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HEALTH & SAFETY LABORATORY

**Falls on Stairways – Literature Review**

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# EXECUTIVE SUMMARY


The primary aim of this piece of work was to provide an overview of the literature relating to falls on stairways. Falls from height is currently a Priority Programme for the Health and Safety Executive. Analysis of the RIDDOR statistics between 1996/97 and 2001/02 showed stairs to be the most common agent in low fall accidents (below two metres). Analysis of the 2001/02 statistics showed the number of stair incidents to have decreased, however, there remained 500 low falls involving stairs, making stairs the second most common agent, behind ladders in this year.

The objectives for this piece of work were as follows:

- Identify and analyse existing information and evidence of stairway falls
- Evaluate the quality, reliability and relevance of existing information and data
- Identify information and data gaps
- Provide an analysis of the possible causes of stair fall accidents including their relative importance
- Provide an analysis of the possible control measures that can be adopted by employers and their potential effectiveness
- Make recommendations for potential interventions by enforcing authorities, intermediaries and industry groups

The scenario of falling down stairs was summed up quite poetically by Templer (1978, cited in Hemenway, 1994): "To fall down stairs is not only to fall off a cliff, but to fall on rocks below, for the nosings of steps presents a succession of sharp edges."

Most stair accidents occur in domestic settings. This means that there is less information available to persons wishing to consider and reduce injuries from falling on stairs in the workplace. Industries that experience relatively high numbers of falls in the UK are the service, manufacturing and construction industries.

The building regulations have controlled stairway design since 1944, however, they are not retrospective. As a result, there are many buildings in existence which do not meet the current required standards. Building regulations control aspects such as handrail and balustrade heights; step widths, goings and risers, and the step materials and lighting requirements for stairs.

Existing literature for stairway falls is based mainly on information derived from accident reports, casualty reports, coroners' reports and compensation reports. A small proportion of these studies relate to falls in the workplace. Videotape has been used to analyse stair fall incidents, a relatively novel approach to the stair fall topic. The laboratory setting has also been the focus for studies to determine the step dimensions that maximise safety for pedestrians.

In terms of the quality of existing information relating to stairway falls, the majority of the evidence presented is based on accident records. Detail is often lacking in such records and researchers in the field acknowledge this shortfall. There is a need for a thorough and structured method for investigating stairway accidents, which as a consequence will yield more detailed information for research purposes.

There are gaps to be filled in the research relating to stair falls. There has been relatively little research carried out relating to falls in the workplace, with most information relating to falls in the domestic setting. The use of videotape for assessing falls in real time is an avenue of research that could be explored further. Criticism in the past has been directed towards studies

set in the laboratory because the environment does not adequately simulate the conditions experienced during actual stair falls.

Avenues for future research may include:

- Interrogation of industry-specific accident data to allow specific interventions to be developed instead of suggesting general and broad-based interventions.
- The use of video to assess pedestrian traffic control measures (such as ‘keep left’ signs and painted lines to separate up and down traffic).
- The development of a checklist for the investigation of stairway accidents, to enable more thorough and detailed accident investigations to be carried out.
- A survey to assess the prevalence of inconsistency in stairway dimensions.
- The effects of riser height on fatigue
- The effect of various flooring surfaces on the likelihood of slipping when using stairs.
- The monitoring of the slip resistant properties of stair nosings with use.
- The effect of different styles of footwear (for example, heeled versus non-heeled) on the likelihood of slipping when using stairs

Stairway falls are usually caused by a combination of different factors. Falls may be influenced by stair design, stair maintenance, the wider environment, the characteristics of the stair user (age, gender, physical fitness etc) or their behaviour. There is no evidence to suggest that one single factor is more important than any other.

Control measures exist that may be used by employers to reduce stair fall occurrence. Regular housekeeping, maintenance and inspection are key to reducing the likelihood of stair falls. Features such as handrails, colour-contrasting anti-slip nosings and adequate lighting will improve the stairway environment. It has been suggested that controls to reduce the severity of injuries may be an avenue for exploration. Features such as carpet underlay may reduce the likelihood of bone fracture, particularly in the elderly.

For control measures to be applied at a more global level, it is believed that changes to the building regulations, in particular to increase stair goings, will be an effective intervention. Awareness campaigns to implement behavioural changes for stair behaviour is an avenue which deserves further exploration. Lessons can be learnt from private companies who have successfully implemented behavioural changes relating to stair use in their employees.

# 1 INTRODUCTION

This piece of work was carried out at the request of Mr Ben Keene (HSE), of the Falls From Height priority programme. The primary aim of the work was to provide an overview of the literature relating to stairway falls. Analysis of RIDDOR data between 1996/97 and 2000/01 showed stairs to be the most common agent involved in low fall accidents (below two metres). The number of stair falls has since fallen, but in 2001/02 there were still 500 low falls involving stairs, making stairs the second most significant agent after ladders.

The objectives for this piece of work were as follows:

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# 2 BACKGROUND INFORMATION

## Stair terminology

Stair geometry may be described using three terms: rise, going and pitch (Figure 1).
*Rise* – the vertical distance between two consecutive treads, or between a tread and a landing.
*Going* – the horizontal distance between two consecutive nosings. The nosing is defined as the part of the tread that overlaps the tread below.
*Pitch* – the angle between a line joining consecutive nosings and the horizontal.

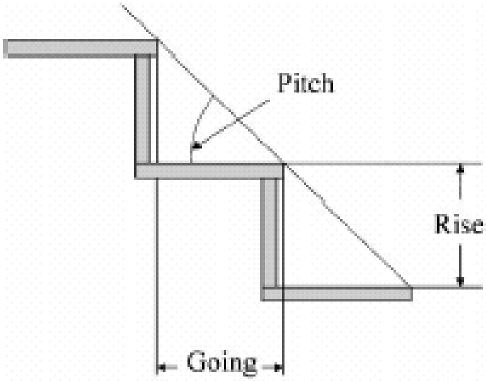


**Figure 1 –** Schematic diagram of stair terminology (Roys, 2001)

## Walking on stairs

Walking on stairs requires a different style of gait to that required for walking on the level. When walking on stairs, each step initiates on the toes and ball of the foot rather than the heel, as for level walking. In addition, the transfer of vertical weight during stair walking requires extra effort in ascent or a controlled fall in descent (Roys, 2001). Stride length on stairs is controlled by the size of the going and to some extent by the size of the rise. The traditional view is that for every unit increase in rise, the going should be decreased by twice as much to maintain the same stride length (Roys & Wright, 2003).

