

SYSTEMIC STAIR STEP GEOMETRY DEFECTS, INCREASED INJURIES, AND PUBLIC HEALTH PLUS REGULATORY RESPONSES

Daniel A Johnson¹ and Jake Pauls²

¹*Daniel A. Johnson, Inc., Olympia, Washington, USA*

²*Jake Pauls Consulting Services, Silver Spring, Maryland, USA*

Steep stairs, caused by risers that are too great and or by goings (runs) that are too small, contribute to an increased risk of missteps, falls and injuries. Traditionally, building codes have allowed such conditions in homes and this appears to be a major factor in relatively high injury occurrences related to home stairs. Risk of missteps and falls is even more potently influenced by variations in step geometry. Systemic, top-of-flight dimensional uniformity defects currently appear pervasive in new stair construction in the US and Canada. This might be the major factor in an apparent doubling, over the last decade, of home stair-related injury risk, relative to other settings, in the US. Designers, builders, regulatory officials, consumers and others appear unaware of the defects, even though they are prohibited by building codes and easily identified by using simple tests.

Introduction

Over thousands of years stair step geometry has been a subject of fascination, speculation, rule making, analysis, controversy and, more rarely, formal ergonomics study. This paper provides only a scant introduction to this history. While there are multiple reasons—such as comfort, energy expenditure, and safety—for choosing one geometry over another, the focus here is on fall-related injury prevention. Two potent patterns of systemic stair step geometry defects have been identified recently by US-based ergonomists. The first systemic defect has two components that, in combination, increase the steepness of a stairway. The first is a riser that is too great, and the second is an undersized going. “Going”, “run” and “tread depth” are interchangeable terms used in the UK, Canada and the USA, respectively, for the horizontal dimension of the tread *measured nosing to nosing*. (The “nosing” is the tread’s leading edge). An undersized going is generally a more potent defect than an oversized rise in contributing to missteps, departures from normal gait, which can lead to falls. The second systemic defect, non-uniformity of step dimensions at the top of stair flights and, to a lesser extent, at the base of stair flights, has only recently been recognized by ergonomists as

warranting special attention. Non-uniformity has long been identified as a danger although, traditionally, there might have been more emphasis on rise uniformity than going uniformity. So stair design and construction regulations have traditionally addressed the need for step dimensions to be uniform. However, there have been serious deficiencies in the ways rules are stated and then enforced, and these are now the subject of relatively intense examination.

Using stairs as a learned behaviour

Archea *et al* (1979) state that, as a result of climbing stairs, we build an internalized image and response to the structure, the stairs. Successfully using the stairs occurs when there is a match between the internal image and the actual structure. In the first few steps users will test to see if the actual stair conditions and the initial perceptions are matched. If their internalized images and expectations are confirmed in the first several steps, users will probably conclude that their image and responses are correct and will proceed to use the stairs without calling forth unusual behaviours needed to successfully negotiate the steps. If, from the first few steps, users notice that the internalized images and expectations are at variance from the actual geometry of the steps, appropriate modifications in the behaviour will be made. If there is a subsequent change in step geometry it will not be expected and can lead to a misstep and perhaps a fall.

An important question for future research is how few steps need a person experience to establish an expectation for a particular stair descent? A related question is how does information from the first step down a stair flight affect the foot placement on the second step, typically done by the opposite foot? Can we process the information from, say, the right foot taking the first step and put that information to work almost immediately in taking the second step with the left foot? Or is the information from the right foot more completely applied in the movement of that foot from the first stair tread to the same foot's descent to third stair tread? These questions are being increasingly considered by ergonomists (like the authors) and will be prominent in research priority and methods discussions planned during and immediately after the Ergonomics Society Annual Conference 2010.

