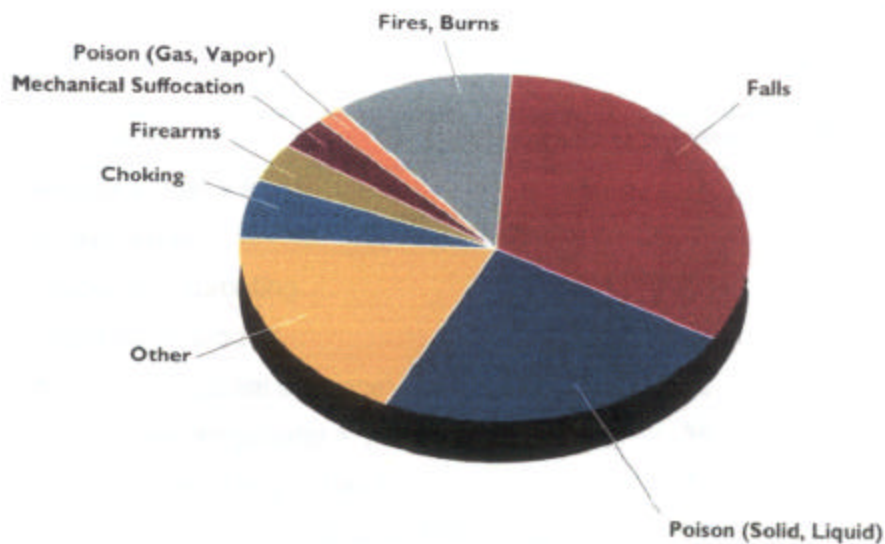




Stair Safety: Causes and Prevention of Residential Stair Injuries

Housing Fact Sheets

In the United States during 1997 about 27,000 people were killed by unintentional home injuries.¹ Figure 1 illustrates the causes of some of the injuries that resulted in death. As you can see, falls account for the majority of incidents.



Pie Graph Illustration from *Accident Facts* (1998)

Also in 1997, 6.8 million people suffered home accidents that resulted in disabling injuries.¹ While data on the number of injuries related to stairs and steps are not available for 1997, data from 1996 show that 984,000 people experienced injuries related to home stairs or steps during that year.¹

¹ Home and farm injuries. (1998 edition) *Accident Facts*, pp. 128-129. Published by National Safety Council.

Prevalence of Stair Hazards in New York Homes

A recent study conducted by the Department of Design and Environmental Analysis at Cornell University examined stairs in 68 houses in 6 upstate New York counties. The study assessed stairs with respect to a variety of potentially hazardous characteristics, including articles left on the stairs, broken treads, loose or torn carpeting, badly eroded tread, absence of a handrail, and riser height irregularity² at the bottom, top, or in the middle of a run of stairs. Data collected during that study indicate that stair hazards are prevalent in New York's houses. For example, eighty-one percent of the 68 stair cases examined had at least one of these hazards; 55% exhibited two or more of these hazards. While hazards such as broken tread, loose or torn carpeting, and badly eroded tread were relatively uncommon, factors presenting a trip hazard such as articles left on the stairs and the absence or partial absence of handrails were relatively common-28% and 22% respectively. These data are summarized below in Table 1.

Table 1:

Stair Hazards	Frequency	Percentage
Articles left on stairs	19	28.4
Broken tread	2	2.9
Loose/ torn carpeting	3	4.5
Tread badly eroded	3	4.5
Absence (or partial absence) of handrail	15	22.4
Bottom riser irregularity > 1 inch	35	56.5
Top riser irregularity > 1 inch	31	49.0
Riser irregularity > 1 inch in middle of run	12	20.0

Causes of Falls

When discussing falls it is important to be aware of two very different types of causes. The first are environmental factors-stair configuration or the presence of floor obstacles, for example. The second, as described by Perry (1982), are host-related factors: falls associated with dizziness and fainting, neurological disease, and other individual health factors. This Fact Sheet is concerned primarily with environmental factors that contribute to falls on residential stairways.

Researchers have identified common elements in falls on stairs.

- Slipping is the primary cause of stair falls.
- Most stairway falls that cause injuries occur while people are walking down the stairs.
- Absence of handrails account for a large percentage of falls on stairs that result in injuries.
- Unexpected location of stairs leads to many falls. For example, stairs of just one or two steps in a hallway or doorway can be especially hazardous.

Several accident-encouraging factors that contribute to stair falls have been identified:

- Stair Design

² A difference of 1/4 inch or more between adjacent risers creates a significant tripping hazard. This issue is discussed more thoroughly on page 3.

