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An Analysis of Occupational Stair Accident Patterns

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This report describes an analysis of existing occupational injury data concerning stairway-related falls. Injury data based on reports obtained from the Ohio and California workers' compensation agencies were analyzed to identify common stair injury patterns. Frequency tabulations are provided for the following factors: (a) location (indoors vs. outdoors, on vs. off employer's premises, site category); (b) task (ascending vs. descending, body movement on the stair, task being attempted); and (c) events (precipitating actions and conditions). One of the most outstanding findings is that 92% of the injuries occurred when the worker was descending the stair, i.e., 636 of the 688 cases in which direction of travel was indicated. Additionally, injury records from the New York and Ohio workers' compensation agencies were used to rank industries in terms of combined frequency and severity rates of stairway-related injuries.

Accidents related to work surfaces are responsible for a large percentage of U.S. occupational injuries. One of the more complete tabulations of occupational injuries, that for workers' compensation cases in New York State during 1966–1970, reported that 120,682 injuries related to work surfaces occurred during that period (20% of the total). Almost 14% of these involved stairs. These cases accounted for about 3% of all injuries and of all awarded compensation indemnity costs. A recent analysis of 3,270 fall injury reports (Cohen & Compton, 1982), collected from a broad range of industry types, sizes, and geographical distributions, indicated that approximately 10% were stairway-related.

Despite the magnitude of the problem, little research has been performed to define the characteristics and etiological factors related to *occupational* stair accidents. The workload demands and hazards inherent in the task of stair climbing in public and private residential settings are well documented, however (Archea, Collins, & Stahl, 1979; Fitch, Templer, & Corcoran, 1974; Templer, Mullet, Archea, & Margulis, 1976). For example, Ar-

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chea et al. suggest that a greater likelihood of misstepping and falling exists on stairs because of the unusual gait and excessive energy expenditure required by stair climbing. Added to this is the increased human information-processing load related to negotiating many sequential changes in elevation.

Templer (1974) points to the opportunity for increased severity of accidents on stairs as compared with accidents on other work surfaces. According to Templer, this is a function of the elevation in a stairwell coupled with the sharp edges of the stair tread nosings to which falling persons are exposed. Add to this the fact that overall employee exposure to stairs is considerably greater than other elevated work surfaces, i.e., ladders, scaffolds, catwalks, and platforms (Cohen & Compton, 1982), and it becomes apparent that understanding the factors associated with occupational stair accidents remains an important area for detailed study.

The present paper describes the results of the first phase of an in-depth study of the factors associated with accident occurrence during the use of stairways in industry. It describes an analysis of available workplace injury data related to falls on stairs. The purposes of this analysis are to: (a) identify those industries that experience the highest injury rates from falls on stairs and (b) characterize predisposing factors and precipitating events that are commonly associated with falls on stairs in the workplace. The results of in-depth video analysis of select industrial and commercial stairways and employee stair use are presented in a companion paper.

METHOD

Precoded Injury Data Tapes

As a first step to understanding the factors associated with occupational stair accidents, an analysis was undertaken of precoded injury data tapes available from both the Ohio and New York workers' compensation agencies. These data tapes were made available to Safety Sciences through arrangements with the U.S. Bureau of Labor Statistics (BLS), Department of Labor. These data, available for all "closed" cases in the year 1977, were particularly advantageous for several reasons: (a) They represented a readily available, precoded source of broadly representative and recent data on occupational stairway accidents; and (b) although precoded for certain limited select factors, they could be used for identifying high risk industries.

Another major advantage of these data over other available tabulations is that the New York and Ohio data are coded for *agency of accident*, not *source of injury*. According to the American National Standards Institute (ANSI) Z16.2 (1969) method of coding occupational injuries, the source of injury is defined as the object or substance that directly injures the worker. In the case of a fall from a defective stairway to a floor, the source of injury would not be the stairs; rather, it would be the floor. The agency of accident, on the other hand, is defined as the object about which a hazardous condition exists. In the above example, the agency of accident is the stairway. Clearly, then, the agency of accident is more appropriate for identifying injuries associated with stair use.

