Acute Traumatic Occupational Hand Injuries: Type, Location, and Severity

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The National Electronic Injury Surveillance System reports that the fingers and hand are the most frequent body parts injured at work and treated in hospital emergency departments. In this study, we describe the type, location, and severity of occupational hand injuries among 1166 patients recruited from 23 occupational health clinics in five New England states. Subjects ranged in age from 18 to 77 years, with a mean of 37.2 years (SD, 11.4), and approximately 75% were men. In decreasing order of frequency, subjects were employed in machine trades, service work, structural work, and less frequently, in benchwork, professional, technical managerial and clerical, and sales work. The majority of subjects (83.4%) had a single type of injury: 62.6% were lacerations, 13.1% were crush injuries, 8.0% were avulsions, and 6.1% were punctures. Metal items, such as nails, metal stock, and burrs accounted for 38.4% of the injuries, followed by hand tools with blades and powered machinery (24.4% and 12.3%, respectively). Hand tools with blades were least likely to result in multiple types of injuries, whereas powered machines or nonpowered hand tools were more likely to result in multiple types of injuries than other injury sources. The generalizability of these results should be limited to clinic-based patients employed in similar occupations. The results of this study may suggest possible prevention strategies for acute traumatic hand injuries. (J Occup Environ Med. *2002;44:345–351*)

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Acute traumatic hand injuries, which include lacerations, crushes, and fractures, are common at work. The National Electronic Injury Surveillance System reported that the fingers and hand were the most frequent anatomic sites injured at work and treated in hospital emergency departments.[1] In this setting, each year, at least 1,080,000 persons are treated for finger and hand injuries at work. The incidence is particularly high in industries and jobs in which hand-intensive work is necessary. The highest numbers and rates of acute hand and finger injuries are found in the manufacturing, construction, and retail industries. Such injuries are most likely to occur to machinery maintenance workers, machine operators, and tenders, craft and kindred workers, manual material handlers, and food preparation workers. In seven published epidemiological studies of injury in manufacturing environments, the annual incidence rate ranged from 4 to 11 injuries per 100 workers.[2] The most severe injuries (amputations) occur much less frequently, ranging from 0.01 to 0.04 per 100 workers per year. Surprisingly, given the frequency of acute trauma to the fingers and hand at work, very few large series of such cases have been described in the literature.

The Bureau of Labor Statistics provides details on hand injury cases involving at least 1 day away from work. According to Bureau data, workers with lacerations of the fingers and hand are second only to those with back strains, sprains, and tears in the number of cases involving days away from work (109,000 annually).[3] Courtney and Webster indicated that acute trauma accounts for the majority (70%) of upper extremity cases involving days away from work.[3] The median number of days away from work for the most common injury (finger laceration) was 3 days, for the most severe (finger amputation) the median was 22 days.[2]

In this study, we describe a large series of generally less severe but more common hand injuries. These cases were primarily treated in free-standing occupational health clinics, where the rate of hand injuries has been reported to be 2.3 per 100 workers per year,[4] and they tended to involve less than 1 lost day of work. This report describes the type, location, and severity of 1166 workers with acute traumatic hand injury. In addition, we describe the source of injury and the occupation of the injured workers.

Patients and Methods

Study Population

The study methods have been published in detail elsewhere[5] and are briefly summarized here. Subjects were recruited over a 3-year period (September 1997 to November 2000) from 23 occupational health clinics in five New England states: Massachusetts, Connecticut, Rhode Island, Vermont, and Maine. The recruitment sites included 16 free-standing outpatient clinics as part of two large networks of occupational health clinics, three manufacturing companies, two hospital-based and one rehabilitation-based occupational health care centers, and one hand surgical practice.