The greatest chance of a fall occurring on stairs is during the swing phase. At this point the rear foot passes over two nosings and this is where the risk of tripping is at its highest. Another risky situation occurs in stair ascent when the rear foot pushes off the lower tread. If the slip resistance of the tread is too low at this point then there may be a risk of slipping (Roys, 2001).

## Injuries

"To fall down stairs is not only to fall off a cliff, but to fall on rocks below, for the nosing of steps presents a succession of sharp edges" (Templer et al, 1978). This quote depicts how a fall on a staircase may be likened to falling from a great height, but also that injuries may be made more serious by virtue of the bumpy landing that follows.

The types of injuries incurred in non-fatal stair accidents are bruises, bone fractures and sprains (Nagata, 1991). These may occur to the legs and feet, the trunk, the head, the arms and hands. For fatal accidents, common injuries are fractures to the skull, fracture to the trunk and fracture to the lower limbs (Webber, 1985). Fracture of the femur is a frequent lower limb injury that often precedes fatality in the elderly. Fracture of this region may require a hip replacement, which on average costs £3755 (National Audit Office, 2000). Survival following a hip fracture is not particularly high, with a mortality rate of 35% seen over the first year (Janaway et al, 2005).

The injuries sustained whilst ascending stairs are generally less severe than those sustained whilst descending stairs. In ascent, the forward momentum of a fall is arrested by the stair structure itself, whilst in descent there is potentially a much greater distance to fall. The number of injuries sustained after a fall whilst descending stairs grossly outweighs those whilst in ascent. Templer et al (1985) reported that 92% of injuries were incurred during stair descent, and Nagata (1991) also reported a similar proportion of injuries experienced in stair descent (78% for males and 92% for females).

## UK Statistics

Most stair injuries occur in the home. In the UK there are nearly as many deaths each year from accidents in the home as from traffic accidents. Falls account for over half of these accidental deaths, and half of the deaths from falls relate to stairs. There are an estimated further one-quarter of a million non-fatal accidents on stairs in the home each year, which are serious enough to cause the victim to visit their GP or hospital accident and emergency department. It has been calculated that this rate of falls is equivalent to a domestic accident on stairs every 2.5 minutes (BS5395-1:2000).

For non-domestic stairs, it is estimated that each year in the UK, there are over 100,000 injuries (DTI, 1999 cited in Roys & Wright, 2003) and around 100 fatalities (Office of National Statistics, 1996/7/8 cited in Roys & Wright, 2003).

During 2001/2002 there were 500 RIDDOR reported accidents involving low falls (below two metres) from stairs. For this time period, this made stairs the second most significant agent in low falls behind ladders. The majority of these falls result in over 3 day injuries although a significant portion involves major injuries.

In the UK, the industries most affected by stairway falls are the service industries, followed by the manufacturing and construction industries. Examples of occupations experiencing relatively high numbers of falls in the service industries are: post workers, police officers, sales assistants, care assistants, nurses, clerical staff, HGV drivers, teachers and cleaners. For the manufacturing industry, 'baker' has been identified as a high-risk job role and in the construction industry, electric fitters have been identified as a key occupational risk group (Bomel, unpublished).

## World Statistics

In Japan during 1976, almost as many people died from falling on steps or stairs (541) as from fires (865) – and this in a country with many wooden structures (Kose, 1982 cited in Templer, 1992). In Canada, injuries and fatalities on stairs greatly outnumber (by about one order of magnitude) those from all natural disasters (Pauls, 1985).

Studies in the US, Japan and Sweden have also shown that most stair accidents occur in the home (US 80%, Japan 68% and Sweden 72%). In Sweden most of these stair falls occur in the victims' own homes. In Japan, of those accidents that do not occur at home, more than half occur in shops, restaurants or railroad stations. In the workplace in the US, falls on stairs have become one of the major causes of compensation claims and lost work hours (Templer, 1992).

Cohen et al (1985) identified from an analysis of state workers' compensation claims for New York and Ohio that high risk industries included: police, fire protection, public health administration, building construction, trucking and membership organisations (social, fraternal and religious). Highly ranked industries often involved service functions or transitory conditions away from the employers' premises and thus were not directly controllable by the employer.

These statistics demonstrate that falls on stairways are a common source of injury, and occasionally may result in fatalities to stair users. Some researchers have even gone so far as to say that "Stairs are the most serious accident hazards that individuals encounter in the everyday environment" (Merril et al, 1957 cited in Templer et al 1985). Most falls occur in the home, however targeting stairway falls at work is a key area identified by the HSE for accident reduction.

## Building Regulations

Building regulations control stairway design. The relevant document is The Building Regulations for England and Wales, approved document part K (BS 5395-1:2000). British Standards for stairs have existed since 1944 (Webber, 1985). The regulations were introduced as a contribution to safety in buildings by controlling the rise, going, pitch and headroom of stairways and by requiring adequate balustrades or rails.

The following paragraphs summarise the main points of the Building Regulations that apply to stairway design.

Stairs and landings should be provided with protection against falling over the edge of the treads. Guarding height should be no less than 900mm above the pitch line of the stairs and not less than 1100mm above landings.

In addition to guarding, every step with two or more rises should have a continuous handrail to provide guidance and support to those using the stair. Handrails are required to be beside the bottom two steps in a stairway if the stairway is in a public building or is intended for use by disabled people. Handrails should help an individual to regain balance in the event of a fall, and thus reduce the severity of injuries that may result.

Handrails should be:

- i) fixed securely at a vertical height above the pitch line of not less than 900mm or more than 1000mm
- ii) rigid and strong enough to provide adequate support for users
- iii) comfortable to grip and without sharp projections yet able to provide adequate resistance to hand slippage
- iv) a poor conductor of heat if exposure to heat is likely.

Circular handrails are usually the most comfortable to grip. Recommendations for handrail diameters are between 32mm and 50mm. For the elderly and for people with disabilities, handrails with diameters of between 40 and 50mm are recommended. The handrail should be supported at a distance of between 50mm and 100mm away from any guarding extending beneath the bottom edge of the handrail or from any wall, to prevent entrapment of fingers or hands.

It is preferable to have handrails on both sides of the stairwell. Where people are likely to be ascending and descending the stair at the same time, eg, on stairs with a width of 1000mm or more, it is essential to have a handrail on both sides.

Where public or assembly stairs (see page 9 for definition of public and assembly stair) have a stair width greater than 1800mm, the stair width should be divided by handrails into two or more channels so that all persons using the stair are within reach of a handrail.

A single step is likely to cause a trip and should not be placed across a circulation route. If a single step is used, it should be well lit and be prominently marked by a contrasting colour.