The first step in the data analysis process was to extract all cases coded as agency of accident from the master New York and Ohio tapes onto working data tapes. The working tapes, one each for Ohio and New York, were then used to generate a series of matrices through a computer program available from the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). The matrices yielded measures of frequency and severity, i.e., number of cases by industry and average lost workdays per lost-workday case by industry for both the Ohio and New York data. An index of relative risk was obtained by using published Bureau of Census data, which provided population figures for each industry in each state (New York and Ohio) for the 1977 calendar year (U.S. Department of Census, 1979). Frequency and severity rates were then calculated using the following standard formulas:

$$1.\ \text{Frequency Rate} = \frac{\text{No. of Cases} \times 100}{\text{No. of Employees}}$$

$$2.\ \text{LWD}^1\ \text{Rate} = \frac{\text{Total LWD} \times 100}{\text{No. of Employees}}$$

The following steps were then taken in or-

[1]LWD = Lost Workday

der to derive a single index representing the combined data from both states:

1. Both the New York and Ohio frequency and LWD rates were normalized, yielding four separate normalized rates.
2. The New York rates were then weighted by 1.2 to account for an approximately 20% greater number of cases.
3. The four normalized and weighted rates were then summed and averaged, yielding a single, average adjusted rate for each industry.
4. These rates were then ranked, from the highest to the lowest, for all reported industries.

Injury Reports

In order to study actual case reports, copies of "Employer's First Reports of Injury" with an ANSI Z16.2 accident type code "035: Falls on Stairs" were requested from the workers' compensation agencies of California, Georgia, and Ohio, i.e., the sites of the subsequent video study.[2] The reports from Georgia, however, proved to be impossible to access, since their records system was not automated at the time of the study. Ohio provided 308 and California provided 522 usable reports for 1979, the year immediately prior to the analysis. All personal and company identifying information was deleted by agency personnel upon request.

The procedures for analyzing these data involved accessing the information contained on the injury reports and performing frequency tabulations of selected factors. (In addition, the Ohio data included lost workdays, a measure of severity.) These factors were chosen on three bases:

1. Relevance to stair accidents as identified from previous stairway accident research in settings other than occupational.
2. Relevance to the types of information that are appropriate for injury report data analysis (Safety Sciences, 1977).
3. Availability of information on the specific reports analyzed.

Table 1 shows a list of the factors that were analyzed and the availability of data related to these factors on the injury reports. *Precipitating events/conditions* do not result in injury, but lead to the injuring event. Some cases indicated the presence of more than one precipitating event or condition. The analysis included all identified events and conditions, not a judgment of the single most important cause.

TABLE 1
AVAILABILITY OF FACTORS FROM INJURY REPORTS RELEVANT TO STAIR ACCIDENT ETIOLOGY[a]

	% AVAILABLE FROM REPORTS	
ANALYSIS FACTORS	California	Ohio
Location		
Standard industrial classification	98	83
Indoors/outdoors	88	61
On/off premises	99	96
Site	>99	81
Task		
Direction of travel	94	64
Body position	99	97
Work activity	59	62
Events		
Accident (fall) types	80	63
Precipitating events/conditions	64	64

[a]Factors recommended in NIOSH model (Safety Sciences, 1977).

RESULTS AND DISCUSSION

Injury Reports

Table 2 presents a breakdown of the number of stairway falls by general environment (inside/outside). These data show that, overall two times more accidents occurred at indoor locations than at outdoor ones. This is probably because more work is performed in-

TABLE 2
STAIR ACCIDENTS BY GENERAL ENVIRONMENT

ENVIRONMENT	CALIFORNIA		OHIO		TOTAL	
	n	%	*n*	%	*n*	%
Inside	362	69	85	29	447	54
Outside	94	18	103	33	199	24
Unspecified	64	12	120	39	184	22
Total	522		308		830	

[2]A prior NIOSH study performed by Safety Sciences (1977) to determine whether the data on occupational injury records presently used are of sufficient research value found that this data source was substantially reliable and accurate.

doors than outdoors. Nevertheless, regional differences between the two states are reflected in these data. Nearly twice as many outdoor accidents were recorded in Ohio as in California. It is apparent from reading the accident reports that this difference is more related to environmental conditions (e.g., rain and ice) than to other factors, such as differences in task exposure. Despite the opportunity for more outdoor work activity in California, exterior stair users in Ohio are more likely to be confronted with more weather-induced work surface hazards, such as stairs slippery from rain, snow, and ice, than are those in California.