To be eligible for the study, subjects must have had one or more of the following types of injury to the fingers, hand, or wrist: laceration, crush, avulsion, puncture, fracture, contusion, amputation, or dislocation, and they must have reported for clinic treatment within 36 hours of the time of the injury. After the subjects were asked to give their written informed consent for a telephone interview, a clinician reported the date, time, type, and severity of injuries on a case information form. The case information form also included a hand diagram to identify the location of the injury, total length of laceration, and number of sutures, and any tendon, ligament, or nerve involvement. Both forms were faxed to the data-coordinating center and then sent to interviewers, who conducted the telephone interviews. Self-reported information was collected using the Hand Injury Study structured questionnaire. This instrument was designed to elicit detailed information on transient exposures that preceded the onset of the hand injury and other data relating to the subject's work equipment, work practices, and worker- and workplace-related factors. The study was approved by the Harvard School of Public Health Human Subjects Committee and the Liberty Mutual Research Center Institutional Review Committee.

A total of 1616 subjects agreed to participate at the clinic sites. Of this total, 94 were not called for an interview for the following reasons: failure to meet the entry criteria (n = 35), too much time between injury date and time of proposed interview (n = 32), or did not have a fully completed informed consent form (n = 27). Of the remaining 1522 subjects eligible for an interview, 1179 (77.5%) completed the interview using a structured questionnaire and are included in the analysis.

Interviews were not completed on 343 subjects for the following reasons: an answering machine was reached or the subject was not at home after three attempts (n = 244), a wrong or nonworking phone number was provided (n = 58), the injury did not meet the study criteria after speaking with the subject (n = 15), refusal to be interviewed (n = 14), language barrier (n = 10), and other (n = 2). Thirteen subjects who were interviewed were excluded from further data analysis because of the following: four subjects had burn injuries, two had sprain injuries, two had a previous injury, four had poor quality of responses during the interview, and one injury was caused by the subject's violent behavior. Therefore, the final total for evaluation was 1166 subjects.

Coding of Occupation and Source of Injury

We coded occupation according to the 1990 *Dictionary of Occupational Titles*[6] using the job title and the three most commonly performed tasks reported by the subject. The source of injury was coded according to an earlier Bureau of Labor Statistics study of hand injury.[7]

Injury Severity

Injury severity was determined using two methods. The first was the Hand Injury Severity Score.[8] This scale is based on the magnitude of injury to skin, skeletal, and soft tissues and has been used primarily with surgically treated patients. The Hand Injury Severity Score is categorized into three categories (I, minor; II, moderate; III, severe) based on the type of injury (eg, crush, laceration, etc), extent of injury (eg, length of laceration), location of injury (eg, thumb, hand, or finger involvement), and on the tissue(s) involved. The second method categorized subjects into two groups: those with one type of injury (eg, crush) versus those with two or more injury types (eg, laceration and crush).

Comparison With Source Data Clinics

The 16 free-standing clinics from two large clinic networks (Occupational Health + Rehabilitation and Industrial Health Care, Inc) provided age and gender distributions of all patients with hand injuries, including their International Classification of Disease, 9th Revision, codes for the two similar years of data collection. We compared the distributions of our subjects by age, gender, and type of injury to determine whether our vol-

TABLE 1

Characteristics of Hand Injury Study Subjects From Occupational Health Clinics in New England (1997–2000)

Characteristic	Male (*N* = 891)		Female (*N* = 275)		*P* Value
	n	%	*n*	%	
Age* (yr)					0.01
<25	140	15.9	43	15.9	
25–34	284	32.2	70	25.8	
35–44	263	29.8	69	25.5	
45–54	134	15.2	62	22.9	
55–64	51	5.8	24	8.9	
65+	11	1.2	3	1.1	
Race/ethnicity†					0.47
White/non-Hispanic	537	78.1	184	75.1	
Hispanic	81	11.8	32	13.1	
Black/non-Hispanic	39	5.7	20	8.2	
Other	31	3.4	9	3.2	
Handedness					0.95
Right	774	86.9	240	87.3	
Left	98	11.0	32	11.6	
Ambidextrous	7	0.8	2	0.7	
Hand injury in previous year					0.11
Yes	109	16.1	28	11.7	
No	588	83.9	212	88.3	
Job experience					0.02
Months ± SEM‡	81.6 ± 3.2		66.8 ± 5.2		
Occupational category					<0.01
Machine trades	323	36.3	60	21.8	
Construction	163	18.3	9	3.3	
Service	101	11.3	73	26.5	
Packaging and material handling	81	9.1	27	9.8	
Benchwork	68	7.6	35	12.7	
Clerical/sales	49	5.5	21	7.6	
Prof/tech/managerial	48	5.4	37	13.5	
Miscellaneous	58	6.5	13	4.7	
Company size					0.12
<50	296	42.9	88	36.1	
50–249	239	34.6	79	32.3	
250–499	66	9.6	30	12.3	
500–999	34	4.9	17	7.0	
1000+	35	5.0	19	7.8	
Unknown	20	2.9	11	4.5	