Steep stairways cause falls

The height of the riser and the size of the going are each critical in determining the safety of a stairway. Probably everyone recognizes that the steeper the stairway the more difficult the descent. Templer (1974) provided a good history and Pauls (2002) reviewed the history with greater attention to how US building codes and standards responded in recent decades. Experimental studies confirmed the relationship between stair steepness and falls. Subjects were tested as they ascended and descended stairs at three different slopes (25, 35 and 45 degrees), with three different riser-to-tread ratios. In descent, risers with the fewest missteps ranged from 117 mm (4.6") to 183 mm (7.2"). Risers greater than 183 mm (7.2") had a greater number of missteps. And "treads that were 312 mm (12.3") or more had the fewest missteps at all speeds; treads that were 269 mm (10.6") to 292 mm (11.5") had more missteps, followed by treads that were 254 mm (10.0") to 262 mm (10.3"). All treads that were 229 mm (9.0") or less performed uniformly poorly regardless of riser height" (Templer, 1974). Later Templer *et al* (1985) videotaped workers using 31 flights of stairs where there had been high frequencies of severe stair-related injuries. They identified 98 stair users who experienced "incidents" (falls, slips, trips, missteps, and moments of temporary

instability). Examination determined that incident rates were associated with stairs with risers greater than 180 mm (7") and having tread depths less than 280 mm (11").

The most recent and best research in this area, conducted in the UK, has been presented and published, mostly within the context of Ergonomics Society conferences (Roys, 2001; Roys and Wright, 2003, 2005, 2008; Wright and Roys, 2005, 2008). For example, Wright and Roys (2005) also found that the foot pivoting and/or slipping off of a nosing could be attributed to risers that are too high or goings that are too short. They found that preferred goings were longer than those usually found on stairs. Goings greater than 300 mm (11.8") were optimal. *Further, higher risers resulted in more of the shoe being placed further forward on the tread regardless of going length.* This indicates that a foot pivoting/slipping off of a tread could be due to a riser that was too high. Optimal rise height was 190 mm (7.5") and less.

The probability of a shoe slipping over the nosing, based on going length and exposure, has been calculated (Roys and Wright, 2003). For instance, a flight with 14 steps, and having goings of 225 mm (8.9") and being used by five people every day, can be expected to result in a slip of the foot over the nosing once every three years. If there were 2,000 uses each day a slip could be expected every three days.

Later research by Wright and Roys (2008) utilized a maiback survey where respondents measured the stair in their home and reported whether or not the stair had been the site of an "accident" in the prior two years. Their conclusion: "Across the range of stair geometries found in a random sample of English dwellings there is a very significant influence on accident rate of going size, with larger goings reducing the likelihood of a stair accident being recorded." Table 1, derived from Wright and Roys (2008) with respect to estimated relative risk of falls, also shows the minimum going dimensions permitted by widely used US and Canadian model building codes as well as by the National Association of Home Builders.

Table 1. Risk of falls on home stairs with various going dimensions
Risk estimates derived from Wright and Roys (2008) Figure 4

Going dimension	Relative risk of falls	Used for home stairs by
255 mm (10.0")	0.03	ICC Codes in USA
245 mm (9.6")	0.07	
235 mm (9.3")	0.11	NAHB in USA
225 mm (8.9")	0.12	
215 mm (8.5")	0.13	
205 mm (8.1")	0.14	NBCC in Canada
195 mm (7.7")	0.21	

ICC—International Code Council; NAHB—National Association of Home Builders; NBCC—*National Building Code of Canada*

The NAHB is politically powerful enough to dictate the minimum going dimension requirement—230 mm (9")—actually used in some state and local codes that have been adopted in place of the minimum going required in the model. ICC's *International Residential Code* stipulates the minimum going at 250 mm (10"). The *National Building Code of Canada*—with a minimum going of 210 mm (8.25") for homes—has

what appears to be the least demanding going requirement of English-language model building codes.

Variations between risers or between goings cause falls

Templer (1992,151-152) reports that Velz and Hemphill (1953) found that 15 percent of stairs examined had variations, but on steps where people fell, 75 percent had variations. And Templer also reports that Miller and Esmay (1958) found tread depth irregularities on 47.6 percent of the stairs where falls had occurred as compared to only 20.7 percent of the sample group of stairs where falls had not been reported. The average irregularity was 15 mm (0.6"). Jones (1963) found more variations in the rise heights of stairs where falls had occurred (78.8%) as compared to stairs where no fall had been recorded (28.4%).