Given the wide variety of staircase designs and environments, another important factor is the employee's familiarity with the features of the location where the accident occurred. A factor that is available from injury report data and bears a strong relationship with familiarity is *on/off employer's premises* (Table 3). A check of the occupations of employees involved in the "off" category showed that most were of a service nature (e.g., route drivers, bottled water deliverers, case workers, public health inspectors, etc.). These occupations typically involve both a high exposure to stairway use and a high exposure to new and unfamiliar stairs.

Table 4 presents a categorization by type of stairway sites where stair accidents occurred. Such information can be useful for pinpointing areas with high exposure or unusual concentrations of hazards. Fifteen percent of all accidents occurred on stairs at entrances or exits (both at employer's premises and at field locations). The unique problems faced by stair users at entrances and exits include: (a) abrupt change of environment and visual cues from inside to out; (b) abrupt change in level, surface materials, and conditions (many of the Ohio cases involved slips on ice and snow while leaving work); (c) increased traffic volume as a result of funneling at entrances and exits; and (d) haste due to lateness in reporting to work or eagerness to leave. The incidence of falls on basement and attic stairs may be related to several features typical of these locations: (a) limited usage and therefore limited familiarity; (b) stair design inconsistent with other facility stairs (i.e., steeper angle of incline), resulting in unexpected or more difficult to negotiate circumstances; and (c) poor lighting conditions.

TABLE 3
STAIR ACCIDENTS BY GENERAL LOCATION
(ON/OFF EMPLOYER'S PREMISES)

	CALIFORNIA		OHIO		TOTAL	
LOCATION	*n*	%	*n*	%	*n*	%
On	442	85	228	74	670	81
Off	75	14	69	22	144	17
Unspecified	5	1	11	4	16	2
Total	522		308		830	

In the category designated as *industry-specific areas*, it is interesting to note the high total percentages of cases occurring in office and manufacturing areas (20% and 13%, respectively). Other analyses, to be discussed, indicate that this high concentration of accidents is not only due to high relative exposure, but to several important inherent hazards as well.

The *field locations* category represents another indication of familiarity, because such locations are typically used by the accident victim only once or infrequently. Conditions and circumstances leading to falls in these areas cannot always be controlled in the same manner as those in more captive locations, i.e., the employer's premises. The subcategory *construction sites* also suggests the presence of inherent hazards, such as incomplete stairway construction (e.g., loose floor boards, handrail not in place, etc.), task-related overextending (e.g., reaching with a paint brush or dry wall knife), and prolonged exposure while working on stairs.

Information on activities being performed at the time of accident occurrence is extremely valuable to safety research. It not only assists in understanding how accidents happen, but also allows countermeasure development to go beyond mere physical guarding of hazards, suggesting changes in work design, training, and supervision. Table 5 shows the direction of travel of the victim at the time of the accident occurrence. It is suspected that the difference in reported accident frequency between going up and coming down stairs (6% and 77%, respectively) is related less to design or behavioral factors than to reporting differences. A fall while ascending stairs is generally of lower severity because

TABLE 4
STAIR ACCIDENTS BY TYPES OF SITES

SITES	CALIFORNIA n	CALIFORNIA %	OHIO n	OHIO %	TOTAL n	TOTAL %
Structural Types	103	20	122	40	225	27
Entrance/exits	37	7	60	19	97	12
Basement/attic	26	5	25	8	51	6
Lunchroom/lounge	15	3	6	2	21	3
Parking structure/lot	8	2	1	<1	9	1
Machine steps	6	1	21	7	27	3
Restroom stairs	5	1			5	<1
Loading dock	4	1	5	2	9	1
Trailer steps	2	1	4	1	6	1
Industry-Specific Areas	341	65	89	29	430	52
Office areas	140	27	29	10	169	20
Manufacturing	75	14	31	10	106	13
Retail stores	40	8	5	2	45	5
Schools	32	6	6	2	38	4
Restaurants	22	4	13	4	35	4
Hospitals	26	5	2	1	28	3
Warehouse	6	1	3	1	9	1
"Field" Locations	68	13	57	19	125	15
Construction sites	21	4	18	6	39	5
Private residences	10	2	4	1	14	2
Private residence entrances	10	2	15	5	25	3
Miscellaneous job site	25	5	12	4	37	4
Emergency response sites	2	<1	8	3	10	1
Others	8	2	13	4	21	3
Unspecified	2	<1	27	9	29	3
Total	522		308		830	

forward momentum is arrested by the staircase structure itself, whereas a fall down a staircase is likely to result in higher severity because there is a greater distance to fall. Injury reports, because of reporting criteria based on minimal severity levels, are skewed toward the selection of higher severity incidents. Previous research on public and private household stairs (Archea et al., 1979; Templer et al., 1976) confirms that while missteps would be expected to be more frequent in ascent, serious accidents resulting in injuries are more common in descent.