The use of stair coverings made from highly contrasting colours used in irregular, busy or regular geometric or striped patterns should be avoided. Dazzling surface patterns may camouflage the actual positioning of the step edge.

Step dimensions have been the focus of many scientific research projects. Stairs should be designed so that everybody using the stair can do so comfortably and safely whilst exerting the least amount of energy. It is generally accepted that the stride length for most persons moving at normal speeds on stairs is between 550mm and 700mm (BS5395-1:2000). When climbing stairs, extra effort is required in moving both forwards and upwards and this reduces the horizontal distance that an individual can travel in comfort. To ensure comfortable use and adequate proportioning, rise and going should be considered together. If the rise is small, the going should be proportionately greater to ensure that the stair is comfortable to use.

The step dimensions specified in the building regulations depend on the number of people using the stairway. Assembly stairs are frequently used by large numbers of people at the same time moving slowly, and so these steps should be designed with a large going and a small rise. Public stairs are used by people moving faster and unconstrained by other users, and so the rise may be greater. The rise for private stairs may exceed the maximum riser recommendations since the users will be familiar with the stair and space is usually at a premium. Private stairs often fall outside the recommendations given in the building regulations because many domestic dwellings pre-date the regulations, which are not retrospective. It should also be noted that many large (and old) houses are converted into offices or nursing homes and this may have implications for the occupants' safety, since the stair design may not meet The Building Regulations' current requirements.

**Table 1-** Recommended sizes for straight stairs and winders (measured in millimetres) (adapted from BS5395-1:2000)

| Stair category | Rise, r | | Going, g | | Sum of g+2r[a] | | Pitch | Stair clear width | | Handrail height | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Max | Min | Reduced min where limited use | Min | Max |
| Private stair | 100 | 220 | 225 | 350 | 550 | 700 | 41.5 | 800 | 600 | 900 | 900 |
| Public stair | 100 | 190 | 250 | 350 | 550 | 700 | 38 | 1000 | 800 | 900 | 1000 |
| Assembly stair | 100 | 180 | 280 | 350 | 550 | 700 | 33 | 1000 | | 900 | 1000 |

[a] – A comfortable gait is expected for most people if the value of (g+2r) (where g is going and r is riser in millimetres) is within the range given in Table 1.

Steps with shallow risers tend to make people trip, especially when the rise is less than 100mm. 220mm is the maximum rise that people are expected to negotiate safely (BS5295-1:2000). Risers should be equal throughout the whole stair. There should be no fewer than three, or more than sixteen rises in any one flight. Open risers may cause a sense of insecurity for stair users, especially the elderly, so careful consideration should be given when evaluating their installation.

For step goings, they should be sufficient to provide adequate support to the shod foot. During ascent, the going should be large enough to allow at least part of the heel to rest firmly on each step. In descent there should be no need to place the foot at an awkward angle.

Within limits, the flatter the pitch, the safer the stair is to use. Table 1 summarises the recommended pitches for the three categories of stair; private, public and assembly.

Treads and landings should have a surface (including the nosing) that does not become slippery in use. Most slips on the level occur between the shoe heel and floor, but when ascending or descending stairs, it is the sole of the shoe that makes first contact with the stair, often with the nosing. If slip resistant strips or inserts are used, they should be fitted as close as possible to the leading edge of the tread and should be of contrasting colour or brightness. The strips should be securely fitted and maintained to remain so. A minimum Rz roughness of 20μm for strips or inserts is recommended (BS5395-1:2001).

Where landings, stairs or steps are likely to become wet (for example, adjacent to an external doorway), appropriate matting should be used to reduce the amount of wet contamination carried inside by footwear. In addition, steps and landings should be designed to shed water and to prevent pooling of water.

Adequate artificial, and where possible, natural lighting, should be provided on stairs so that at all times, stair users are able to see where they are going. Users should be able to see each step, and most importantly, the first and last steps. Windows should not be positioned such that they allow light to shine directly into stair users' eyes.

## Some issues for the future

When considering how to reduce the numbers of falls, it is worth trying to foresee what circumstances may be like in the future. In this section, the factors of an ageing work population and the role of litigation are considered.

The average age of our population is getting older, which means that the average age of our working population will also become older. As we speak there are moves to increase the pensionable age for UK citizens. Nagata (1991) explained that in Japan in 1950 life expectancies at birth were 58 for males and 61.5 for females. In 1989 life expectancies were 75.9 for males and 81.8 for females, and inevitably these numbers will now have increased. Nagata estimated in 1991 that by the year 2000 approximately one quarter of all employees in Japan would be over 55. The issue here for stairs is that older people are more likely to have problems with vision and balance on stairs and are therefore more susceptible to falls. Bone density also decreases with age, particularly in females, so given a fall, older people are likely to sustain more serious injuries. In addition, the reaction times of individuals decreases with age, so the likelihood of successfully grasping a handrail diminishes. Given this circumstance, design of stairways for less physically-able people in the workplace will become more important.

Cohen and Jackson (1997) stated that, 'the one discipline most likely to have an effect on building codes and standards is litigation'. We live in an increasingly litigious society, and with this in mind, buildings should be designed to standards that meet high levels of safety rather than just aiming to meet the minimum requirements. It is often perceived that building codes are designed to maximise safety when in fact they often only achieve a minimum level of safety.

# 3 EXISTING LITERATURE CONCERNING STAIR FALLS

There are a number of studies relating specifically to falling on stairways. The majority involve the analysis of accident records, coroners' reports, casualty reports and compensation reports. Few studies have actually analysed falls in real time. There are exceptions however, and video footage has been used to investigate causative factors in actual stairway falls. Laboratory studies have also been conducted to investigate the effects of stair dimensions on stair safety and behaviour.

Most stair accidents occur in the home. Webber (1985) carried out an analysis of fatal falls on stairs and steps for England and Wales. Of the 652 deaths on stairs or steps, 560 occurred in the home (85%), 37 in public buildings, 27 in residential institutions and 4 in industrial premises. Nearly 70% of the fatal falls on stairs and steps involved elderly people, aged 65 years and over. Within this age group twice as many involved fatalities of women as men.

Cayless (2001) analysed 1035 coroners reports of fatal domestic slip, trip and falls (STFs). The data was derived from a database of domestic deaths between 1993 and 1996, produced by The Office of National Statistics. The main aim of the study was to relate building features and information in coroners' reports to ascribe causation of death. Of STF deaths, 61.4% related to falls from stairs, 6.7% to falls from steps or ladders and 5.5% to falls from windows or roofs. About 60% involved infirm individuals, and alcohol was involved in 60% of the falls in the under 50 age group. Footwear was a factor commonly linked to stairways falls. Movable furniture positioned near to stairs and radiators situated at the bottom of stairs were a common cause of harm to stair fall victims.

