both the 30 selected subjects and their workmates was compared to that of the initial interviews.

RESULTS

A total of 210 subjects were successfully recruited from 263 eligible patients attending the OMU in November 2002. The

Table 2 Matched pair interval analysis of the eight transient risk factors

Transient risk factor	Exposed only in hazard period	Exposed only in control period	Exposed in both periods	Odds ratio	95% CI
Malfunctioning equipment/ materials	42	2	10	21.0	5.5-179
Unusual work method	26	1	5	26.0	4.3-1065
Unusual task	20	1	8	20.0	3.2-828
Distracted	21	2	4	10.5	2.6-92.4
Rushed	31	2	17	15.5	3.9-134
Feeling ill	7	0	0	infinite	-
Working overtime	10	0	6	infinite	-
Wearing gloves	18	22	10	0.818	0.41-1.59

CI, confidence interval.

Table 3 Usual frequency analysis of the eight transient risk factors

Transient risk factor	No of subjects exposed in the hazard period	Relative risk	95% CI
Malfunctioning equipment/materials	53	28.3	14.4–55
Unusual work method	31	11.5	5.6–23.5
Unusual task	28	16.2	8–33.1
Distracted	25	22.3	6.4–77.5
Rushed	48	11.9	6.0–23.8
Feeling ill	7	18.3	3.7–33.4
Working overtime	16	8.0	2.82–22.2
Wearing gloves	28	0.71	0.38–1.34

CI, confidence interval.

most common reason for refusal to join the study was lack of time for the interview. Among the 210 cases, 196 (93%) were successfully interviewed; 7% were unreachable through the telephone number provided. Four subjects were excluded from the data analysis because of poor data quality caused by language barriers in information collection, leaving 192 subjects. The initial telephone interview was conducted 31–89 days after the injury, with the median interval being 61 days. Each interview lasted for 15 minutes on average.

The mean age of this sample population was 38.6 (SD 11.1) years; 141 (73.4%) of the subjects were males. There were 61 (31.8%) smokers and 176 (91.6%) drinkers. The mean working experience was 78.6 (SD 69.4) months; they worked for a mean (SD 6.3) of 54.2 hours per week. As listed in table 1, the four major job categories with the most job-related hand injuries were construction site worker (22.3%), machine operator/maintenance worker (19.8%), cook (14.6%), and clerical and sales staff (13%). The majority of the subjects suffered from lacerations (44.3%), followed by contusions (30.7%), punctures (12%), fractures (9.4%), and abrasions (3.6%). The injuries occurred evenly from Monday to Friday (16% each); 10% of the injuries occurred on Saturdays and 9% on Sundays. The largest proportion (21.8%) of hand injuries occurred between 10 00 am and 10 59 am. In our study, right hand injuries (68%) were more common than left hand injuries (32%).

The results of the matched-pair interval analysis are shown in table 2. The risk of occupational traumatic hand injury was significantly increased with exposure to the following five transient factors: using malfunctioning equipment/materials, using a different work method, performing an unusual work task, being distracted, and rushing. The wide 95% confidence interval of the odds ratios for these transient factors, however, indicated that they might be unstable. Wearing gloves decreased the odds ratio slightly but not significantly. The odds ratios for feeling ill and working overtime could not be calculated because no subjects reported these two exposures only in the control period. By adding 0.5 to the control period, the estimated odds ratios for feeling ill and working overtime would be 14 (95% CI 2.1 to 592) and 20 (95% CI 3.2 to 829) respectively.

Results of the usual frequency analysis of the transient risk factors are shown in table 3. Statistically significant associations were found between the occurrence of hand injury and the exposures to these seven factors: using malfunctioning equipment/materials, using a different work method, performing an unusual work task, working overtime, feeling ill, being distracted, and rushing. Wearing gloves was found to have an insignificant protective effect on the occurrence of hand injury.

To evaluate the reliability and validity of self-reported exposure of the transient risk factors, 30 subjects were recruited

randomly for a follow-up interview. Both the demographic characteristics and types of injuries between these subjects and others without the follow-up interview were similar. Table 4 shows the number of exposed and unexposed subjects to each transient factor in the initial and the follow-up interviews together with the corresponding kappa statistics. The kappa statistics ranged from 0.62 to 1 for the transient risk factors, which represented substantial to perfect agreement. In addition, moderate agreement was shown between the self-reported and the workmate-reported exposure to malfunctioning equipment/materials during the hazard period (kappa = 0.56, 95% CI 0.20 to 0.91). The reliability of the usual frequency of exposure to various transient risk factors was assessed by the ICC. Table 5 shows the hours of exposure to the eight transient risk factors in the previous work-month preceding the injury and their corresponding ICC, which ranged from 0.71 to 0.98. The reliability was highest (ICC > 0.9) for feeling ill, working overtime, wearing gloves, and using a different work method, while that for other risk factors was in the range of moderately reliable (ICC > 0.8) to acceptable (ICC > 0.7) level.

