NOMMA Climbability Research, Analysis, and Communications Planning
Outline Prepared May 31, 2006

Abstract
This work represents the first deliverable in an engagement between the National Ornamental & Miscellaneous Metals Association (NOMMA) and Whorton Marketing & Research (WM&R), an association-based research consultancy. In the following document we lay out a blueprint for an industry effort that first seeks to compile in one location the variety of evidence, arguments, and positions that have been staked out over time. Our opinion in reviewing the information is that NOMMA's position on guard safety is in the right and the association does not need to do much to expand its position for the long term.

1. Outline

Our goal is to develop research that definitively establishes rules and evidence based protocols for establishing the link between architectural designs and implementation with the incidence of accidents in residential and commercial structures. This document is a preliminary compilation of what we have learned through NOMMA and our experience with other associations. Our goal is also to represent the ornamental metals industry fairly while respecting all legitimate considerations of consumer safety.

The industry's assertion is not, as one might predict, that there is no linkage between designs and accidents. Rather, it is an empirical question of how influential these factors are, including consideration of their magnitude, consistency, and the underlying dynamics driving unsafe designs.

In the interests of fairness, we agree that 'absence of evidence is not evidence of an absence'—that is, the well-documented weaknesses of emergency room visits have fundamental, systematic flaws that must be pointed out in the interests of fairness. However the nature of insurance rules, hospital staffing, and the simple urgency of parents admitting children or other family members translates into a permanent state in which actual observed behavior through aggregate statistics.

*2. **Overview***

Over time there has been considerable literature prepared regarding the correlation between accidents and designs of homes. This literature has pointed in the direction of three primary contributors in residential settings: the physical structure, the interplay between furniture and railings, and the presence or absence of adult supervision.

For some reason this research has focused primarily on one setting and one population group—residential homes, and small children. This is unusual given the high level of interest that has been generated over the past 15 years leading up to the implementation of the Americans with Disabilities Act (ADA) and the importance of modifying residential and commercial structures for the betterment of all individuals who have limited mobility. In turn prominent studies and considerable research in the building industry has also focused on delivering products that are better suited for the needs of elderly residents, which de facto has to include features that facilitate access and increase home safety for the largest population to suffer falls and other home based injuries.

In the following section we discuss the positions taken and evidence cited by proponents of code changes. To some degree we are framing problems in the language of parties representing other positions, but this is because most of the debate has been initiated by these individuals.

3. Proponent Positions

Proponent Positions
In “Climbable Guards — Special Enemy of the World’s Children" Elliott Stephenson writes “For many decades during the past century the needs of young children in buildings have been given inadequate consideration by our building codes with the results that there are literally millions of unsafe guards in our existing homes, apartments, motels, hotels, and schools.” The article calls this situation “an unfortunate legacy that has been left by building code authorities.

Data Sources
The National Injury Surveillance System (NEISS) records detailed injury reports from 101 participating hospitals from a period of January 1, 1994 to October 19, 1999. The articles cite total incidents rather than injuries related to climbable guards, up to age 10. The data is analyzed and linked to an assertion that horizontal members lead to a “ladder effect.”

This data is projected using a straight line method (multiplying by 40) to represent all U.S. hospitals without having any basis for determining how representative this sample is or making appropriate statistical adjustments such as confidence intervals that stem from traditional sampling. Because the participating hospitals are not representative of the average U.S. hospital—participants are considerably larger and with a focus on pediatrics and child patients a realistic adjustment factor would require considerably more work and yield a far smaller total accidents so this simplifying assumption is one that serves their purposes very well.

Limited Experimental Studies
Proponents have conducted a series of informal tests without scientific controls or precise quantification. Their conclusion: “During the testing described, every guard type illustrated could be climbed by some four-year-olds. That includes solid guards 42 inches in height without openings ..." The premise is that all guards are climbable including:

- Guardrails with wood panels or vertical members up to 34" with an open spacing between 34" and 42".
- 42" guards of woven wire mesh, with narrow 1-1/4" openings.