Jackson and Cohen (1995) concluded from an in-depth analysis of 40 stairway accidents that the greatest problem with accident stairways was not individual (user) or external variables, but dimensional inconsistency inherent in some stairways. This American study was based on forty stair accidents where authors were safety consultants or expert witnesses. In this study, 73% of plaintiffs were descending stairs at the time of the accident. 50% (20) of accidents involved stairs with four or fewer risers. Of the 20 cases with four or fewer risers, 60% took place on stairways with only one or two risers.

Cohen et al (1985) carried out an analysis of occupational stair accidents, with data collected from worker's compensation agencies in Ohio and New York. 14% of falls involved stairs. Two times more accidents were found to occur indoors as outdoors, probably because more work is performed indoors than outdoors. The familiarity of the environment was highlighted as being an important aspect. Occupations such as delivery drivers and public health inspectors were flagged as being key because such individuals often find themselves on unfamiliar premises and thus may be more prone to suffering a stairway fall. 15% of accidents took place on stair entrances or exits. In these locations there are rapid changes of environment, for example, changes in level, surface material and condition, varying visual cues and changes in the amount of traffic due to funnelling at entrances and exits. A high proportion of cases occurred in office environments (20%) and manufacturing areas (13%). Where accidents were due to surface material problems, metal and cement surfaces contributed to two-thirds of the cases where slips were causal. Carpeted and brick surfaces commonly involved tripping incidents.

Templer et al (1985) carried out a novel study using videotape as the primary means of data collection. The aim was to identify risk factors for stairway falls using video footage of 31 flights of stairs taken from industries with high frequency and severity of stair-related injuries. Two video cameras were focussed on the top and bottom of the flight of stairs (where most incidents take place). Recordings were made throughout the day for five days of the week. It was found that individuals most prone to stairway incidents (falls, trips, slips, missteps, moments of imbalance) were those whose movement was impeded by others and who were older. Individuals less prone to incidents were wearing glasses and were very large or heavy. Steps with high incidence rates had larger riser heights (in excess of 15-18cm) and smaller tread depths (less than 25-27cm). For descent (92% of injuries) the size of the nosing projection appeared to be key. Nosing projections exceeding 1.8cm were associated with higher incidence rates. Higher incidence rates were consistently associated with linoleum or tile treads, whereas lower rates were associated with concrete or stone.

Nagata (1991) conducted a study based on labour casualty reports from occupational stair accidents occurring within greater Tokyo. Victims were identified and interviewed with questions posed relating to speed of walking, footwear type, carriage of objects and their perceptions of the likely cause(s) of the fall. Site surveys of stairs were also conducted with tread dimensions measured and the materials of treads and nosings recorded. Most accidents were found to occur whilst descending stairs in haste. Young female employees wearing high or semi-high heeled shoes were common victims. The proportion of female victims was relatively high compared to their male counterparts. Employees were more prone to experiencing a misstep when using straight flights of stairs.

The laboratory setting has been used to establish the step dimensions that result in a reduced likelihood of losing balance on stairs. Stair rigs may be used which can be altered to decrease or increase both the rise and going. Loo-Morrey et al (2004) recommended the minimum goings to be revised as follows: Private stairs 250mm, semi-private stairs 300mm and public stairs 350mm. These results were based on objective data for four key measures: hesitations, missteps, glances at feet and use of the handrail. Subjective measures of the perception of safety for the stair users were also recorded. Roys and Wright (2005) describe how research has shown that the gait of stair users depends on the size of the going such that if the going is large enough users can, and do, place the whole of their foot onto the flat part of the tread. As going decreases, the user allows their toes to hang over the edge of the tread or significantly turn their feet in order to continue their descent, which may increase the likelihood of a stairway fall.

Although most of the studies described above relate to falls in occupational settings, the relative amount of information available relating to falls in the workplace is very small compared to that for domestic settings.

# 4 RELIABILITY AND QUALITY OF EXISTING INFORMATION

Many of the studies conducted in the area of stairway falls are based on data gathered from accident reports. The issue here is that accident records often lack in detail. Cayless (2001) commented how information in coroner's reports is generally insufficient to link building features to stair injuries. In only 46.9% (241) of accident records were descriptions of the stairs recorded. Very few quantitative dimensions were included: width was recorded in one case and tread dimensions recorded in three other cases. Cayless also commented how coroner's reports are kept on paper and that examination of these records is highly time consuming and thus expensive. A computerised system would be a much easier system to interrogate.

Webber (1985) stated that death certificates do not include any classification of environmental factors such as the type of stair involved in the fatality. Only a small proportion of inquest notes used in Webber's study included some description of the stair. The usual source of the stair description would be the police constable attending the scene. Only very occasionally were tread dimensions included. Webber also commented how changes in the recording of deaths over time have affected the quality of the data that may be gleaned from inquest notes.

Hemenway et al (1994), in a study of stairway accidents in the home reported that there is a lack of information in accident reports relating to risk factors such as alcohol consumption, problems with vision, balance or other physical or cognitive impairments.

Jackson and Cohen (1995) commented that research with qualitative data (accident reports) is problematic due to the subjectiveness of the information involved. The NAHB (National Association of Home Builders) suggested in 1992 that future research into stairway falls should focus on personal interviews of stair accident victims. Templer (1992) was slightly wary of this approach however, due to the fact that stair accidents take place so quickly that the individual is not entirely aware of how they fell. Hemenway et al (1994) also suggested that reliance on self-reports could be potentially problematic due to the fact that detail may be forgotten. Jackson and Cohen (1992) also explained that in their experience most people describe their fall as initiated by 'slips', the easiest concept to comprehend.

Another aspect concerning the reliability of data is that of litigation. Where individuals intend to make claims for their stairway falls, aspects such as self-evaluation of speed of travel may be unreliable. Plaintiffs in personal injury lawsuits may intentionally or unintentionally perceive their actions quite differently to that of an objective researcher.

There is a clear message here that the quality of information gleaned from accident records is limited by the quality of the evidence given in the original accident reports. There seems to be a need for a structured and thorough method for investigating stairway incidents.

# 5 GAPS IN THE LITERATURE AND FUTURE WORK

## Gaps in the literature

The research into stairway falls is by no means complete.

The majority of studies relating to stairway falls concern falls in the home. The main reason for this is that this is where most stairway falls occur, and there is therefore more information available to interrogate. For employers looking to reduce falls on stairways, there is less literature available relating to falls at work.