Stairs with just one or two steps are associated with a high number of falls. This is a design feature. So if you are planning an addition or extension to a building, avoid differences in floor heights that require just a few steps. Treads less than 9" wide result in the greatest number of missteps. Research indicates that riser heights between 6-8 inches and tread widths of 10 to 13 inches are most comfortable and fit most people's preferences. Optimal stair dimensions are 7.2 inch riser heights with either an 11 or 12 inch tread width.

Use this information to inform the design of stairs if you are considering remodeling or replacing a stairway in your home. Carpenters and home improvement contractors are typically excellent craftspeople, but may be inclined to use older traditional stair building formulae not informed by *human factors** research, so be sure to discuss these issues with your contractor if adding or replacing stairs is part of any remodeling project you are planning.

- Stair Construction and Maintenance

Dimensional uniformity in tread widths and riser heights is one of the most important safety factors in stair construction. A difference of just 1/4 inch between adjacent riser heights can cause an accident. Existing stairs that are not dimensionally uniform are significant hazards. Whenever possible, they should be replaced with correctly built stairs, especially if they are in a home or apartment with elderly users. Articles left on stairs create a tripping or slipping hazard. This is age-old advice, but needs to be continually repeated: keep stairs clear. Broken treads, loose or torn carpet and other coverings are a hazard. They should be repaired immediately. Use of non-slip surfaces on treads can also help prevent accidents. A broken light over the stairs or a poorly lit stair case run also creates a fall hazard. Make certain stairways are well lit.

- Stair Placement.

Many times people are not aware of the presence of a stair. The steps are often the same color and texture as surrounding surfaces (top and bottom levels) and they are often poorly lit and marked, making them difficult to see. This is probably the primary reason that a disproportionate number of falls occur in stair runs of just one or two steps. It is often not obvious to a person that there is a change in the floor level.

If you live in a home with stairs of just one or two steps, make certain that people can easily tell a stair is present. Visual or tactile clues that draw attention to the stair, changing floor materials or colors for example, can be used to signal people of a change in floor levels. Providing a handrail for just one or two steps may seem unnecessary, but the railing protruding from the wall surface adjacent to the stair provides a visual clue of its presence.

- Stair Use.

User behavior is a contributing factor to stair falls. Hurrying or running and not paying attention can contribute to a fall. Carrying items down stairs is also often associated with falls.

- Handrails

Templer (1992) lists two ways that stair handrails prevent falls:

- 1) they help in preventing a loss of balance for users ascending or descending stairs;
- 2) they provide a means for users to quickly regain balance after a slip or stumble.

Building codes and research findings do not completely agree over how to place handrails so they might serve the above functions. Research done by Maki and Fernie (1988) indicates a handrail height of 36 to 40 inches is most effective in preventing falls when descending stairs. But handrail heights set by national and state building codes require a height of 30 to 34 inches. So at what height should you install handrails in your home? The *Human Factors Design Handbook* suggests a handrail height of 34 inches (Figure 2). Given that this dimension falls within the range required by most building codes, this is a sound recommendation.

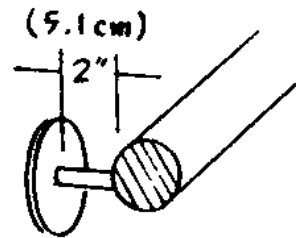


Figure 1
Clearance for knuckles



Figure 2:
Suggested Handrail Height



Illustrations from Human Factors Design Handbook (1992).

Pinch Grip versus Power Grip

Many researchers have examined grip force capabilities of the human hand. Results of this research indicate that the power grip (Figure 3) optimizes grip forces in the hand. Round-shaped rails with a diameter of about 1.5 inches maximize grip forces for adults, while a diameter of between 1.125 and 1.25 inches maximizes grip forces for children.

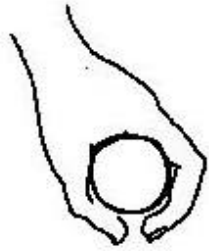


Figure 3
Power grip
Illustration from *The Staircase* (1992)



Figure 4
Pinch Grip
Illustration from
The Staircase (1992)

Rectangular shaped boards tipped on edge produce a nice decorative effect as a handrail and are often easier to attach than round shaped railings. But, as you can see from Figure 4, this type handrail requires a pinch grip, the least effective grip for maximizing the gripping forces in the human hand.

Falls on residential stairs kill and injure many people in the United States each year. By using the research-based information presented in this article, and by taking a human-factors approach to stair design, construction and maintenance, many falls can be prevented.

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