Observational notes taken during the test and subsequently published show that children could use the safety features as toe holds which were not essential for children able to put their fingers through openings and place their feet flat against a guard.

4. Defining a NOMMA Long-Term Response

A. Creation of Standards
A movement has been afoot, to establish an ASTM standard for NOMMA products. There is considerable documentation of standards and it will take time to fit one or more standards within ASTM. There are several areas we need to establish including the degree to which this is a solution: Naturally there are many standards already in place—a quick review indicates that there are standards for semi-finished shapes and fabricated parts with many subunits among them.

B. Demand for Primary Research
To some degree there are signs that NOMMA feels accountable for a dearth of additional primary, experimental research. However we do need to respect the evidence that has been collected in the form of collected accident reports, psychological insights applied from non-industry studies, even the limited observational/experimental designs in the past, because of the expense of mounting these activities and the questionable relevance of additional detailed analysis to the real issue of definitively drawing causal relationships between design and accident rates and identifying what, if anything, in building codes can reduce the accidents caused here. Because research is required, it will be critical to conduct in a manner that offers input into the planning in advance of the actual trials and not proceed without some implicit approval from all sides (industry and at least a sufficient number of safety advocates).

5. History of NOMMA's Response

As NOMMA notes in their press release "Since the mid 1980s, increasing code requirements and the Americans with Disabilities Act have actually made railings a highly regulated product in the U.S. NOMMA applauds current codes and standards that provide proven safety benefits and increased access for persons with disabilities. In fact, NOMMA formally supports the railing requirements found in the 2001-2006 International Codes."

The following timeline represents a reasonable summary for members and others unfamiliar with how the issue has progressed:
mid-1980s — Increasing code requirements from ADA begin to affect railings.
1988 — First articles published by Elliott Stephenson in building code publications.
1994 — Approximate timing of code changes supported by NOMMA that reduced 6" to 9" openings to 4" based on research and evidence that the wider spacing led to fall and slip incidents.
1999 — NOMMA works for the disapproval of the “ladder effect” from 2000 International Building Code. Ladder effect appears in 2000 International Residential Code.
2000 — NOMMA gets “ladder effect” removed from 2001 International Residential Code Supplement.
2000 — NOMMA publishes position paper authored by Tony Leto, President of J.G. Braun Co. and NOMMA Technical Committee Chair in *Ornamental & Miscellaneous Metal Fabricator*, July/August.
2001 — Tim Moss publishes "The Industry's Response To ‘Climbable’ Guards” in the November/December *Ornamental & Miscellaneous Metal Fabricator*.
2001 — *Southern Building* publishes “Climbable Guards — Special Enemy of the World’s Children” by Elliott Stephenson in September/October 2001.
2002 — Attempts begin to resubmit “ladder effect” in code hearings.
2005 — CTC Study Group reviews design configurations in November, concurring that all guard configurations are potentially climbable. Group is charged but cannot finalize developing design criteria for configurations compliant with current codes that are “climb resistant.”

One thing that is unusual is that NOMMA has staked a position very effectively six years ago that is analytical, based on science, and carefully considers human behavior.

In fact, one of the difficulties encountered in staking a unique position for NOMMA is the very clear sense we have that the research has been conducted and the case has been made. We present a summary of the key evidence and arguments cited in this article, which remains compelling and definitive six years later.

NOMMA’s Past Research
Previously we cited studies conducted by code change advocates that undermine their own policy implications—that all barriers are climbable and thus more rigid requirements are unlikely to reduce accidents, which have been overestimated in the past in any event.