Many stairways research projects have been conducted in the laboratory. Cohen and Jackson (1997) reported how the authors of an NAHB report believed that stair accident research at the time was inaccurate because the work was based on experiments conducted in laboratory settings, or in non-injury incidents, not actual stairway falls which resulted in injuries to persons.

The use of videotape has been used by some key researchers in the stair falls field. The advantage of videotape is that it can capture actual stair falls in real time, and the evidence can then be replayed over and over. Cohen (2000) described how he used video evidence from a stairway where a fall was being litigated. The plaintiff was attempting to claim that he had caught his trailing foot on a slightly raised vinyl strip. Cohen demonstrated that this occurrence would have been very unlikely, because the loose part of strip was only 4 to 5 inches away from the handrail. Video evidence demonstrated that most people placed themselves 32 inches from the handrail and no one was ever observed to be closer than 7 inches from the handrail. The plaintiff's case was subsequently dismissed.

Templer et al, (1985) (and earlier, Archea et al, 1979) used video cameras to capture stairway falls in the occupational setting. The cameras were set up in the work premises of industries that experience a relatively high prevalence of stairway falls. Video is a useful medium for analysing stairway falls, there are however difficulties. Capturing fall incidents requires a long and sustained sampling time period, due to their relative rarity. Secondly, the use of trained researchers to watch back the videotapes to analyse the data is a very labour intensive process. However, the 'marking' of videotapes so that incidents can more easily be found would assist this data analysis.

Another potential issue is that of the growing (physical) size of our population. The younger populations are showing an upward trend in all basic anthropometric dimensions. This should be considered when recommending minimum going requirements for stair treads. If the average foot size is increasing, and stair safety is partly determined by the proportion of the foot that can fit onto the tread, then stair going recommendations become very important for stair safety. It should also be recognised that foot sizes are measured for the unshod pedestrian, which means that approximately 30mm should be added to foot lengths to account for shoes (Roys, 2001).

In 1995, Jackson and Cohen commented that there have been no studies carried out to examine the frequency of use of stairways for different age groups and their subsequent accident rates. No studies have been identified that have changed this position. It is believed that elderly groups may intentionally avoid stair use, and given this relatively low exposure, the risk of falling on stairs becomes disproportionately high for elderly groups. By determining the level of risk for different age groups, awareness campaigns can be targeted at the most vulnerable stair users.

## Future Work

For industries with particularly high prevalence of stairway falls, it could be beneficial to interrogate industry specific data. There may be common themes that can be extracted and used to develop targeted interventions rather than using broad and generalised interventions. To illustrate, it could be that certain industries, for example, food and drink, suffer from wet or greasy contamination of stairways and therefore improving cleaning regimes may be an effective intervention.

Video could be used as a method for examining the effectiveness of pedestrian traffic control interventions. Interventions may include the painting of lines and arrows onto stair treads to separate traffic flows. Video footage could be taken pre and post intervention to examine the effectiveness of the modification.

The effect of riser height upon the fatigue of stair users has yet to be researched. This aspect of stair design may be investigated using an adjustable stair rig in the laboratory setting.

The likelihood of a slip occurring on a stair tread is, in part, affected by the proportion of the foot that can be placed on the stair tread. The slip resistant properties of the stair tread will also affect the likelihood of a slip. There could be scope for investigating the proportion of the foot that is required to be placed on stair treads to gain a firm footing for surfaces with different slip resistant properties. This type of work has already been investigated (to a very limited degree) at HSL, in conjunction with BRE, and the work could be worth revisiting with larger sample sizes.

Since stair nosings seem to be particularly important in negating stairway falls, it would be interesting to monitor how their slip-resistant properties change with wear. There are measuring devices available (such as pendulums that measure the coefficient of friction and surface microroughness meters) that may be used to monitor these changes.

Researchers have commented in the past that there is insufficient detail available in accident reports for stairway falls. In depth interviews with victims of stairway falls could be used as a method for extracting details associated to the human factors elements involved in stairway falls. These interviews may, however, be subject to the biases of individual recall mentioned previously.

It may be worthwhile to develop a checklist for the features of stairways that should be investigated following a stairway incident. This would enable stair fall incidents to be investigated in a thorough and standardised way, which will ultimately increase the quality of data available for research purposes.

A questionnaire may be used for evaluating the effectiveness of, for example, poster campaigns in raising awareness to reduce the occurrence of stairway falls. It would be necessary to gauge opinions and awareness before and after the poster campaign.

Different types of footwear may be influential in the occurrence of stairway falls. Nagata (1991) reported that females wearing high or semi high heels experienced relatively high fall rates. The effects of wearing various footwear types, for example, heeled versus flat, could be investigated on a variable dimension stair rig. Force plates may be used to calculate the required coefficient of friction necessary for different shoe types for stairway descent.

Dimensional inconsistency in stairways has been cited as a primary cause for stairway falls (Jackson & Cohen, 1995), however we do not know how widespread this inconsistency is. It would be interesting to measure the dimensions of a sample of stairs in occupational settings to establish the prevalence of dimensional inconsistencies.

# 6 CAUSES OF STAIRWAY FALLS

One of the problems with ascribing causation for stairway falls is that they are very rarely caused by a single factor. A number of factors usually combine together resulting in a stair fall, for example, an elderly user moving on a poorly lit stairway with a carpet pattern that disguises the tread edges. The types of factors present in stairway falls may, however, be divided into a number of categories. These categories are: stair design, stair maintenance, environment, user and behaviour.

## *Stair design*

The dimensions of stairways are very important for preventing stairway incidents. The going of a stairway is crucial in determining the proportion of a users' foot that can be placed on a stair tread. For this reason there has been a great deal of interest surrounding the minimum tread dimensions given in building standards. Nagata (1991) found that the proportion of goings below 119mm was 11.6% for accident stairs compared with 0.1% for non-accident stairs, thus demonstrating the importance of larger goings in reducing stairway accidents.

Cohen & Jackson (1997) indicated that inconsistencies and variations within stairways to be greater than the required building codes (In the US, variation of three-eighths of an inch is permitted). Cohen & Jackson's measurements showed the average variation in tread dimensions to be almost half an inch, and so in this case variation was more prevalent than previously thought. An in depth study of forty stairway accidents led Jackson & Cohen (1995) to believe that the strongest pattern for stairway accidents lies in dimensional inconsistency within stairways. The presence of dimensional inconsistency in stairway treads has also been evident in forensic investigations of stairway falls investigated by HSL staff (Personal communication).

