Behavioural Team, A Corporation
75 Kenwood Avenue, Toronto, Ontario M6C 2S1
Voice (416) 656-6676, Fax (416) 658-6878
Website: http://www.bteam.com
2003 June 1

PERSONAL AND BUILDING FACTORS IN STAIR SAFETY

Ben Barkow, Ph.D.

ADAPTED FROM A PAPER PRESENTED AT THE
INTERNATIONAL CONF. ON BUILDING USE AND SAFETY TECHNOLOGY
SPONSORED BY THE NATIONAL INSTITUTE OF BUILDING SCIENCES
AND THE AMERICAN INSTITUTE OF ARCHITECTS
LOS ANGELES, MARCH, 1985

ABSTRACT

The study reported here is based on intensive interviews with victims and on-site cause investigation for a sample of 81 recent stair accidents. Accident sites included homes, work places, and public stairs. Each of the victims required medical attention after their fall. The accidents that happened while the person was travelling down the stairs were both more common and more costly than those occurring during travel up the stairs. The average direct cost - primarily medical expenses and lost income - for each accident was about $1750.

The study related both building and personal factors to the accidents. The leading building factors include handrail problems, inadequate or irregular stair dimensions, stair coverings and maintenance problems, inadequate lighting, and visual distractions. The leading personal factors include hurrying, not paying attention, having one's arms full, and wearing improper footwear.

The study has found further evidence for a "psychomotor learning theory" of stair accidents. Thus accidents tend to start at the beginning of a set of stairs, before the user has "learned" the pattern of risers and treads. Falls that occur later on the stairs are associated with greater irregularities of stair dimensions. These findings have implications for both stair design and user education.

INTRODUCTION

Falling accidents on stairs and steps can lead to serious injuries or death. It is commonly assumed that design features of the stairs and the behaviour of the user each contribute to stair falls. However, there have been very few studies that look at both the personal and building factors associated with specific accidents. This study involves recent stair accidents in Canadian homes, work sites, and public places. The data collection included extensive interviews with the accident victims as well as evaluations and measurements made at the site of the accident.

Adult volunteers for the study were solicited by radio and newspaper advertisements, notices in specialized publications, and contact with hospitals and industrial safety officers. The criteria for inclusion in the study were as follows:

- the accident victim required medical attention as a result of a fall of one or more steps,
- the accident occurred within the previous 3 years,
- the victim was available for an interview and willing to volunteer for the study, and
- the interviewer was able to visit the accident site to make all of the necessary measurements of the stairs, lighting, signs, etc.

The 81 subjects ranged in age from 18 to 90, with an average age of 50 years. To make the sample representative, particular efforts were made to recruit older accident victims since they are over-represented in stair injuries and deaths (Chapman, 1961; Agate, 1966; Svanstrom, 1974.) 88% were English speaking and 12% French speaking. The male/female ratio was 35/65 despite the fact that not all female volunteers were enlisted in the study.

PHYSICAL FEATURES OF THE STAIRS

Location

Part of the design included sampling work, home, and public accident sites. Subjects came from two large cities, one medium-size city, and several smaller towns. 75% of the stairs were inside buildings. The distribution of accident sites is as follows:

• 36% in a work context • 37% at home, and • 27% in public places.

Lighting

Light measurements were made on indoor stairs to determine lighting adequacy. Public stairs tended to have the most light and home stairs the least. The majority of home stairs and several of the work and public sites had less than the suggested minimum level of 215 lux (Kaufman and Christensen, 1972.) In 21% of the cases there was a change in illumination as one approaches the stairs. The intensity on the stairs (in lux) varied by more than 10% in over half of the accident sites.

Stair Dimensions

The average across all 81 sites is 178mm for the risers (s.d.=23mm) and 280mm for the treads (s.d.= 70mm.) These average dimensions are near the maximum riser height and minimum tread depth recommended by researchers. It follows that about half of the sites had risers that were higher than they should be and half of the sites had treads that were too small.