Unpublished studies by one of the authors suggest that dimensional non-uniformities can result in greatly increased risk—*by as much as two orders of magnitude size*—in the rate of missteps on stairs. Both were documented in the course of field observations, the first as part of the large documentation of spectator behaviour at the 1976 Olympic Games in Montreal (in which both John Archea and John Templer participated on the ten-person study team). The second was in 1987 at the Molson Indy race in Toronto. In the Olympics case, an unfinished stair was being used for crowd descent but the top steps were non-uniform in both rise and going dimensions. Misstep rates averaged one in 20. Study team recommendations to close the stair were not heeded by Olympic authorities but spectators were verbally warned by Olympics Games staff of stair dangers.

Later, under comparable crowd conditions, when the stair construction was complete and steps uniform, misstep rates were reduced by a factor of 50 to approximately one per 1000. (This was still not a good rate but there were other stairway defects.) In the 1987 observations a stair used exclusively for crowd ascent had an odd rise dimension in mid flight; the misstep rate here was one in 16. In this case the stair was rebuilt during the event, simply by replacing an odd-thickness wooden tread with one comparable to other treads in the flight. Within an hour of the pre-condition, post-condition observations revealed no missteps in about a couple of thousand uses, a ratio again of about two orders of magnitude improvement over the defective condition. Of course both these cases posed unusual ethical challenges for the observers; mitigation or elimination of the defects took precedence over meticulous scientific documentation; thus only order of magnitude estimates could be made.

More recently, Cohen *et al* (2009) analyzed 80 actual stairway falls that were the subject of forensic investigations. They report that the most significant factor associated with falls was the variability between risers, and, secondly, the variability between goings. They found that in 60 percent of the cases there were riser variations in excess of 9.5 mm (0.375"). In 34 percent of the cases there were variations between goings in excess of 9.5 mm (0.375").

Variations in stairway geometry are often both unexpected and difficult for the user to perceive. A person must accurately place the ball of the foot near to, but not beyond, the nosing of the tread. Any variation in riser height or going increases the chance that the ball of the foot will be placed too far beyond the nosing so that when weight is transferred to that foot it will pivot and/or slide over the edge—an overstepping misstep, possibly resulting in a fall.

While the ball of the foot, in descent, is usually placed near to or on the nosings, there is some variability within subjects as to actual foot placement (Roys and Wright, 2005). When those variabilities are combined with excessive and unexpected variability in stair construction the chance of a misstep increases.

Top-of-flight defect

This defect, found increasingly often in forensics work performed over the last 30 years by first one of the authors, and then the other, has been found to exist in many structures, but most commonly in homes, especially newer homes. The first going below the top landing is greater than subsequent goings because the floor nosing does not project beyond the riser as do all other nosings in the flight. One reason this might be occurring more often now is the increased use of (off site) manufactured stair flights, with projecting nosings, being connected to a floor structure, the top landing of which does not have a projecting nosing. The top-of-flight defect conveys erroneous information to the user who undoubtedly expects goings on subsequent treads to have similar dimensions to that of the first going.

One of the authors, collaborating with a professional home inspector, has learned that up to 90 percent of new homes could have this defect which was featured in a paper by Pauls and Harbuck (2008). Instances have been recorded where the second and third goings were as much as 50 mm (2") shorter than the top going. A foot placed on the second or third tread is much more likely, under this condition, to be placed too far forward and will pivot and/or slip over the nosing. Since this defect is found at the top of the flight, the consequences of a fall are likely to be more severe than they would be for a fall from a lower level. This defect was found, by both of the authors (in their forensics practices), to be associated with falls that resulted in serious and even fatal injuries (Johnson, 2009).

Although the top-of-flight defect violates building codes, the violations were not detected prior to the buildings being occupied. This may be because inspectors did not receive specific information on the problem or how to easily detect it. Pauls and Harbuck (2008) describe a simple detection technique illustrated in Figure 1. By sighting down the stairs the top-of-flight defect can be detected with a high degree of reliability.