Tread risers are also an important aspect. If risers are too high, stair users may fatigue quickly and be more prone to tripping. If risers are too shallow, users may be tempted to take two steps at a time and increase the chance of mis-stepping.

The steepness, or pitch of a stair may influence the likelihood of a fall. British Standards control the angle of steepness, however in private buildings the pitch may often exceed the maximum of 41.5 degrees.

Protruding nosings above the level of the stair tread can pose a trip hazard. Nosings should preferentially be inset within the tread such that they do not protrude above the level of the tread.

The ill positioning of a single step often catches people off guard. Pedestrians may not notice a single step, and so where they cannot be avoided, they must be made visually obvious to pedestrians through the use of strong colour contrast.

The type of stairway is thought to influence the occurrence of falls. Svanstrom (1997 cited in Templer, 1992) found that straight flights of stairs without landings accounted for 52% of all accidents but only 29% of stairs. Similar findings were uncovered by Kinoshita et al (1978, cited in Templer, 1992) with 36% of accidents occurring on straight stairs, which accounted for only 13% of the stair type in the study. Straight flights tend to be very short or very long, and short flights are the locus for more accidents (Templer, 1992). One reason for why straight flights may be the scene of a greater number of accidents is that their path is often clear and uninterrupted and so stair users are lulled into a false sense of security and reduced attention. Straight flights may also result in more severe injuries, because there is no place on the stairway where the fall may be broken (as would occur with a helical or dogleg stair). Building codes usually prohibit the construction of long, straight flights of stairs (a maximum of 16 treads is permitted under current UK Building regulations).

Special attention should be paid to the top and bottom three stairs in a flight. Studies have demonstrated that a disproportionate amount of stairway accidents occur on these top or bottom stairs (Templer, 1978). At these locations, the user may be looking around for the next part of the journey, or the route to be taken and so their attention may not be entirely focussed on the stairway (Templer, 1992).

Any visual cue that may distract a pedestrian's attention away from a staircase could be potentially dangerous. A distracting view or artwork on stairwell walls should therefore be avoided.

Carpets or flooring with dazzling patterns may disguise the edge of stair treads and may cause a misplaced foot. These patterns should be avoided and contrast should be used on the edge of the stair tread to increase its visibility and definition. Similarly, lighting provision that results in glare over stair treads should be avoided.

### *Stair maintenance*

Issues associated to stair maintenance and the causation of falls is relatively self-explanatory:

- Stairs should not be cluttered with obstacles that users may trip over.
- Carpets or nosings that become loose or torn may become a trip hazard.
- Contamination of stair treads with liquid or dust will increase the likelihood of a slip on stairs.
- The absence of a handrail or a damaged handrail may increase the severity of a stairway fall because the user has nothing to grasp on to.
- Lighting in the stair area should be well maintained. A study relating to stairway falls and lighting (Carson, 1978, cited in Templer, 1992) showed that when light levels were reduced from 86 lux to 22 lux, accident rates increased from 11% to 22% respectively.

### *Environment*

External environmental factors mainly concern weather-related factors and thus affect external staircases. Ice, snow and water on stair treads greatly increase the likelihood of slipping on a stairway. In icy spells of weather, there are often peaks in accident occurrence on outdoor stairs, where clearing of snow or gritting has not adequately been carried out. It should also be noted that outdoor staircases may often form evacuation routes. Maintenance of these routes is therefore crucial since pedestrians may be using them in emergency situations where rushing might occur. Nagata (1991) also commented that thick clothing worn in winter months might impede free movement contributing to higher accident prevalence in winter.

### *User*

Falls on stairways may often be attributed to the personal characteristics of the stair user.

Age is a factor that influences the likelihood of a stairway fall, with the elderly particularly prone to falling. Pauls (1985) reported that persons over 65 account for approximately 85% of deaths resulting from stair accidents. As the number of elderly people in the population increases, the problem of stair accidents is likely to increase. Hemenway et al (1994) in a study of falls in the home showed that individuals over 75 have thirteen times the injury rate of children aged 0-9. The US National Safety Council statistics (1989) showed that 84% of those who die after a fall are over 65 (Templer, 1992). In addition, stairway injuries among the elderly (in this case over 65) are more likely to result in hospitalisation.

Two reasons for the high prevalence of stairway injuries for the elderly is that vision and balance deteriorate with age. Visual performance often diminishes in moderate to low illumination. Presbyosis (loss of ability to focus on near objects) may also reduce the ability to see clearly step edges. These visual problems may be exacerbated by the development of cataracts that also decrease visual performance. Balance is affected by somatostomatory function and is often degraded in the elderly. This decreased function may affect the perception of the stair edge by the pressure receptors in the feet, and also the sense of joint position, which is necessary for judging the step clearance of the swinging limb (Cavanagh, 1997). To potentially make matters worse, bone density also diminishes with age and so the injuries sustained may be more serious.

A number of studies have demonstrated females to be more prone to stairway falls than males (Hemenway et al, 1994; Nagata, 1991). The high accident rates for females is probably due to the fact that most stair accidents occur in the home and adult females still spend more time in the home than adult males. Templer (1992) says that in public settings there are no differences in accident rates for males and females, presumably reflecting their similar relative numbers in this setting. Women also have less upper body strength than men which may prevent women from stopping falls once they have been initiated (Jackson & Cohen, 1995). The wearing of high-heeled footwear by young females was identified by Nagata (1991) as an influential factor for the high prevalence of falls in this relatively young age group.

The familiarity of an individual to an environment is thought to be influential for stair falls. If a stair user is familiar with the characteristics of a stair site, then the inherent hazards are already recognised and can more easily be avoided. Cohen et al (1985) raised the point that job roles such as delivery drivers and public health inspectors experienced high prevalence of stair falls on premises in the field, because the environment is unfamiliar to them. Another circumstance where familiarity may become an issue could be due to transient changes on a routinely used staircase, where poor housekeeping or maintenance may be the key. The users who routinely use such staircases would therefore not expect any changes and may become a fall victim.

Other individual characteristics, which may increase the likelihood of a stairway fall include dizziness or faintness, or physical weakness in the joints such as the knee or ankle.

### *Behaviour*

Certain behaviours may influence the likelihood of experiencing a stairway fall. Carrying items is commonly linked with falls on stairs. Nagata (1991) reported that 24% of victims were carrying an object at the time of the fall. Carrying items decreases the chance of recovering from a loss of balance because the hands are not free to grab onto a handrail. The item may be bulky and obstruct the view of the stairway. The carriage of the item may also alter the balance of the stairway user which may lead to a fall.