TABLE 5
STAIR ACCIDENTS BY VICTIM'S DIRECTION OF TRAVEL

DIRECTION	CALIFORNIA n	CALIFORNIA %	OHIO n	OHIO %	TOTAL n	TOTAL %
Down	474	91	162	53	636	77
Up	18	3	34	11	52	6
Unspecified	30	6	112	36	142	17
Total	522		308		830	

Generally, injury report data on body position or movement are not definitive, because, on most report forms, information related to the position of body parts (i.e, head, hands, feet, trunk) and force and direction of movement is not specifically requested. Table 6 classifies stairway accidents by available data on body position. Nearly 90% of the cases are reported as involving *walking* as the body position. This proportion may not be unusually high, but may indicate that other important information (e.g., objects carried, etc.) is missing. The other categories shown are

TABLE 6
STAIR ACCIDENTS BY BODY POSITION
AT TIME OF ACCIDENT

BODY POSITION	CALIFORNIA		OHIO		TOTAL	
	n	%	*n*	%	*n*	%
Walking	468	90	266	86	734	88
Walking, holding handrail	11	2	3	1	14	2
Sweeping, mopping movements	11	2	3	1	14	2
Bending/reaching	9	2	4	1	13	2
Running	6	1	13	4	19	2
Stepping backwards	5	1	5	2	10	1
Pushing/pulling (e.g., handcart)	4	1	3	1	7	1
Turning around	4	1	2	1	6	1
Unknown	4	1	9	3	13	2
Total	522		308		830	

somewhat indicative of the commission of gross, often intentional, errors and are consistent with expectations of body positions associated with falls on stairs. Nevertheless, the low reported frequencies suggest that performance errors that lead to the majority of stairway accidents are not the obvious gross ones, but minute or subtle missteps, etc. Many of the movements appear to be related to overextending the body's mass beyond its base of support (e.g., bending/reaching and pushing/pulling), resulting in unbalancing.

Activity being performed at the time of the accident could be determined in every case, but some of the information may be overly generalized. (About 40% stated that the victim was "walking on stairs" and were categorized as transit, unspecified.) Activity being performed is specifically requested on the California report form, but not on the one used in Ohio. The work activity data studied does, however, indicate specific recurring accident patterns. (See Table 7.)

Sixty-four percent of all cases were related to the activity of *transit*. This is an expected finding, because a staircase is a specialized walking surface intended for transit from one elevation to another. The other broad categories in Table 7 show the types of secondary task performance that were found in the injury report data. Workers who *make rounds* probably have a higher exposure to stairs, because their jobs require them to rove around the premises. They may also be exposed to more poor lighting conditions (e.g., security patrol) and diversion of attention (e.g., inspection, escorting persons). *Materials handling* subcategories attempt to classify types of loads as they may be related to accident occurrence (e.g., *visual encumberances*, a subcategory used to describe loads that obstruct vision and/or require attention-sharing). Workers *working on stairs* are specifically not involved in transit, yet are attempting to use the staircase with its inherent hazards as a regular, i.e., level, working surface.

Table 8 shows the reported frequencies for various precipitating events or conditions found in stairway injury reports. Only conditions or events that were directly related to the accident occurrence were tallied. Four broad categories of events were identified: (a) design-induced conditions, (b) environmentally related conditions, (c) inherent user characteristics, and (d) performance factors. Under *design conditions*, problems with surface materials accounted for a fairly high proportion (11%) of the total events/conditions. Metal and cement materials (reported as slippery) made up almost two thirds of these, while carpet and brick involving tripping incidents amounted to one fourth of the problems related to surface materials. Protruding nosings related to trips while ascending, open risers resulting in distraction while ascending, and doors that opened abruptly onto staircase tops or bottoms were the most prominent design-induced problems that emerged from these data. About 1% of the cases specifically reported the involvement of missing or slippery handrails.