* Age was missing for 12 subjects, handedness for 13, and job experience for 19.

† Race/ethnicity, hand injury in the past year, and company size were collected in final 2 years of study only; therefore, totals will differ for these variables.

‡ SEM, standard error of the mean.

unteer sample was comparable with all patients with hand injuries presenting at these 16 clinics.

Data Analysis

Means and standard errors were calculated for continuous variables, and cross-tabulations were calculated for frequency counts of categorical variables. Statistical comparisons between men and women for categorical variables was made using Fisher's exact test or a chi-squared test of independence, as appropriate. Continuous variables (eg, job experience) were compared using a two-sample *t* test.

Results

Subject Characteristics

The age distribution of the study population, stratified by gender, is presented in Table 1. There were 891 (76.4%) men and 275 (23.6%) women in the study. The subjects ranged in age from 18 to 77 years old (mean ± SD, 37.2 ± 11.4 years; median, 36.1 years). Seventy-five percent of subjects were younger than 44 years old. The women tended to be older than the men. Most subjects were white/non-Hispanic and right handed. Men were more likely than women to have reported another work-related hand injury in the past year.

Women had fewer months of job experience than men. Men tended to be employed by companies with fewer than 250 employees more often than women. Compared with men, women were more frequently employed in ser-

TABLE 2
Type, Number, and Location of Injury

Injury Characteristic	*n*	%
Type of injury*		
Laceration	877	62.6
Crush	183	13.1
Avulsion	112	8.0
Puncture	86	6.1
Fracture	67	4.8
Contusion	58	4.1
Amputation	16	1.1
Dislocation	2	0.1
Total	1,401	
No. of injury types		
One	972	83.4
Two	153	13.1
Three or more	41	3.5
Total	1,166	
Location on finger*,†,‡		
Distal	600	57.6
Medial	277	26.6
Proximal	165	15.8
Total	1,042	

* Subjects may have more than one type of injury and/or finger location.

† In addition, there were 200 injuries to the hand and 14 to the wrist.

‡ Injuries to the middle of the thumb were classified as medial.

vice work (26.5% vs 11.3%); in professional, technical, and managerial positions (13.5% vs 5.4%); and in benchwork (12.7% vs 7.6%).

Injury Characteristics

The types and locations of the injuries are presented in Table 2. Most patients (83.4%) had only a single type of injury (ie, laceration or crush only). Because 194 patients had multiple types of injuries, a total of 1401 injuries were recorded among the 1166 patients. Overall, 62.6% of the injuries were lacerations, 13.1% were crush injuries, 8.0% were avulsions, and 6.1% were punctures. There were very few amputations and dislocations. The average total laceration length was 2.0 ± 1.2 cm, requiring an average of 4.5 ± 2.3 sutures. There were very few subjects with tendon ($n = 27$), nerve ($n = 9$), or ligament ($n = 4$) damage from their hand injury. Of the 1042 finger injuries, most occurred to the distal (57.6%), followed by the medial (26.6%), and proximal (15.8%) phalanx of the finger.