NOMMA has collected an impressive array of research studies in the past which tend to challenge proponents positions by emphasizing common-sense reasons for common child practices, coupled with parental neglect, as primary causes of accidents for which the family is ultimately liable. Among them we cite, with attribution:

- "Toddlers and preschoolers lack the judgment needed for risk assessment and safety precautions."
  -- "Falls From Windows," National Pediatric Trauma Registry Fact Sheet
- " ... even a very small child is presumed by the law to understand some dangers - for example, falling from a height or touching fire."
  -- Nolo's Legal Encyclopedia 1994
- "Playgrounds can be exciting areas where children explore their environment while developing motor and social skills. Yet each year, almost 200,000 children are treated at hospital emergency rooms for injuries occurring on playgrounds (Frost, 1990). About 60 percent of all playground equipment-related injuries result from falls (CPSC, 1990)."
  -- Safer Playgrounds for Young Children, Educational Resources Information Center, Charlotte M. Hendricks 1993
- "Never leave a child alone on a balcony, fire escape, or high porch." "Make sure railings are sturdy."
  -- *Children's Hospital of Wisconsin safety guidelines*

6. Current NOMMA Position

NOMMA Position—The NOMMA position has been expressed in a variety of formats, and we paraphrase it below from a variety of industry statements going back a number of years.

- NOMMA embraces sensible guidelines for improving the safety and quality of railing products.
- NOMMA disagrees with assertions that there are only two types of guardrail designs suitable to protect children under the age of three from climbing.
- NOMMA agrees with reputable advocacy organizations who employ evidence based analysis of child falls, that falls from climbing guards should be considered in context with appropriate action taken based on the volume of annual accidents. For example over 120,000 children a year are injured in falls from playground equipment.
- NOMMA has searched vainly to accurately document the number of falls from children climbing guards, but this is not recorded as a separate incident by organizations that track accident volume, presumably because there are too few incidents to warrant a separate line item.
- NOMMA also objects to the tactics of code change proponents, who rely heavily on emotional appeals to parents. Code proponent analysis ignores key elements of child behavior including the need for children under 5 for constant adult supervision, and studies proving that most children over the age of 3 can and will climb most barriers present including guardrails of all designs, balanced only with a steadily increasing understanding and judgment of the risks involved.
- NOMMA also represents the commercial interests of its members and affiliates, which depends on the installation of safe guards in all configuration requested by customers and which conform to building codes. The lack of precedent found in the form of product liability lawsuits and judgments underscores the fact that the products that NOMMA members manufacture and install are safe.

7. *Providing Facts for Industry*

Below is a sample of the type of information that NOMMA can help to disseminate.

NOMMA Information Briefing: ***Twenty Facts About Home Injuries***
Considerations in residential and commercial design and ornamentation.
According to the 2004 State of Home Safety in America™

1) For every home injury death, there are more than 650 nonfatal home injuries.

2) Falls are the most common nonfatal unintentional home injury, making up 41% of all industries.

3) The definition of injuries is relatively broad and accidents are commonplace—using this official definition, you have a 4.4% chance of having a home injury occur to you.

4) Injuries are far more likely to affect elderly and children in one specific age range. Using the average 4.4% as a base, persons 80 and older are more than 2.5 times more likely to experience a fall, and children ages 1-4 are 2.3 times as likely.

5) The risk drops off sharply as children grow slightly older than, and for older individuals nearing their at-risk ages. For example people 70-79 are 1.7 times as likely to suffer a home injury, and children 5-9 are 1.3 times as likely as the average American.

Age Range	1	1-4	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Index	80	227	134	116	93	89	102	102	116	127	173	261

6) The risk of death from a fall is relatively low: in 2004 there were 5,961 fatalities out of 5.1 million reported falls—or one out of 860 result in death.

Age Range	1	1-4	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Index	179	94	28	221	32	51	87	101	78	106	215	704

7) The general trend in home safety among consumer advocates is, logically enough, on accidents that have far higher fatality rates: for example 0.7% of all poisonings results in fatality, as do 1.3% of all fire injuries, and 4.9% of firearm injury incidents. While these are odd comparisons, if the focus is on ensuring safe children and adults there are other signature events that warrant far greater regulatory scrutiny and action.