Environmental conditions, which can large-

ly be corrected through improved housekeeping and maintenance, probably have the greatest potential for immediate correction. Many of the low coefficient of friction (COF) conditions on exterior staircases (e.g., wet from rain), which are beyond the purview of improved housekeeping, can be corrected by surface modifications to increase the COF of the surface material by, for example, providing an adequate wash (slope of tread) to ensure proper water run-off, acid-etching of concrete, and application of nonskid tread material. The difference between the two states in the category *low coefficient of friction conditions* supports the earlier contention that increased occurrence of accidents out of doors in Ohio was related to climatic differences. While the percentages of slips in rain puddles was approximately equivalent, 42 cases (19%) were specifically related to snow and ice in Ohio, compared with only one such case in California.

Stairway *user characteristics* accounted for about 8% of the total reported events/conditions. About half of these were related to design, condition, and/or maintenance of shoes, and the other half to predisposing physiological impairments, e.g., weak knee or ankle from previous injury "gave out." Several cases, however, involved fainting or dizziness due to fumes from industrial processes near the staircase.

TABLE 7
STAIR ACCIDENTS BY WORK ACTIVITY

	CALIFORNIA		OHIO				TOTAL	
WORK ACTIVITY	*n*	%	*n*	%	Days Lost	Days per Case	*n*	%
Transit	343	66	191	62	1,369	7.1	534	64
Leaving work	50	10	35	11	313	8.9	85	10
On break	41	8	5	2	29	5.8	46	6
Changing work area	30	6	17	6	82	4.8	47	6
Reporting to work	21	4	21	7	149	7.0	42	5
Unspecified	201	39	113	37	896	7.9	314	38
Making Rounds	52	10	20	6	118	5.9	72	9
Inspecting	17	3	7	2	56	8.0	24	3
Security patrol	16	3	5	1	26	5.2	21	3
Domestic/custodian	10	2	6	2	22	3.7	16	2
Escorting persons	9	2	2	1	14	7.0	11	1
Materials Handling, Types of Loads or Methods	82	16	47	15	302	6.4	129	16
Visual and balance encumbrance	17	3	14	5	83	6.0	31	4
Balance encumbrance (i.e., weight distributed off base of support)	14	3	9	3	69	7.7	23	3
Multiple objects	14	3	7	2	22	3.1	21	2
Visual encumbrance (e.g., visual obstruction, attention sharing)	11	2	6	2	61	10.2	17	2
Light to moderate	11	2	1	<1	3	3.0	12	1
With coworker	3	1	2	1	2	1.0	5	1
With device (e.g., handcart)	2	1	5	1	50	10.0	7	1
Unspecified load	10	2	3	1	12	4.0	13	2
Working on Stair	19	4	15	5	73	4.9	34	4
Construction	8	2	7	2	13	1.9	15	2
Cleaning	7	1	4	1	34	8.5	11	1
Other	4	1	4	1	13	3.3	8	1
Field-Related tasks (e.g., Route Delivery, Visiting Client)	26	5	35	11	242	6.9	61	7
Total	522		308			6.8	830	

TABLE 8
PRECIPITATING EVENTS/CONDITIONS IDENTIFIED FROM STAIR INJURY REPORTS

TYPES OF CONDITIONS	CALIFORNIA		OHIO				TOTAL	
	n	%	*n*	%	Days Lost	Days per Case	*n*	%
Design Conditions	64	17	27	12	108	4.0	91	16
Surface materials (e.g., slip on metal step, trip on carpet)	46	13	17	8	176	4.5	63	11
Physical design features (e.g., protruding nosing, narrow tread)	15	4	9	4	30	3.3	24	4
Handrail missing/slippery	3	1	1	<1	2	0.2	4	1
Environmental Conditions	82	22	90	40	670	7.4	172	31
Low coefficient of friction conditions (e.g., wet, oily, rain, ice, snow)	45	12	63	28	414	6.6	108	19
Object/obstruction on stairs (e.g., hoses, refuse, etc.)	16	4	13	4	145	11.0	29	5
Maintenance problems (e.g., broken step, loose nosing)	8	2	6	3	49	8.2	14	2
Poor lighting, dark	13	1	8	<1	62	7.8	5	1
User Characteristics	36	10	9	4	45	5.0	45	8
Footwear/clothing (e.g., high heel caught in step, shoe broke)	20	5	4	2	22	5.5	24	4
Physiological dysfunction	16	4	5	2	23	4.6	21	4
Performance Factors	184	50	99	44	667	6.7	283	50
Misarticulated foot placement[a]	94	26	55	24	364	6.6	149	27
Inattention/preoccupation (e.g., looking away from staircase)	46	13	15	7	114	7.6	61	11
Extending mass beyond base of support (e.g., reaching)	30	8	21	9	136	6.5	51	9
Haste (i.e., running)	14	4	8	4	53	6.6	22	4
Total	366		225		1,490	6.6	561	