In 23%, there was considerable variability among both the risers and treads; risers-only were variable in 9% of the sites and treads-only in 4%. 65% of the sites showed little dimensional irregularities. 9% had winders (the wedge-shaped treads used when the stairway turns.)

Rail

There was some sort of handrail or banister in 87% of the sites. The stairs at home were about twice as likely as the public and work sites to have no rail of any sort. The interviewer noted problems with 46% of the sites: design and placement that made the rail difficult to grasp, or the rail not extending the whole length of the stairway.

Other Problems

The interviewers and victims noted a variety of other problems with the stairs at the accident site. About 1 out of 4 (24%) were judged to have inadequate friction on the tread surface and the same proportion had serious maintenance problems. Other common problems related to tread slope, visual distractions, and doorways adjacent to the stairs. Only one of the 81 sites was deemed totally free of unfavourable features.

BEHAVIOURAL CHARACTERISTICS

Several features of the users' behaviour prior to the accident were investigated. In addition, the accident victims rated the importance of several contributing factors.

Familiarity

11% of the accidents involved first-time users of the stairs. The stairs had been used by the victim more than once a week for over a year in 73% of the cases.

Prior Disabling Conditions

Most of the subjects (82%) noted one or more disabling conditions affecting them before their accident. Visual problems were most common (73% of the total sample) followed by mobility problems (14%.) Other problems included medication, fatigue, and prior injuries or medical conditions. Visual and mobility problems were more common for the subjects over 50 years old.

Direction of Travel

Serious accidents were more than 5 times more likely during travel down the stairs than during travel up the stairs. As described later, the downward falls were more costly and were rated as more serious. Analyzing the data separately for the two directions of travel also clarifies some other issues. The first is the majority of female volunteers in the study. Women comprise 71% of the downward accidents but only 38% of the upward accidents. Women may be over-represented in the occurrence of downward accidents due to their footwear. Women in the present study frequently mentioned footwear as a contributing factor but men did not.

The portion of the stairs where the accident started also differed for upwards versus downwards travel. For those persons travelling down the stairs the majority of accidents started near the top (54%.) The people travelling up the stairs were more likely to fall near the bottom (39%) or middle (46%.)

These results support a "psycho-motor learning theory" of accident causation. Accidents are more likely to occur when you start using the steps and less likely after you have "learned" the pattern of risers and treads. This theory is further supported by a closer examination of the falls going down the stairs. If 54% of these accidents start at the top of the stairs because the

user's psychomotor model isn't fully functional, what about the 46% that don't start at the top? In these accident cases the stairs were more irregular in their riser and tread dimensions. Table 1 shows that the risers and treads are more irregular for those stairs where a downward accident started at the middle or bottom of the stairs than for the cases where a downwards fall started at the top of the stairs.

where fall started	mean riser variability	mean tread variability
top (36 cases)	3.4 mm	3.0 mm
mid or bottom (31 cases)	11.5 mm	24.0 mm

Table 1. Average of the largest successive change in treads and risers for downward accidents.

These results strongly support the psychomotor learning theory. Falls starting near the top of the stairs happen because the user hasn't yet learned the pattern of the stairs. Falls that start in the middle or near the bottom of the stairs happen because the stairs are irregular in their dimensions and differ from the mental/behavioural model that the user has formed during the first few steps.

Contributing Factors

There was close agreement between the interviewers' and the victims' ratings. It is the victims' ratings that are described below.

Building Factors - Handrail Use. 25% reported using the handrail at the time of their fall. Handrail use can limit the severity of an accident by preventing a long fall down the stairs. Of the 7 accident victims who fell the farthest (more than 10 steps) none of them were using the handrail. Handrail problems (no handrail, handrail ended too soon, etc.) were the 4th most important contributor to the accident in the victims' ratings.

Shoes. The majority of accident victims were wearing low heel shoes with leather soles (35%) or rubber/crepe soles (22%.) Eight women and one man had heels over 40 mm high. Other footwear included boots, sandals, slippers, safety shoes, and stocking feet. Three of the victims were barefoot at the time of their fall. Although relatively few victims were wearing them, high heels were seen as a major contributor by most of those wearing them.