Accidents may occur due to undue haste or rushing. Authors in the stair research field have commented that rushing when reporting for work or when leaving work is relatively common (Cohen et al, 1985). This issue can potentially be tackled by employers with training and work practice reinforcement.

The use of handrails whilst moving on stairs varies. Pauls (1985) reported use of handrails in Canadian stairs research as varying between 40% and over 80% for persons within reach of the handrail and for stairs having one of the following: long flights, steep slopes, distracting views, poor step visibility and crowded conditions. In the Edmonton Commonwealth Games study (Rhodes et al, 1980 cited in Pauls, 1985), handrails were used by 55% of adults who made up 87% of the sample studied. Handrail technique in ascent commonly involves using a discrete grip along with a pulling action. For descent, handrail use ranges from sliding or guiding to discrete grips (Rhodes et al, 1980 cited in Pauls, 1985).

Researchers in the stair field have often wondered whether alcohol intoxication is an influential factor for deaths and injuries on stairs. In 1977 in Japan, the Ministry of Health and Welfare reported that around 30% of males suffering fatalities from accidental falls were reported to be alcohol intoxicated. Hemenway et al (1994) commented that there is often a lack of information in accident reports relating to risk factors such as alcohol consumption. Other researchers including Pauls, Templer and Johnson believe that excessive alcohol consumption is causal in stair falls.

In terms of which causal factors are the most important for stairway falls, this is a difficult aspect to determine. The studies completed to date tend to focus on certain groups of causal factors in influencing stair falls. For example, there are studies that consider building features in relation to falls and studies that consider age and gender in relation to falls. There are no definitive pieces of work that consider all risk factors together and give an overall ranking of the most important factors to consider for stairway falls. The table below summarises the main causes of stairway falls for a number of studies by leading stairways researchers.

**Table 2 -** Leading causes of stairway falls from the literature.

| Author | Date | Main causes |
|---|---|---|
| Templer, Archea & Cohen | 1985 | Impeded movement<br>Older age groups<br>High riser height<br>Small goings<br>For descent, nosing projections exceeding 1.8cm |
| Cohen, Templer & Archea | 1985 | Descent<br>Lack of familiarity<br>Shared attention |
| Nagata | 1991 | Descent<br>Haste<br>Young females<br>High heels<br>Straight flights |
| Jackson & Cohen | 1995 | Dimensional inconsistency |
| Cayless | 2001 | Infirm persons<br>Alcohol |
| Roys | 2001 | Small goings |

It can be seen from Table 2, that there are number of different types of causal factors cited as being key in stairway falls.

The main points to be drawn out from this rather generalised analysis are:

- Stair descent results in many more stair fall injuries than stair ascent.
- For design-related issues, narrow goings and tall riser heights contribute to increased numbers of falls. Maintaining consistent dimensions is also key.

- The maintenance of stairways to ensure adequate lighting and good condition of treads is necessary to maintain safety.
- Older users and users unfamiliar with the stair environment seem to be individuals at high risk.
- Behaviours such as rushing, wearing of inappropriate footwear and the consumption of alcohol are risky behaviours for stairway falls.

# 7 REDUCING THE OCCURRENCE OF STAIRWAY FALLS

## Control measures suitable for employers

For many proprietors, the staircases are already present in their buildings so there is no luxury to influence stair design before their actual installation. There are however, a number of measures that building owners can apply to reduce the likelihood of stairway falls and to reduce the severity of the injuries sustained from a fall.

The housekeeping of the stairs in a building is just as important as the cleaning and clearing of corridors and open areas, which are routinely tended to. The same kind of attention is necessary on stairways. Treads must be kept clean and free from obstructions. When cleaning stairs with detergents, the treads must be rinsed thoroughly with clean water, to make sure that no soapy residues remain and so reduce the risk of slipping. If any spillages occur, employees must be encouraged to report these immediately to maintenance staff or take action themselves to clear up the contamination.

As with most pieces of equipment, stairs should be regularly inspected for wear and tear. Particular things to look out for are nosings that have come away from the step edging and fraying carpets that may pose a trip hazard. A loose nosing may pose a sufficient distraction under a user’s feet as to cause an individual to lose their balance. The handrails and balustrades should also be inspected regularly to make sure they are in good repair, firmly fixed and structurally sound.

Carpet is a common option used in offices and some public buildings. Carpet is a suitable material for steps, however it is prone to becoming worn smooth through excessive use. In places where carpet is used and is exposed to heavy traffic, it may be a good option to install nosings over the step edges. The nosings should have suitable slip resistance. A microroughness of at least 20μm is necessary for step nosings to provide slip resistance in water-wet conditions (a higher level of microroughness is required for more viscous contaminants) (BS5395-1:2000). The nosings should be flush with the rest of the tread and not stand proud, which would reduce the effective contact area for the shoes. Where nosings are installed, they should be of a colour and luminance that contrasts with the remaining step. This will provide the user with a clear visual indication of the tread edge. If steps are to be highlighted using colour contrast, the first and last steps should certainly be highlighted and where single steps occur, these should also be highlighted. For exit stairways, Pauls (2005) recommended that both the handrails and step nosings should be marked with photoluminescent material to be visible under all expected lighting conditions, including loss of power.

A common intervention that many employers use is to install anti slip tape to tread edges. This tape can be effective if installed appropriately. The tape should be installed on the very edge of the tread where the nosing shape is square. Where the nosing is rounded, the slip resistant material must continue at least to the vertical front face of rounded nosings (Figure 2, Roys & Wright, 2003). It should be noted that strips might move with use and subsequently become a trip hazard. Also, anti-slip strips will wear smooth over time and so should be regularly inspected and replaced when necessary.

**Figure 2 –** Positioning of slip resistant nosing should continue to the vertical front face of rounded nosings (Roys & Wright, 2003).

Safety on stairs can be improved by ensuring good lighting, whether by artificial or natural means. Charman (1997, cited in Davies et al, 2001) described how in low light, hazards would be less visible. In addition, the depth of field of vision will be poor because of dilated pupils, making judgement of distance more difficult. The IES handbook recommends a range of 108-125 lux for commercial, institutional, residential and public assembly interiors, and 54-108 lux for industrial settings (Templer, 1992). The illumination across the stairwell should be reasonably constant and shadows on steps should be avoided. The switches that control stair lights should also be positioned such that there is no risk of a person falling while reaching for the switch, three way switches should be used at the bottom and top of stairs (Templer, 1992).