[a]Possibly includes some types of events/conditions that may be design- or environment-related, but insufficient information was provided in order to confidently make the determination.

Fully 50% of all events/conditions were classified as due to *performance factors*. Design interface problems may have played a more significant role than these data indicate. However, even with very high quality data sources, such as in-depth accident investigation reports involving victim interviews and site surveys, it is not easy, or necessarily desirable, to identify a single cause related to either design or behavior. On the contrary, it is likely that in most cases multiple factors interact to result in an accident. For example, one third of *misarticulated foot placements* can be attributed to patterns that may be design-related, e.g., "foot placed off edge of step" and "caught heel on step." Twenty percent of misarticulated foot placements can be confidently attributed to purely behavioral or judgmental errors (e.g., skipping steps, changing direction of travel on midstairs, and stepping backward). More than half of the cases in this category occured while victims were transferring from stair to level surface or vice versa, at the top or bottom of the staircase. It is likely that many of these occurrences are related to the user having not yet changed gait or walking behavior required when approaching or leaving the stairs.

Inattention/preoccupation cases involved such problems as directly looking away from the stairs, juggling multiple objects, and concentrating on not spilling open containers of hot liquids (often coffee). *Extending mass beyond base of support*, which resulted in unbalancing, involved both excessive reaching and carrying large and bulky objects, which effectively increased and extended the user's weight beyond the base of support provided

by the feet. This can be especially dangerous while descending stairs because of the forward and downward momentum and the opportunity for misstepping off the end of a step if the step edge is visually obscured by the large object being carried or if attention is momentarily drawn away from the task of stair descent by distractions in the workplace, many of which can be eliminated by improved workplace layout and stair design (Archea et al., 1979). Undue haste, particularly when reporting to or leaving work, is a problem more amenable to training and work practice reinforcement countermeasures.

Precoded Injury Data

Table 9 presents a summary of overall industry ranking with respect to combined frequency and severity of stairway-related injuries derived from analysis of the precoded Ohio and New York injury data tapes. Industries are classified according to the Standard Industrial Classification (SIC) scheme (Office of Management and Budget [OMB], 1972). As can be seen, a broad range of general industry is represented on this list. Miscellaneous manufacturing industries show by far the highest overall rate of stairway-related injuries, over 50% greater than the next two industry groupings. A number of highly ranked industries are noted to involve service functions or transitory conditions away from the employer's premises and, hence, not directly controllable by the employer through structural design changes. This follows from the injury reports data analysis as well. Some examples include: police and fire protection, public health inspection, building construction, trucking, membership organizations (social, fraternal, religious, etc.), laundry services, etc. Other highly ranked industries identified from the New York and Ohio tapes are probably overrepresented, or even peculiar to those states. Examples include motion pictures—production, distribution (New York) and foundries (Ohio).