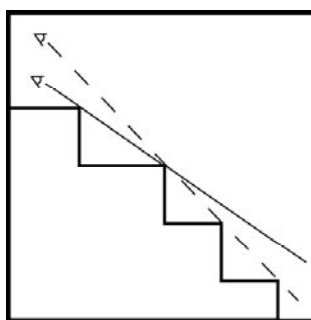


Figure 1. The “crouch and sight” technique can detect a top-of-flight defect

Accuracy of this “crouch and sight” test is based on there not being a simultaneous defect of riser height that is exactly proportional to the increased tread going dimension. Thus the prudent inspector will only use this test to confirm a stair is *not*

uniform, not to confirm it is uniform. A reliably high degree of confidence that a stair is indeed consistent in dimensions requires additional measurements, beginning with measurements of the nosing-to-nosing distances of at least the top few steps. Also, the sightline test is of no value at all for bottom-of-flight riser height non-uniformities, occurrences that are also relatively common.

Generally, while the “crouch and sight” test is extremely useful, the prudent inspector will utilize the proper tools to accurately measure the nosing-to-nosing dimensions. This will require use of a spirit or digital level, the latter becoming the tool of choice for inspectors, such as the two authors, who have developed methods based on two measurements per step. The first is the nosing-to-nosing angle (relative to horizontal) and the second is the nosing-to-nosing distance—*being very careful to measure to the same points on each nosing, a difficult task with beveled, rounded or thick-carpet-covered nosings*. The rise and the going are then calculated using the sine and cosine functions respectively (Johnson, 2006; Pauls, 1998).

Public health and regulatory responses (or lack thereof)

Thus far, although the public health ramifications of defective stairs come from data collected by major US Government agencies (e.g., the US Consumer Product Safety Commission) there has been no official response to public release of graphs such as Figure 2 which indicate a rapidly growing problem with home stairs. Such stairs have systemic defects of all the kinds discussed thus far in this paper. Currently, it is only possible to speculate if the long term, five times ratio is mainly due to the systemically lower standard for step geometry in homes, relative to all other settings and if the newly reached, ten times ratio is due to recent increases in the systemic top-of-flight occurrence of non-uniformity.

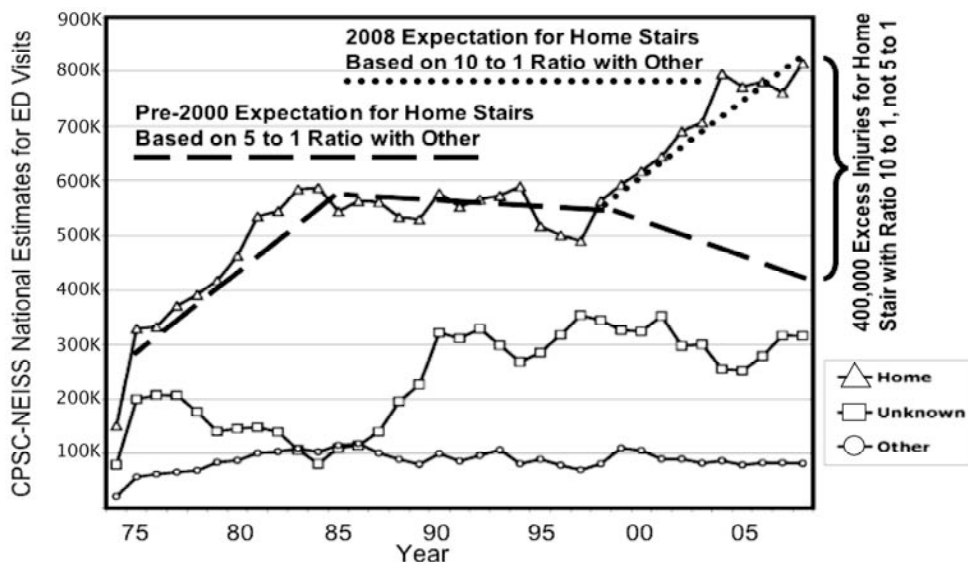


Figure 2. Trends in hospital-treated stair-related injuries in the USA based on data accessible at www.cpsc.gov/library/neiss.html

Both trends should be seen as unacceptable. So far, however, neither the public health community nor the building regulatory community has acknowledged, let alone discussed, the need for strategies plus tactics to mitigate or, better still, prevent the huge injury toll. The toll for medical care alone in the US for stair-related injuries is about one million dollars per hour. The societal cost is about ten times that amount.