Table 3 shows the location of injury stratified by type among patients with a single type of injury. The majority of injuries were to the index, thumb, and middle fingers, with the highest percentage of injuries occurring to the index finger. The frequency of crushes to the ring finger was also high (18.3%). The palm of the hand was more often injured than the back of the hand, except for crush and avulsion injuries. The nondominant hand was injured more often than the dominant hand: right-handed people injured their left hand more frequently (55.4%); left-handed people injured their right hand more often (57.7%).

Hand Injury Severity Score

Using the Hand Injury Severity Score in this series of patients, 97.2% ($n = 830$) of injuries were categorized as minor, 2.6% ($n = 22$) as moderate, 0.2% ($n = 2$) as severe, and 315 were not classifiable because the Severity Score was not appropriate or lacked information for the type of injuries. Because nearly all injuries were minor and a large number were not classifiable, we did not perform further analysis using the Hand Injury Severity Score.

Single Versus Multiple Types of Injury

Two or more types of injury occurred to 194 (16.6%) subjects. Table 4 presents data on occupational group and injury source stratified by the number of types of injuries. We categorized the source of injury based on the patient's description of the circumstances of the injury. The categories consisted of metal items, hand tools with blades, powered machines, nonmetal items, other powered machines, and other nonpowered hand tools. In addition, 61 injuries had miscellaneous injury sources that were not otherwise classified. Metal items, such as nails, metal stock, and burrs, accounted for 38.4% of the injuries. Hand tools with blades and powered machines each accounted for 24.4% and 12.3% of the injuries, respectively. The remaining three categories each accounted for less than 10% of the injuries.

Overall, single injury types were more common than multiple injury types (Table 4). However, the percentage of multiple injury types varied for some occupational categories. Service work was associated with the lowest likelihood of multiple types of injury (7.5%). Machine trades, structural work, and clerical and sales were associated with a 17% to 20% likelihood of a multiple type of injury. Although the numbers of subjects were small, motor freight, within the miscellaneous category, was associated with a 42% likelihood of a multiple type of injury. It is important to note that occupational category and injury source may be related because specific tools and items are used within a given trade.

Overall, all sources of injury were more likely to result in a single injury type (83.4%) rather than multiple injury types. However, there was wide variability between sources in the likelihood of sustaining multiple injury types. Hand tools with blades were very unlikely to result in multiple injury types. At the other extreme, multiple types of injuries were more common among patients injured by other powered machines (36.1%) or other nonpowered hand tools (31%).

Table 5 presents data on a single type of injury by occupational category and injury source. Machine trades had the highest percentage of laceration, crush, and other injuries, whereas avulsion injuries were highest among service workers. The miscellaneous category accounted for 17% of all crush injuries. The injury source for 74% of the lacerations were metal items or hand tools with blades. No crush injuries (excluding multiple injury types) were reported while using hand tools with blades; however, 37% of the crushes involved powered machinery. Hand tools with blades (33.9%), powered machines (23.2%), and metal items

TABLE 3
Type and Location of Injury Among Patients With a Single Type of Injury

Location*	Laceration (N = 808) n	Laceration %	Crush (N = 82) n	Crush %	Avulsion (N = 60) n	Avulsion %	All Other† (N = 125) n	All Other† %
Finger								
Thumb	160	19.8	10	12.2	18	30.0	15	12.0
Index	206	25.5	24	29.3	19	31.7	32	25.6
Middle	131	16.2	15	18.3	13	21.7	18	14.4
Ring	83	10.3	15	18.3	3	5.0	12	9.6
Little	64	7.9	8	9.8	4	6.7	11	8.8
Wrist	14	1.7	0	0.0	0	0.0	0	0.0
Hand								
Palmer surface	91	11.3	2	2.4	0	0.0	27	21.6
Dorsal surface	59	7.3	8	9.8	3	5.0	10	8.0

* Subjects may have more than one finger location for each type of injury.
† The All Other category includes punctures, fractures, contusions, amputations, and dislocation.