TABLE 9
OVERALL INDUSTRY RANKING WITH RESPECT TO STAIR-RELATED INJURY

RANK	SIC NUMBER	SIC INDUSTRY DESCRIPTION	AVERAGE OF ADJUSTED
1	399	Miscellaneous manufacturing industries	6.437
2	94	Administrations of public health; social & income maintenance	4.262
3	9221 & 9224	Police and fire protection	4.022
4	83	Membership organization; social, fraternal, & religious	2.967
5	421	Trucking—local and long distance	1.997
6	331, 332, 336	Blast furnaces and rolling mills, iron, steel, and nonferrous foundries	1.964
7	78	Motion pictures—production, distribution, theaters	1.712
8	70	Hotels, motels, rooming houses, camps, and lodgings	1.688
9	82	Educational services; elementary through college (public and private)	1.659
10	91	General local and state government	1.617
11	01 & 02	Agricultural products—crops and livestock	1.611
12	20	Food and kindred products; meat, dairy, bakery, beverages, canned fruits, and vegetables	1.526
13	281 & 286	Industrial inorganic and organic chemicals	1.390
14	56	Apparel and accessory stores	1.250
15	47	Transportation services	1.102
16	7211-7215	Laundries and laundry services	1.074
17	95	Air and water resources, solid waste management	1.028
18	15 & 17	Building construction; general building contractors	0.973
19	801	Offices of physicians; health practitioners, labs, nursing facilities	0.964
20	581	Eating and drinking places	0.889
21	59	Miscellaneous retail	0.839
22	372	Aircraft parts	0.830
23	57	Furniture, home furnishings, and equipment stores	0.808

CONCLUSIONS

The findings of the injury data analyses indicate several accident-related patterns associated with occupational stair use. One of these involves the occurrence of a variety of design and environmentally induced hazards that stair users frequently encounter. Such hazards appear to be especially troublesome when they are unexpected by the user. If the user encounters a characteristic of the stair site that is different from his expectation, an adaptation in stair-use behavior must be made or an accident may occur. If a stair user is familiar with the characteristics of a stair site, then the inherent hazards are already recognized and can be more easily avoided.

The data show two general types of unfamiliar stair situations: (a) sudden changes on a familiar, routinely used staircase, such as transient housekeeping and maintenance problems; and (b) more or less permanent features of a particular stair that is not routinely used by the victim and that is different from other staircases with which the victim is familiar. The occurrence of events fitting the latter case is indicated by the frequency of reports listed in categories such as *off employer's premises*, *field locations*, and *field-related tasks*. The environmental conditions reported in Table 8 indicate some transient hazardous situations common to stairs and other work surface types that are often easily remedied by improved maintenance and housekeeping practices. Design conditions listed in Table 8 describe some of the more or less permanent structural problems, the solutions to which are generally more difficult, but must be ultimately approached through improved design criteria, such as those obtainable from detailed user observations (Archea et al., 1979).

The other major problem associated with stair use is that of user performance errors. While the activities of stair ascent and descent are commonly taken for granted and not typically thought of as specific structured tasks, the negotiation of multiple sequential changes in elevation requires continual information processing and complex biomechanical activity. Although the stair structure enhances the opportunity for performance errors, people can usually negotiate elevation changes without incident when their limited information-processing capability can be focused on that task. When their work duties require sharing attention with the simultaneous performance of other secondary tasks, such as materials handling, or their limited attention is momentarily diverted, information overload and the opportunity for errors in performance of the primary task can occur, particularly in the presence of an unexpected hazard or an unfamiliar setting. The problem of task overload in accident-producing situations is well demonstrated by Saari (1977), who showed that accident rates tend to be higher for tasks that are nonrepetitive and unpredictable. Types of work that are not preplanned or in the same location fall into this category, and stair-related examples include workers who make rounds (e.g., security patrol), construction sites, field, and other unfamiliar and/or unpredictable stair hazard locations.

Accidents are generally the result of system failures. Typically, multiple factors interact, resulting in a series of events leading to an injury. Such is the case with the data reported here. Often, a reported performance error (e.g., running or inattention) preceded and placed the victim in a position wherein a hazardous, environmentally related situation (e.g., ice on a stairstep) could not be recognized or easily avoided. In other cases, performance errors (e.g., missteps resulting in a fall injury) were clearly design-induced (e.g., due to doors opening abruptly onto staircase tops or bottoms). This was particularly true in unfamiliar or otherwise task-loaded situations.

The occupational setting has the unique opportunity of having an almost wholly captive stair-user population. This introduces the possibility of implementing additional types of countermeasures that cannot be readily applied to public and private residential stairways. Such countermeasures are performance or behaviorally oriented. They include training (e.g., manual materials handling on stairs, specific hazard awareness, etc.) and safe work practice reinforcement (e.g., no running on or skipping stairs). Often, such behaviorally oriented countermeasures are the only type of corrective actions that can be applied, for example, with locations remote from the employer's premises, where a relatively high proportion of service and delivery personnel are injured each year from stairway falls.

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