Conclusions

Currently the average annual increase in US home stair-related injuries is about 5 percent, or five times greater than US population growth. At the same time stair-related injuries in all other (non-home) settings are decreasing at about 1 percent annually. Bringing these epidemiology insights to the attention of public health authorities in the USA has had only mixed success. Trying to persuade public health and regulatory authorities to respond to the rapidly growing injury toll has been frustrating. Moreover, US and Canadian organizations responsible for model code development, adoption and enforcement seem to be heavily influenced by homebuilder management. Traditional defects in home stair step geometry—of both systemic types—appear largely to blame. There are some hopeful signs. One is the proposed BS 5395-1:2009 which increases minimum going dimensions for both home and other stairs. Another, in Ontario, Canada, is a proposed mainstreaming of the widely used 180 mm maximum rise with 280 mm minimum going (the so-called “7-11” step geometry in inch units) for use in new homes and elsewhere.

What is needed is the systematic recording of falls and injuries as they occur, especially in homes, and determining if and how those falls are related to the design characteristics of the stairs. Further, additional information is needed to determine if the stairs on which falls have occurred met the standards specified in local codes (in which case the standards may be implicated) or whether the stairs did not meet standards (in which case the building design and inspection process may be implicated).

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INJURIOUS FALLS ON STAIRWAYS: BACKGROUND FOR INTERNATIONAL CONFERENCE IN JUNE 2011

J. L. Pauls

Jake Pauls Consulting Services, Silver Spring, Maryland, USA

Based on an international, personal perspective, comments are provided on over four decades of research, standards and codes development, public health advocacy, plus litigation-based investigations, documentation and evaluation—all associated with *injurious falls on stairways*. A prime purpose is to provide a context for the International Conference on Stairway Usability and Safety (ICSUS) in Toronto, June 9-10, 2011. ICSUS builds on the one-day meeting on this topic held in April 2010 at the UK Health and Safety Laboratory, with two larger goals. The first, for day 1 of ICSUS, is a condensed summation of what is known and ready to be applied with confidence. The second, for day 2, is to set out a research agenda for what remains to be learned, how and by whom. Unlike prior falls-oriented meetings, contributions from more-diverse perspectives are enlisted, for example on public health and legal contexts, to address stairways.

Introduction

Prepared for the International Conference on Slips, Trips, and Falls 2011, this paper expands on typical person-activity-environment interactions and time perspectives, both past and future, considered in such conferences. Stairways pose, and will continue to pose, challenges for usability as well as safety. These challenges are addressed by a diverse collection of people drawn from many walks of life, including several professions. These challenges date from mankind's early discovery of stairs—*produced by nature*—to their current manifestations in a wide range of stairways influenced by many functional, stylistic and ethical factors linked to tradition, engineering, architecture, public health and law (to name only concerns with which the author has been involved since the early 1960s beginning in Canada and culminating there in mid 2011).

Epidemiology, injury burden and research investments

In the USA, where the influences listed above are perhaps best identified, there is also a relatively clear trend in stair-related injuries that result in hospital emergency department treatment. The trend has been mostly identified outside of the government, university and other organizations from which one would expect close monitoring of, and response to, injury epidemiology (e.g., the US Centers for Disease Control, CDC, and the US Consumer Product Safety Commission, CPSC). The author has often highlighted this trend with graphs such as Figure 1 in papers, conference presentations and the website, <http://web.me.com/bldguse>. Figure 1 shows a dramatic increase, in US home settings between 1997 and 2009, of about 60 percent in stair-related injuries and about twice this increase in relatively serious stair-related injuries—*while US population grew by only 12 percent in this period*.