TABLE 4
Single Versus Multiple Type Injuries by Occupational Category and Injury Source

	Injury Type* Single (N = 972) n	%	Multiple (N = 194) n	%
Occupational category				
Machine trades	308	80.4	75	19.6
Service	161	92.5	13	7.5
Structural work	143	83.1	29	16.9
Benchwork	91	88.3	12	11.7
Prof/tech/managerial	73	85.9	12	14.1
Clerical and sales	56	80.0	14	20.0
Miscellaneous	140	78.2	39	21.8
Packaging, material handling	89	82.4	19	17.6
Other	51	72.8	20	27.2
Injury source				
Metal items (nails, metal stock, burrs)	371	82.8	77	17.2
Hand tools with blades (utility knife, razors)	278	97.5	7	2.5
Powered machines (drills, slicers, presses)	114	79.2	30	20.8
Nonmetal items (glass, wood, tiles)	88	80.0	22	20.0
Other powered machines (stackers, folding machines)	57	64.0	32	36.0
Other nonpowered hand tools (hammers, screwdriver)	20	69.0	9	31.0
Not elsewhere classified	44	72.1	17	27.9

* An example of single type injury would be a laceration only, whereas a multiple type injury could be a laceration and a crush, or any other combination.

(21.4%) were involved in the majority of all avulsion injuries.

Comparison of Study Subjects With Clinic Population of Patients With Hand Injuries

The majority of study subjects ($n = 873$; 74.9%) were recruited from two large networks of occupational health clinics. The two clinic networks provided data that permitted the calculation of age, gender, and injury distributions for all patient visits for traumatic hand injuries for 1998 and 1999. The male-to-female ratio for the clinic patients ($n = 11,919$ visits) and the study subjects from the clinics ($n = 873$) were similar, ie, 76% male to 24% female. A majority of both the study and clinic populations were aged 20 to 39 years, 59% and 53%, respectively. The study population, however, consisted of patients with more lacerations than in the clinic population, 62% versus 56%. One major difference between the study and clinic populations was the number of individuals with contusions. In the study population, only 5% of subjects had

TABLE 5
Single Type of Injury by Occupational Category and Injury Source

	Type of Injury							
	Laceration (N = 747)		Crush (N = 60)		Avulsion (N = 56)		All Other* (N = 109)	
	n	%	n	%	n	%	n	%
Occupational category								
Machine trades	242	32.4	22	36.7	14	25.0	30	27.5
Service	131	17.5	4	6.7	20	35.7	6	5.5
Structural work	111	14.9	8	13.3	4	7.1	20	18.3
Benchwork	59	7.9	9	15.0	6	10.7	17	15.6
Prof/tech/managerial	55	7.4	3	5.0	4	7.1	11	10.1
Clerical and sales	39	5.2	4	6.7	1	1.8	12	11.0
Miscellaneous	110	14.7	10	16.7	7	12.5	13	11.9
Packaging, material handling	73	9.8	5	8.3	2	3.6	9	8.3
Other	37	4.9	5	8.3	5	8.9	4	3.7
Injury source								
Metal items (nails, metal stock, burrs)	301	40.3	19	31.7	12	21.4	39	35.8
Hand tools with blades (utility knife, razors)	254	34.0	0	0.0	19	33.9	5	4.6
Powered machines (drills, slicers, presses)	75	10.0	8	13.3	13	23.2	18	16.5
Nonmetal items (glass, wood, tiles)	57	7.6	7	11.7	7	12.5	17	15.6
Other powered machines (stackers, folding machines)	26	3.5	14	23.3	3	5.4	14	12.8
Other nonpowered hand tools (hammers, screwdriver)	13	1.7	1	1.7	0	0.0	6	5.5
Not elsewhere classified	21	2.8	11	18.3	2	3.6	10	9.2

* The All Other category includes punctures, fractures, contusions, amputations, dislocation.

hand contusions, whereas in the clinic population, 28% of patients had hand contusions. No data were available on the occupational distribution of the clinic-based population of patients with hand injuries.