DISCUSSION

Occupational hand injuries were shown to cause significant long-term hand function impairment and require intensive rehabilitation.¹⁹ The case-crossover design was used in our study to identify the transient risk factors associated with the occurrence of acute traumatic occupational hand injuries. Seven transient risk factors, namely using malfunctioning equipment/materials, using a different work method, performing an unusual work task, working overtime, feeling ill, being distracted, and rushing, were shown to be positively associated with the occurrence of occupational traumatic hand injuries. The use of gloves, on the other hand, was negatively associated with occupational hand injuries, but not statistically significant.

Both the matched-pair interval and usual frequency approaches were used to evaluate the association of the exposures and the hand injury risk; both methods showed that the seven transient risk factors increased the risk of occupational hand injuries. However, the 95% confidence intervals by the matched-pair interval approach were much wider than those obtained by the usual frequency approach. The wide 95% confidence intervals by the matched-pair interval approach reflected that the odds ratio was unstable and probably unreliable. Such a finding was consistent with the results in other case-crossover studies³ as well as demonstrated by Mittleman *et al.*²⁰ This study confirmed that the usual frequency approach might be more appropriate for future studies investigating transient risk factors of hand injuries at work.

Although comparable to the statistics in a descriptive study in Shanghai, China,²¹ our results showed different patterns of occupational hand injuries from that revealed in the previous studies in the northeastern United States.^{3–5} For instance, our subjects had fewer lacerations (44.3%) but more types of other injury. This might have resulted from the differences in the economy and thus the range of industries; 22.4% and 19.8% of our subjects were construction site workers and machine operators/maintenance workers, respectively, compared to 15% and 42% respectively in the study by Sorock *et al.*⁴ On the other hand, the study by Sorock *et al.*, using the usual frequency approach, also found that using malfunctioning equipment/materials, using a different work method, doing an unusual work task, being distracted, being rushed, and feeling ill were positively associated with the occurrence of occupational hand injuries. Furthermore, our relative risk estimates on two risk factors (using malfunctioning equipment/materials, doing an unusual work task) were very similar to those

Table 4 Self-reported exposure to risk factors at the time of the injury in the initial and follow-up interview and the corresponding kappa statistics

	(n = 30)					
	Exposed		Unexposed			
Transient risk factor	Initial	Follow-up	Initial	Follow-up	Kappa statistics	95% CI for kappa
Malfunctioning equipment/ materials	7	5	23	25	0.79	0.52–1.07
Unusual work method	4	3	26	25	0.71	0.33–1.10
Unusual task	7	6	23	21	0.73	0.45–1.02
Distracted	4	4	26	25	0.87	0.62–1.21
Rushed	7	5	23	21	0.63	0.29–0.97
Feeling ill	2	0	28	0	1.0	1.0
Working overtime	3	3	27	24	0.62	0.2–1.03
Wearing gloves	8	6	22	20	0.66	0.35–0.97

CI, confidence interval.

obtained in a previous case control study by Hertz and Emmett.²² McGwin *et al* also found that performing an unusual job task and using an unusual tool were transient risk factors for a group of 33 workers with various types of occupational injuries.²³ As these transient risk factors are all potentially modifiable, controlling them in the work environment could effectively reduce the risk for occupational hand injury. Our study found that glove use could be a protective measure against hand injuries at work, though the associations were not statistically significant. This protective effect was also detected in another study by Sorock *et al*, which showed that glove use was protective against hand laceration and puncture injuries but not other injury types.⁵

We utilised a case-crossover study design, which is particularly suitable for evaluating risk factors that change over the study period and is increasingly being used to evaluate the transient risk factors related to acute injury.¹⁷ Self-selection bias, however, could exist in the study; for example, if exposure to some transient risk factors could have an influence on their willingness to participate in the study, then over- or under-estimation of the relative risk of such factors might occur. However, a high response rate of 93% meant that such a bias, if present, was unlikely to be serious. Information bias could be present if the details of exposures were asked differently for the hazard and control periods. This was minimised by utilising a well-structured questionnaire and only one investigator to conduct the interviews. We used 10 minute intervals as the basis for collecting information on transient risk factors; misclassification could occur if the exposure started 10 minutes before the time of the injury and stopped before the injury

occurred. A more refined exposure log could have helped. When the subjects serve as their own controls, the potential inter-person confounding factors, for example age, sex, job experience, injury history, or risk-taking behaviour, are controlled perfectly. The cost and time to conduct a case-crossover study are less in comparison with a similar study with the conventional case-control design, and the potential selection bias for the controls is also eliminated.¹³ Such a design, however, is not appropriate for the evaluation of fixed risk factors for injury, i.e. factors that do not change in a particular subject over the study period. Furthermore, it may be difficult to select an appropriate control period for comparison.