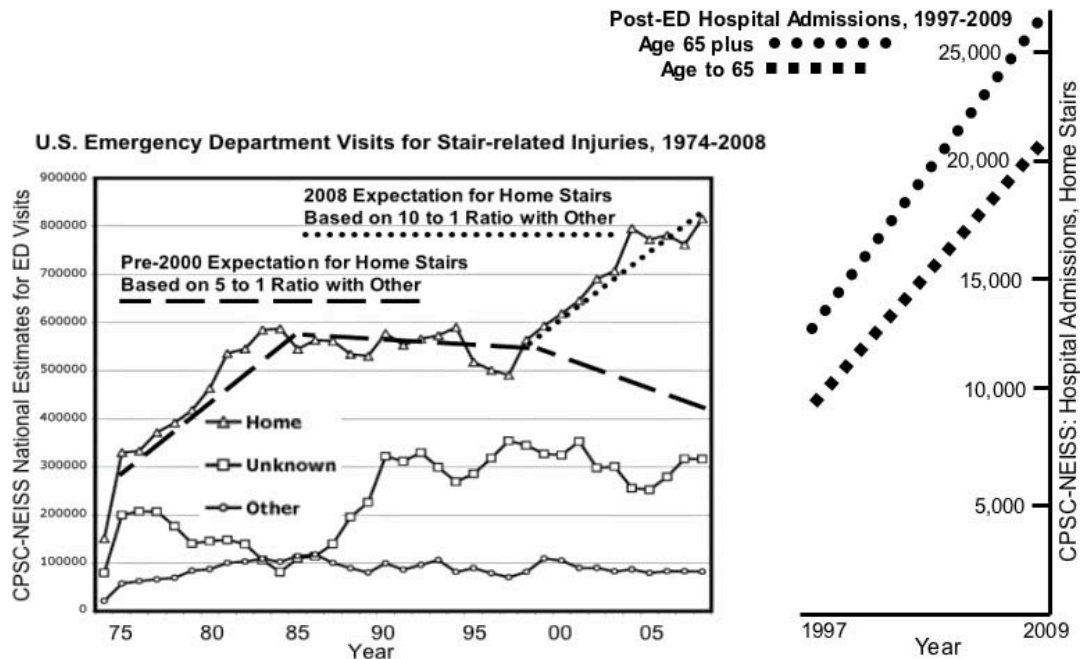


Figure 1. Recent Trend (1997-2009) by Age Group for Post-Emergency Department, Hospital Admission after Home Stair-related Injuries (shown with long term pattern of all US emergency department treatments for all stair-related injuries)

Between 1997 and 2009, for people <65 years of age—with a population growth of about 11 percent, stair-related injuries in US home settings leading to hospital admission (after presenting in an emergency department, ED) increased by about 127 percent (CPSC national estimates 9,022 to 20,459) using National Electronic Injury Surveillance System (NEISS) data from the CPSC (2010). During this same 12-year period, such injuries to people ≥ 65 years of age—with a population growth of nearly 16 percent—increased by about 114 percent (CPSC national estimates 12,413 to 26,582).

In the 12-year period, *age-adjusted rates (per 100,000 population)* of such injuries grew 103 percent (3.8 to 7.7) for people <65 years of age; 85 percent (36.9 to 68.1) for people ≥ 65 years of age.

In the same 12-year period—with 12 percent US population growth—injuries increased by:

- 32% (<65 yrs.) and 45% (≥ 65 yrs.) for hospital admissions related to all *non-home* stairs
- 92% for hospital admissions related to all products—*except stairs*—in all settings
- 38% (to N=1,266,303, cv 0.06) for ED treatments related to all stairs in all settings; with rates per 100,000 rising from 335 to 413; for comparison, in 2009, the *all nonfatal falls* rate was 2,863 (www.cdc.gov/injury/wisqars), thus stairs accounted for nearly 15% of all nonfatal falls
- 26% (to N=13,966,331, cv 0.06) for ED treatments related to all products in all settings.

Summing up, *home* stair-related injuries leading to admission are a relatively rapidly growing problem for *all—not only older people*. Relative to all falls, all stair injury tolls are rising faster.

Also using CPSC-NEISS data, and an injury cost model, researchers in 1999 estimated the (comprehensive) societal cost of US product-related injuries during 1995; the toll for stairs was about 50 billion, 1997 US dollars (Lawrence *et al.*, 1999). Adjusting for inflation and the relatively rapid increase in stair-related injuries in recent years, the current annual societal injury cost for stairs in the USA is now likely about 100 billion dollars or about 11 million dollars per hour, a cost that greatly exceeds the costs of building stairs or of improving usability and safety of existing stairs, especially in homes where 90 percent of the injuries in known locales now occur (Figure 1).

As noted by Pauls (2002) in a code-change proposal for minimum 280 mm run or going dimensions for home stairs, the benefits of improved home stairways—as great as they are for fall prevention/mitigation—are larger for improved stairway usability, especially for older users.