8. Research Protocol
The most important element is to develop and maintain a source of original research. We recommend proceeding beyond scope, to include public opinion research, and compilation of falls data. The data that has been collected should be warehoused and provided as a public service, with appropriate announcements to child welfare advocates *inviting them* to provide additional content or to link to specific accident reports.

The experimental design of a specific study should include live testing with children of specific ages with alternative designs. At some point we should also discuss past code changes that were accepted, such as moving from 6" to 4" apertures.

The research in this area should be open to the involvement (comments period on methodology and pre-release review) to industry partners. There has been some discussion over time of working with other trade organizations in coalition, such as Artist-Blacksmith Association of North America, the Stairway Manufacturers' Association, and the National Association of Architectural Metal Manufacturers.

Climbability Research Critique and Recommended Experimental Design
6/22

Contents

A. Introduction

Beginning in late February we were charged by NOMMA to evaluate the status of industry research. With our background as policy analysts and researchers for many associations in the past, we felt that the proper analysis could help to clarify and settle permanently the safety issue facing NOMMA's members regarding the issue of "climbable" railings.

Although I was unfamiliar with the original challenge facing the industry, based on an initial reading of the evidence we prepared a proposal to NOMMA that outlines the strategy and major steps that would need to be followed to guide an effective industry response.

Frankly we have struggled in this task. Much of the past material that has been prepared by NOMMA members has been done very professionally and comprehensively. And while in theory this should have made our work much easier to do—allowing us to recompile rather than originate evidence, and to adapt rather than create new arguments—it has remained a daunting task in part because of the volume of materials to evaluate, and more because of my knowledge that implicitly NOMMA has only stalled regulatory action by the code bodies, not stopped it entirely. It is difficult to repeat the same arguments again if they have not been found sufficiently compelling in the past when considered against more emotional and unscientific arguments.

To restate my original proposal to you and to NOMMA, our charge has been to review the case that has been developed against the industry in the name of climbable railings.

As part of this I have reviewed many source documents—the postings from the ICC web site, the compilations of accident reports, and the information that has been shared on the NOMMA Technical Affairs Discussion List. While my role has been to be an objective evaluator of the evidence and to provide a critique and alternative it has been most impressive to see the work of staff, consultants, and volunteer leaders of the industry..

B. Safety Lessons from Comparable Products

We believe that the broadest perspective can be obtained by reviewing a variety of industries where safety is an issue. Model codes and product safety are broad fields that must address a wide range of applications. We want to keep this dialogue wide and cross-disciplinary because public health issues and debates occur focusing on various but often similar products and there are precedents created during those debates that should influence our standards for supporting evidence, our methods of collecting the necessary additional data, and the framework with which we collectively make decisions when or how to change standards that affect entire industries and populations.

Pool Safety: Importance of Parental Supervision
For example the CPSC in a recent release concerning pool safety on Memorial Day weekend 2006 reports 280 drowning deaths of children younger than 5 each year in swimming pools, with an estimated 2,100 children treated in hospital emergency rooms for pool submersion injuries in 2005.

And similar to railings, we find that many of the accidents are avoidable stemming not from parental neglect but the simple fact that children may not be watched at all times. "Many drowning deaths occur when young children are not expected to be near the pool area. In a CPSC study, almost 70 percent of the victims were last seen in the house or nearby on a porch or in the yard before the incident. Drowning can occur in the few minutes it takes to answer the phone. About 77 percent of the victims had been missing for 5 minutes or less when they were found."

Although the loss of any life is a tragedy, there are products which are inherently unsafe to children. Pools are another example which result in ten times the number of fatalities that past statistical reviews have suggested were caused by guardrail design.