When retrospective data collection is involved in a case-crossover study, the data collected may be vulnerable to recall bias, which is known to be a major methodological limitation in this study design. When the subjects are interviewed up to 1.5 months after the injury, the reliability of the self-reported exposure to various transient risk factors may be difficult to maintain. It has been demonstrated that an overestimation by recall of the frequency of events for a given time interval in the past could occur because people mistakenly imported events that actually happened earlier than the specified time interval, the so-called telescoping phenomenon.²⁴ This is particularly relevant when recalling personal events more than two months old, and thus prone to occur in our study. We suggest that further studies are conducted in the emergency departments of regional hospitals so that recall bias can be minimised by shortening the lag time between injury and interview. Lombardi *et al*¹⁸ showed a high reliability of self-reported exposure of transient risk factors for occupational hand

Table 5 Self-reported hours of exposure to risk factors in the preceding month and the intra-class correlation coefficient (ICC) for the initial and follow-up interview

Transient risk factor	Reported hours (n = 30)		ICC	95% CI for ICC
	Initial interview	Follow-up interview		
	Mean (SEM)	Mean (SEM)		
Malfunctioning equipment/materials	3.23 (2.2)	2.7 (1.92)	0.86	0.72–0.93
Unusual work method	2.0 (2.2)	2.21 (2)	0.93	0.85–0.96
Unusual task	1.4 (1.6)	1.63 (1.72)	0.71	0.48–0.85
Distracted	2.9 (2.16)	2.12 (1.69)	0.77	0.58–0.89
Rushed	11.24 (4.1)	9.8 (3.81)	0.81	0.64–0.90
Feeling ill	0.67 (1.35)	0.77 (1.47)	0.98	0.96–0.99
Working overtime	4.33 (3.2)	3.53 (2.83)	0.91	0.81–0.95
Wearing gloves	28.6 (6.8)	26.4 (6.2)	0.91	0.81–0.95

SEM; standard error of mean; CI, confidence interval.

Main messages

- The case-crossover design is appropriate for studying transient risk factors leading to acute occupational hand injuries in Chinese workers.
- Seven transient risk factors are associated with the occurrence of acute occupational hand injuries: using malfunctioning equipment/materials, using a different work method, performing an unusual work task, working overtime, feeling ill, being distracted, and rushing at work.

Policy implications

- The identification of transient risk factors associated with acute occupational hand injuries will help raise the awareness among workers and employers.
- Efforts should be made to avoid exposures to these factors by means of engineering and administrative controls supplemented by safety education and training.

injuries, but only limited to a period of 4 days after the first interview. In our study, the moderate to high Cohen's kappa coefficients suggested good test-retest reliability for the self-reported exposures. The intra-class correlation coefficients calculated for various risk factors also confirmed a high reliability. The good reliability of self-reported exposures in our study might be explained by the fact that all subjects would have already been interviewed once regarding the injury by the staff of the OMU during the process of clearance for sick leave, and this might improve the recall of the injury event in the subsequent telephone interview. In addition, the interview was standardised to begin with an open-ended question asking the subject to describe the whole event of the injury, which might also improve the recall and the reliability of the self-reported exposures. The self-reported exposures to malfunctioning equipment/materials during the hazard period were validated by requesting the same information from the workmates of the subjects. Cohen's kappa coefficient (0.56, 95% CI 0.2 to 0.91) suggested a fair agreement between the subjects and the workmates on reported exposures to malfunctioning equipment/materials. The validation of the other self-reported exposures, however, was difficult when no reliable external information could be obtained for comparison.

While the inter-person confounders were well controlled in a case-crossover study with the subjects serving as their own controls, the within-person confounders might still exist, especially for multiple, correlated, transient factors which changed over the study period within a subject,^{3 13} for example if the exposures to two risk factors were correlated in time. This could be explored by subgroup analysis in the matched-pair interval approach. Unfortunately, the sample size in this study was not large enough for performing such subgroup analysis. For the usual frequency approach, since only the average duration of exposure to risk factors was collected, no data were available for estimating the duration of the co-occurrence of two or multiple risk factors in the month prior to the hand injury. If such information were available, conditional logistic regression might be employed to control the within-subject confounding of two or more risk factors. Hence, the possible effects of the within-subject confounders were still unknown in

this study. We did not specifically look into the effects of alcohol and medication as possible confounding factors. Although 92% of the subjects reported drinking alcohol, it was most unlikely that they did so at work. A previous study on occupational injuries among construction workers in Hong Kong did not support alcohol drinking to be an important risk factor.²⁵

Our study confirmed that the case-crossover study design was feasible for assessing the effect of transient risk factors on the occurrence of occupational hand injury in Chinese workers. It might also be employed for studying other transient risk factors on the occurrence of different types of occupational injuries. We identified seven transient risk factors that were mostly modifiable. It is suggested that the workers and their employers should raise their awareness to these risk factors and efforts should be made to avoid exposures to these factors by means of engineering and administrative controls supplemented by safety education and training.

Authors' affiliations

C Y Chow, Occupational Health Services, Labour Department, Hong Kong SAR Government, China

H Lee, J Lau, I T S Yu, Department of Community and Family Medicine, The Chinese University of Hong Kong, Hong Kong SAR, China

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