Among top issues to be addressed are step geometry—and *consistency thereof*, perception and cognition issues with stairway use, handrail functionality, guard functionality, surface characteristics of treads, minimum landing size, and width issues to avoid counterflow and overtaking interference.

In some cases, we (in research and standards-setting roles) once thought there was adequate understanding and control of the issues. Now, we recognize the need to recalibrate or even rebuild our (admittedly) crude models, e.g., of minimum tread depth (run or going) for usability and safety; minimum widths based on body size, biomechanics and pedestrian fitness; handrail graspability, nosing conspicuity, etc. Major questions arise due to wide-spread fitness reductions.

If stairway safety research in the USA had financial support on the order of a million dollars annually—much more than now the case—*injury costs would be five orders of magnitude (a factor of 100,000) greater than the cost of relevant research. Beyond injury reduction, improved stairway usability would be a valuable bonus if we invested realistically in—and comprehensively applied—stairway research that focused on ergonomics (human factors).*

Chief proximate causes and potential contributing factors in stair-related falls

Missteps (the departures from normal gait that are precursors to falls) should never be limited to the conventional description, “slips and trips.” Pauls (2007) discussed several misstep types that are neither “slips” nor “trips.” Of these “heel scuffs” are relatively common on stairs, especially with undersized tread depths (the “run” or “going” dimension, *measured step nosing to step nosing*) and the same stairs increase the risk of the more catastrophic “oversteps” that lead to the most severe injurious falls—forward-facing falls while descending stairs.

Johnson and Pauls (2010) identify prime factors for such more serious falls, chiefly undersized tread depths generally and systemically or randomly undersized individual tread depths. The latter, particularly a systemically larger tread at the top of a flight—due to non-uniform nosing projections in the stair flight—including *the landing nosing*, have been recently highlighted by Johnson and Pauls (2010) as a major problem in stairway safety—one that could be quickly and easily diagnosed using the simple ‘crouch and sight’ test.

In recent presentations (all downloadable from <http://web.me.com/bldguse>), Pauls highlighted the importance of the first minute of observations when trying to determine the dangers of a stairway in a preliminary or detailed inspection. Ten seconds of that ‘golden minute’ should be devoted to the ‘crouch and sight’ test (checking visual alignment of *all* step nosings) to identify almost all top-of-flight defects and many random non-uniformities. The remainder of that first minute should involve simple measurements of at least the top two steps’ nosing-to-nosing distances—which *should be identical*—as well as passing the ‘crouch and sight’ test.

Dimensional non-uniformities can increase the risk of missteps on a stair by orders of magnitude (Johnson and Pauls, 2010). Consistently undersized tread depths can increase risk of missteps fourfold (Wright and Roys, 2008) for the range of home stair minimum run or going requirements currently in US and Canadian codes for home stairs (i.e., 210 mm to 280 mm).

In presentations in 2010 (to ergonomists, falls experts, trial lawyers and medical personnel) and in one paper (Pauls, 2010a), the author has identified several established or potential, leading factors for the relatively rapid, recent increases in home stair-related injuries in the USA.

- (1) Relatively steep stair step geometry permitted traditionally only for homes
- (2) A systemic top-of-flight dimensional non-uniformity on many home stairs, due to flawed code requirements and/or flawed construction and inspection practices
- (3) Reduction—*generally*—in the code enforcement process for new home construction
- (4) The potential deterioration of fitness, especially movement performance, in the USA population (among others, including Canada), stemming from reduced physical

- activity and increasing prevalence of obesity and overweight
- (5) Increased use, for new home stairs, of “Type II” handrails, a US (“International Codes Council,” ICC) code term for railings not graspable with a power grip
- (6) Increasing differential between public and home stairways—an ergonomic challenge.

While the foregoing factors appear to have become influential in the last decade or so, they should be viewed in a longer context going back a few decades. This would include careful (re)consideration of relatively authoritative, lengthy summations of key factors by Archea *et al.* (1979) and Templer (1992) as well as the author’s attempts, over a decade, to condense key considerations to a single-page checklist (Pauls, 2010b). Clearly, *new* insights would be valuable.