Discussion

In the present study of 1166 subjects with hand injuries, 76% were men and 32% were aged 25 through 34 years. Laceration was the major type of injury, followed by crush and avulsion injuries. Metal items and hand tools with blades were most often the source of the injury. The index finger, particularly the distal phalanx, was most often the location of the injury. Injuries tended to be singular in nature and of minor severity, indicative of the sites from which we recruited subjects, which were primarily outpatient occupational health clinics. Workers with more severe injuries were likely sent to hospital emergency departments for treatment.

The results of this study should be limited to clinic-based patients employed in similar occupational categories. Although the age, gender, and injury types were similar, no data were available on the occupational distribution of the clinic-based population of patients with hand injuries.

There are two studies with which we can compare our data: a hand injury study in five occupational health clinics in the Midwest,[4] and a Bureau of Labor Statistics survey of hand injury cases involving more than 1 day away from work.[7] The leading sources of injuries in the Midwestern study and ours were somewhat different: metal items (30.3% in the Midwest study vs 38.4% in our study), machines (22.0% vs 19.9%, respectively), and nonpowered hand tools (12.8% vs 26.9%, respectively). The differences may be a function of the underlying distribution of companies sending patients to the clinics for treatment. The Bureau of Labor Statistics survey of hand injuries focused on workers with 1 or more days away from work.[7] In that study, 69% of workers had cuts or lacerations, 26% had fractures, and 60% were from manufacturing. Machines accounted for 37% of the injuries, followed by metal items (19%) and nonpowered hand tools (16%). These injuries were likely to be more severe than either of the clinic-based studies because of the minimum criterion of 1 day of lost work time. The occupational health clinics in this study often returned treated workers back to their jobs on the same day.

Prevention of hand injury is likely to require multiple interventions, particularly when the risk of a hand injury is high. Use of personal protective equipment, administrative controls, and design of equipment and tools (eg, machine guarding) that reduce the likelihood of contact with moving machine parts, sharp metal items, and knives are all important approaches to prevention. Glove use has been shown to reduce hand injury risk by 20% in a subset of the subjects in the present study[5] and in a case-control study of occupational hand injury.[9] Machinery malfunctions or doing an unusual task may also be high-risk times for a hand injury.[5,9] In this regard, enhancing maintenance audits may have a significant impact on reducing injury in manufacturing environments.[10] Interestingly, in this study, we found that the nondominant hand was injured more often than the dominant hand, regardless of handedness. Because both powered and nonpowered hand-held tools are more likely to be held in the dominant hand, this suggests that one approach to hand injury prevention is to design gloves that have greater cut and/or impact resistance for the nondominant hand.

Moreover, based on our data, small metal items such as nails, metal stock, and burrs on metal pieces were the leading causes of these hand injuries. This finding suggests that the occurrence of these injuries may be reduced by emphasizing the use of personal protective equipment (eg, warning for glove use) when potentially exposed to these types of items.

Among subjects with hand injuries in the present study, 14.6% reported at least one earlier hand injury at work over the past year. Based on a literature review of the incidence of traumatic hand injuries in manufacturing environments,[2] the expected annual incidence ranges from 4% to 11%. The percentage may be high in our study because we asked each subject whether or not they had had any other occupational hand injury in the past year, regardless of the severity or whether they had sought any medical treatment. Asking about injuries receiving medical treatment would probably have reduced this percentage. Alternatively, having one hand injury at work may increase the risk for another injury, assuming job tasks and work practices remain the same. Further research on repeat hand injury circumstances is warranted to address this question.

The number of occupational hand injuries treated in emergency departments in the United States (approximately one million treated cases per year),[1] and in other outpatient occupational settings,[4] suggests that occupational injuries to the hands account for a large burden of morbidity to workers and lost productivity. Despite the importance of these injuries, there has been little prevention research in this area.

The present study suggests that some causes of occupational hand injury are potentially preventable. Because the majority of injuries are caused by contact with small metal objects or hand tools, research into the optimal design of gloves and their use is warranted. Furthermore, because more severe injuries tend to be associated with powered machines and nonpowered hand tools with blades, studies of enhanced engineering controls, maintenance schedules, and safety training may identify important prevention strategies.

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