Amusement Parks: The Need for Systematic Accident Reporting
For a common framework for accident reporting, we cite an objective example from another industry. Saferparks is a nonprofit based in La Jolla California that analyzes and reports safety data for consumers of amusement parks. Their most recent report is a good illustration of methodologies used to document the safety of a variety of products in a specific setting to the public, relying on statistical sources, such as NEISS, and state regulatory reports, and a CPSC annual published report, that have also been employed in analyzing the effect of guardrail designs.

To quote them, "The historical NEISS summaries are the only tool consumers have ... The data is imperfect.. ... Unfortunately it's all consumers have." In their industry this consumer advocacy group recommends addressing the limitations of NEISS combined with publicly available state data to create a national accident reporting system to monitor safety.*
*Saferparks Sources of Data on U.S. Amusement Ride Related Accidents and Injuries, December 2002

We note that, despite this critical assessment, their field is actually better documented regarding accidents and injuries than our own. For example Saferparks cites injury totals by body part and by age range over a twenty year period. They also contacted 40 states and secured data from 12 who responded to their Freedom of Information Act inquiries. (Other states either do not require accident reporting, do not consider safety records to be public data, or they simply lack the staff and access to their own data to share it). Their final conclusion was that the data was difficult to obtain, and particularly at the state level highly variable with regard to the kinds of data being tracked.

Amusement Parks: The Likelihood of Being in an Accident

Another point we cite from Saferparks applies with guardrails as well. In the absence of data that identifies how climbing led to specific accidents, and reliable experiments that help to simulate how and why the accidents occur, we must rely on observed secondary data to determine what the likelihood is of an accident.

- Saferparks' data show a peak of just under 8,000 reported injuries in 1999 compared to park attendance which is now above 300 million person-days, or 3 thousandths of one percent.
- In amusement parks, the likelihood of someone being involved in an accident is very low on a daily basis but would be 1.0% if they attended every day of the year.
- In homes, the likelihood of a guardrail-related accident using the estimates compiled in past published studies showing 340 accidents, and Census Bureau data showing 44 million children under 10 years of age at the time, results in an comparable estimate of a child's chance of falling and being injured of only .001% ... one thousand times safer than an amusement park.
- Of course, this is an imperfect comparison. For one, amusement park data reflects individuals of all ages, while our data pertains only to children. And not all children spend every day in a home with documented presence of guardrails. However the point we are trying to make is that even if appropriate adjustments in reporting led us to be underestimating the risk by a factor of ten, guardrails would still be 100 times safer than amusement parks where parents would not think twice about taking their children.

With guardrails, as with amusement parks and any other product, it is essential to discuss a threshold for what is an acceptable risk of accidents for children given that it is impossible to reduce the risk to zero and if rates already are close to zero, any other are accidents happen.

Probability vs. Mechanics of a Single Event

One feature of the literature that has thus far been presented to the code bodies for their consideration has been the unclear distinction between statements regarding the probability of an event, and the mechanics of what occurs during actual events.

The analogy we draw here is to automobile crash tests. These are tested by engineers under carefully controlled settings that record the visual progression of an accident, and with post-incident evaluations of the effect of the impact. Naturally the studies replace human subjects with a reasonable proxy for a human—a "dummy" with measurement devices that can simulate the probable physiological effects of varying types of accidents (i.e. impacts from a variety of angles, speeds, and internal passenger configurations).

Note that these tests are conducted without underlying assumptions about the overall likelihood of an accident occurring. No doubt human factors account for a large proportion of accidents—inattention, speeding, inexperience, impairments—but these tests are designed to make the product as safe as possible *on the assumption that a certain proportion of accidents will occur*.

This analogy is admittedly strained, and there are limitations to its applicability. Railings are much simpler in design than automobiles, so we can test a wider variety of designs and, if appropriate, materials or settings. However, the single most critical point here is that the underlying policy assumption, that a proper design can reduce the accident rate to zero among a specific target population, is inherently unreasonable. In no other industry can we think of reputable research that has a built-in assumption that the end goal of testing, engineering, and re-evaluation of subsequent designs will be the elimination of a negative outcome when in the real world some level of accidents are already observed.