Comprehensive list of categories of factors and other considerations for stairways

For the International Conference on Stairway Usability and Safety (ICSUS), June 9-10, 2011, in Toronto, a framework has been devised to help establish what is known with sufficient confidence to be applied now to the design, construction, retrofit and regulation of stairways (as well as serving as an ergonomics knowledge base in stairway injury-related litigation).

Here an entire paper or even a dissertation could be devoted to the difficult issue of what constitutes “sufficient confidence.” Is this the ‘more likely than not’ standard common in injury litigation; is it based on what typical building code development processes accept as a sufficient technical base for change proposals; is it based on ‘gold standard,’ randomized control trials (RCTs) that The Cochrane Collaboration® (www.thecochranelibrary.com) considers trustworthy; or what? Of these, the least well defined—and *even less well controlled*—are the evidential bases used in model code development. One measure the author has grown to rely upon—in a US context—is whether or not the development process complies with policy and process principles set out by the American National Standards Institute (ANSI). Thus, in relation to stairways, the standards and codes of an ANSI-complying organization, e.g., National Fire Protection Association, are relatively authoritative.

Leaving aside the difficult matter of “sufficient confidence,” the following are the categories of factors and use/safety contexts where some expert consensus is sought on day 1 of ICSUS.

- | | |
|-------------------------------------|--|
| a. Injury epidemiology | g. Slip resistance |
| b. Economics, including injury cost | h. Handrails and guards |
| c. Misstep and fall mechanisms | i. Persons with disabilities and older users |
| d. Perception and cognition | j. Special settings (e.g., occupational and transportation) and uses (e.g., by crowds) |
| e. Nominal step geometry | k. Codes and standards |
| f. Consistency of dimensions | l. Litigation, law, insurance and advocacy |

Subject matter experts will lead the discussion in the dozen, short panels that are tasked with summarizing what is sufficiently known in these subject areas to serve as a basis for action, such as to advocate changes in codes and standards, to include in checklists, to inform the public, etc.

If there is a lack of consensus on any particular matter, it will be consigned for further discussion in other panels on the second day of ICSUS. Along with general discussion, they will help formulate research agendas with at least a preliminary understanding reached, or at least proposed, as to who would be able to do the needed research. Potential research funding sources will also be discussed.

The conference should help establish two agendas for action: first to slow, stop, or even reverse the growth of injuries and, second, to fill the gaps in our knowledge base.

The June 2011 conference is the largest meeting held to date with an ergonomic focus on stairways. Prior meetings were held in 1985 in Los Angeles, 2002 in Montreal, 2003 in Ottawa and 2010 at the UK Health and Safety Laboratory (HSL). ICSUS in Toronto, on June 9-10, 2011, is the most ambitious of the stairway-focused meetings and the first to facilitate participation of experts in both face-to-face mode and via Internet (which should make meaningful participation possible for certain overseas experts, for example).

Closing remarks and acknowledgments

Regarding conference proceedings publication, the intent with ICSUS is to publish, *online*, a highly condensed summation of what is generally accepted—in the *June 2011 conference*—as now sufficiently understood to form a basis for action to address stairway usability and safety problems. Secondly, it is hoped that research agendas of particular organizations will be influenced by the day 2 deliberations on what remains to be learned about stairway usability and safety. At least one, possibly two current national programs (in Canada and New Zealand) to establish consensus on what can be recommended with confidence about stairway design, construction and retrofit, might be influenced in a major way by the conference.

Hopefully ICSUS will also be of value to the worldwide network of experts working on “slips, trips and falls.” Many of these will be meeting two months before ICSUS at the “slips, trips and falls” conference where this paper is presented. Facilitating this is the leadership in both conferences—in co-chair roles—of Wen-Ruey Chang, PhD, of the Liberty Mutual Research Institute for Safety. Whatever the outcome of ICSUS, the author of this paper is indebted to Dr. Chang for his co-chair role in ICSUS as well as his ongoing lead role in the larger network of “slips, trips and falls” experts worldwide. Also acknowledged is the leadership role of Steve Thorpe of the UK Health and Safety Laboratory (HSL) in hosting the 2010 meeting on stairway safety at HSL and hosting the International Conference on Slips, Trips and Falls, 2011 at HSL.

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