Traction on the Steps. The victims rated wet, icy, or slippery steps as the 2nd most important contributing factor.

Other Building Factors. Sloping steps and nosings were rated 6th as a contributing factor followed by visual distractions or problems seeing the tread edges (7th), lighting problems (9th) and stair steepness (10th.)

Personal Factors - Emotional State. The single most important factor in the opinion of the victims was their emotional state. This includes emotional upset, hurrying, or daydreaming.

In spontaneous descriptions, 51% related something out of the ordinary in their mental/emotional state.

Other Personal Factors. Using the stairs with arms or hands full was rated as the 3rd most important contributing factor. This often prevented the subjects from using the handrail effectively. Being tired or fatigued was the 8th most important contributing factor.

INJURIES

The accidents in this study represent the middle range of severity. All of the victims required some medical attention, but no fatal accidents were studied. About half of the subjects (53%) were seen in a hospital emergency room after their accident while one-third received some first aid on the scene. The remainder went to a doctor's office or clinic. About one in six (17%) were admitted to hospital on the basis of their injuries.

The parts of the body where most of the acute injuries (less than 3 months duration) occurred are listed in table 2.

injured body part	% of total subjects
lower leg, ankle, foot, toes	35%
arm, forearm, wrist, hand, fingers	31%
knee	25%
head, face, mouth, teeth	20%
back	18%
neck, shoulder	17%

Table 2. Most frequently injured body parts. (The total is more than 100% because some subjects received more than one injury.)

Long-term problems were also most common for lower leg, ankle, foot, and toe injuries. Chronic back injuries affected 8% of the victims.

Chronic problems were more common for those who fell down the stairs than for those who fell while going up the stairs. Of those travelling downwards, 54% had some chronic injury. There was an average of 19 days spent in the hospital for each of the 23 people who were hospitalized.

COSTS

Total direct costs were estimated based on information from the subjects and from appropriate medical authorities. These costs only include medical and other patient care costs, lost income, and additional expenses directly resulting from the accident. They do not include suffering or inconvenience - or the cost of repairs made to the stairs!

Based on these figures the average accident cost $1,745 (standard deviation = $2,670.) In terms of costs, accidents while going down the stairs were over seven times costlier than accidents going up. This and several other cost comparisons are shown in Figure 1.

It is interesting to extrapolate these figures to estimate a total annual cost of Canadian stair accidents. If there are 80,000 emergency department treatments annually for Canadian stair accidents (based on Jake Pauls' U.S. CPSC data) and these represent about half of the cases where medical help is required, the total annual cost of non-fatal stair accidents is between $200- and $300-million dollars.

DISCUSSION

This study provides an overview of the personal and building factors involved in stair accidents in a variety of contexts. It is obvious that many serious injuries result from these accidents. Many of the injuries and their associated costs could be avoided, however. This study indicates that attention to both building features and public education could improve the situation. The major areas for improvements in the physical features of stairs are in stair dimensions, regularity of treads and risers, handrails, tread surfaces, and stair maintenance.

Efforts in public education should focus on the seriousness of stair accidents, the need to pay careful attention during stair use (especially at the start of the stairs and where there are any irregularities), and the value of using handrails.

SUPPORT

We would like to Health and Welfare Canada and the National Research Council of Canada for their support.

REFERENCES

1. Agate, J. Accidents to Old People in Their Homes. British Medical Journal, 1966, 5, 785-788.
2. Chapman, A.L. Accidents to the Aged. In Halsey, M.N. (Ed.) Accident Prevention: The Role of Physicians and Public Health Workers. New York: McGraw-Hill, 1961.
3. Kaufman, J. and Christensen, J. (Eds.) IES Lighting Handbook. New York: Illuminating Engineering Society, 1972.
4. Svanstrom, L. Falls on Stairs: An Epidemiological Accident Study. Scandinavian Journal of Social Medicine, 1974, 2, 113-120.