A suggestion made by elderly pedestrians for increasing the safety of stairways in Japanese railroad stations was to separate up and down traffic (Nagata & Lee, 2004). On any staircase, separation of up and down traffic will reduce the likelihood of stairway collisions or distractions from observing other pedestrians. The separation of traffic could be done quite simply by the use of arrows and solid lines (or handrails) to separate the two streams of traffic. Another slightly more expensive suggestion made by the elderly participants was to provide escalators instead of steps.

It could be argued that no amount of safety precaution will completely eradicate the initiation of falls on stairs. However, features may be added to a stairway in order to reduce the severity of injuries once an individual has lost their balance. One common addition is to install handrails. Handrails give the opportunity for stair users to grab hold of something and to avoid a serious fall. A study by Maki et al (1998) showed the accuracy of arm movements to grasp onto a handrail after loss of balance on a stairway rig to be very high. No trials were recorded where the hand missed the handrail completely. The speed of reaching for the handrail was also very rapid, with the earliest muscle activation in the arms occurring within 0.2 seconds of perturbation on the stair rig. Initial contact with the handrail was achieved in 0.5 seconds and a full grip within 0.6 seconds.

Templer (1992) posed the idea of the 'soft stair' in order to reduce the severity of injuries incurred once a person has irretrievably lost their balance on a stairway. Templer describes how stairs should be free from projecting elements, sharp edges and corners. Instead smooth flat surfaces or gentle curves should be used. It is not clear what level of softness would be acceptable for underfoot surfaces, but Templer suggests that underlays and materials similar to those used in aerobatics and judo gymnasiums may be a way forward in the future. It should be noted however, that soft surfaces underfoot may give the perception of unsteadiness and may contribute to loss of balance. Templer also suggested the padding of stair balustrades and walls at the side of stairs or at the end of stairway landings.

Maki & Fernie (1990) researched the impact attenuation of various floor coverings in simulated falling accidents. The reason for using padding under floor coverings is so that the kinetic energy generated during a fall is absorbed through the energy absorbing material rather than through the relatively stiff skeletal structures of the body, which result in large peak forces and may lead to bone fractures. They used a model of the hip region of a human to carry out this work. It was found that padded carpets provided the best impact attenuation for hip impacts. The study demonstrated that stiffer flooring materials (PVC, wood tile and linoleum) have very limited impact attenuation whilst carpet, and carpet with under padding provided the best impact attenuation. A similar concept of padding has been used in care homes and other establishments that take care of the elderly. Undergarments known as hip protectors have been developed which are designed to protect the hip region in the event of a fall. Hip protectors are not particularly popular with elderly people and there has been a high level of non-compliance. Reasons for not wearing hip protectors include poor comfort and poor self-perceived appearance of the user (Dunn et al, 2005). Protection of the hip region has been focused upon in particular because hip fracture is associated with an excess mortality following the fracture event.

The occupational setting has a unique feature in that the stair user population is a captive audience, which introduces the possibility for implementing additional countermeasures that may not be easily applied to public and private stairways (Cohen et al, 1985). These countermeasures may be performance or behaviourally oriented and may include training (eg, safe materials handling on stairs, specific hazard awareness) and safe practice reinforcement (eg, no running or skipping stairs).

In the UK, one petrochemicals company has successfully launched a behavioural initiative to reduce the number of stairway falls in the office environment. The stairways campaign forms part of a much broader safety programme, which each staff member is taken through when they start work. On the first day of work, all staff members are introduced to the safety programme. An important aspect with regards to the stairs campaign is the STOP system. The STOP system encourages everyone in the organisation to stop anyone who is not seen to be complying with the rules stated in the office HSE codebook. If an unsafe act is seen, for example, not holding the handrail a STOP form is filled in for monitoring purposes. Reporting of good practice is also encouraged. There are five stair rules within the organisation, these are:

1. Use lifts if your hands are full
2. Always hold handrails
3. Do not read documents
4. Do not use mobile phones
5. Do not run

In one month, 1000 STOP forms were filled out, most of these being stairs related. Since the STOP campaign was launched, days lost due to ill health and work-related accidents have dropped to zero (although the initial level was already extremely low).

## Recommendations for potential interventions by enforcing authorities, intermediaries and industry groups

When considering how the design of stairways may decrease the number of stairway accidents, evidence strongly indicates that increasing step goings will reduce the number of missteps on stairways. An increase in going size would have to be implemented through changes to the Building Regulations, a potentially laborious and long-term solution.

Roys (2001) carried out a cost-benefit analysis for increasing the amount of floor space available for stairs in new builds. Allowing more floor space, for example, to increase stair goings, may reduce the number of stairway falls. Roys argued that one of the main reasons for not increasing space dedicated to stairs is that they take up valuable floor space. For the domestic property building, a loss of floor area of $0.6m^2$ will be likely for a 900mm wide stair (a $0.3m^2$ hole downstairs and a $0.3m^2$ hole upstairs). However, some of this floor area can be recovered elsewhere, by for example, under-stair storage or provision of space for a downstairs WC. If larger tread goings were applied to all new dwellings, and this prevented 5% of the stair accidents expected on these stairs, then over the first five years this should prevent over 1250 accidents and probably 2 deaths. Roys calculated that this would approximate to a benefit value of over £5 million per following year assuming £800 000 for the cost of a life and £10 000 per injury. Roys calculated that the intervention would be cost effective after 6 or 7 years.

It would be useful to produce a checklist of safety features for stairs. Designers and architects could use the checklist in the design stage of a building. In addition, coroners may also find the checklist useful and will provide a structured and thorough method for investigating stairway falls.

In environments where stair use is likely to be risky (for example in care homes or where there is a need for carrying items) it may be best to avoid stair use altogether, and consider the use of lifts, ramps or perhaps even design the building on one level.

Enforcing authorities may find campaigns to increase the awareness of stairway safety useful. The HSE is planning a poster initiative to ‘Hold the Handrail’, a simple measure that may help to reduce stairway falls. There are also drives to establish links between public sector and private sector organisations that have had success in reducing stair falls in the past. The aim of these initiatives is to bring about behavioural changes in public sector organisations (Wilson, 2005). The Swiss national accident insurance office launched a campaign in 1994 called “Watch your step”, an initiative to raise awareness surrounding falls (Leclerq, 1999). These awareness campaigns can be supported with various media including films, posters and guides, which will assist prevention officers on the ground.

Leclerq (1999) recommended that research into a specific occupational sector or company would allow a suitable list of measures to be drawn up. Given that there is a great deal of heterogeneity in activities and environments in different occupational sectors, strategies to implement stair fall programmes on a national level from a broad-based analysis of accident data may not prove to be fruitful. In larger companies in particular, it could be worth investing effort into establishing what the primary causes for stairway falls are and then tackle these issues directly.

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