Particularly because we have seen that the long term trend of accidents involving children reported and observed through NEISS is extremely low, we may assume that achieving any potential decreases in accident rates over time will be exceedingly difficult. Because we lack valid data tracking accident rates over specific points in time, we do not know if there is a time trend or, if so, its direction, but projecting into the future with an existing low accident rate, reductions of an already low rate are typically asymptotic approaches to an optimal accident rate (zero or a number that reflects some unavoidable accidents due to extreme parental negligence). This means that any further improvements over time may progress very slowly, and be imperceptible to the existing methods in place for tracking the occurrence of accidents.

Premise

It is no accident these advocates rarely recommend change. Causation is a simple factor. As many of us know it is not enough to establish a link that demonstrates that one event occurs commonly in conjunction with another, even if one leads to the other. The next and greater concern is if issues can be demonstrated to be avoidable with a different regime of circumstances. One factor we might assert is the effect of future development on accident rates.

We must accept that for the analysis of data and particularly for their application to policy and other changes requires a uniform application. If accident reports can be cited carefully to include quality and vintage of construction, we can establish the proportion of accidents that might be avoided through further changes in the codes governing railings.

C. Background: Research Methodologies and Limitations

In any policy analysis, there are two general kinds of information, primary and secondary research.

Secondary research generally consists of the collection, compilation and review of existing statistics or incident reports. There are many reasons why we use this approach but in common sense terms, it allows us to re-use data that is openly accessible and has been collected by other parties such as government agencies, universities, associations, press, etc.

ADVANTAGES: Secondary research is openly accessible and can be shared. It generally uses a common methodology to ensure that trends can be reliably estimated over time.

DISADVANTAGES: Secondary research has often not been collected with a specific policy or purpose in mind, so it can tend to be incomplete. Most statistics are available only in summary form. In our examples, re-analysis of data available to us

Primary research generally consists of unique collection of quantitative or qualitative information that is current and generally configured to address a specific issue or test a hypothesis. Methods used here by the researcher generally include surveys, focus groups, and experimental observation.

ADVANTAGES: Primary research is conducted with specific focused goals in mind, allowing us to control for extraneous influences and to definitively collect the necessary information by developing, communicating, and executing a research plan or protocol.

DISADVANTAGES: Primary research is typically under the control of a single study designer and may focus too narrowly, and may have substantial flaws reflecting conscious or unconscious bias.

Current State of Secondary Research

There has been considerable secondary research conducted over years regarding the climbability of railings. This process has been hindered by inherent limitations in data that has been collected:

- Hospital admissions data for childhood injuries and falls
- Individual incident reports from the press

Hospital admissions data are collected for a wide range of populations and accident types. Generally they are consistent but lack detail that does not support their core purpose for collection, which is to identify the patient for subsequent timely care.

Because press reports are collected by many reporters, there is no consistency in how accidents are reported, nor do we expect them to do anything more than report the most notable features and to accept eyewitness accounts. Standards of journalism and penalties are generally far lower than standards for legal depositions.

Neither of these conditions are likely to change in the future, and because they govern years of historical data, we effectively must proceed from analysis of flawed and incomplete secondary data to primary research that will provide us with a proxy that helps demonstrate what we need to prove—under what conditions are children at greatest risk of climbing, falling, and being injured.

In addition, any secondary research analysis of data being collected suffers from the presence of an observer bias. We typically find that individuals motivated to report data, while lacking de facto bias in their reasons for filing complaints, must at the same time have a systematic common set of characteristics that leads them to report. For example, a children's hospital has an incentive to track solely student admissions at the expense of other patient populations. For simple reasons if you have a accident involving a child, you will take the child to a children's hospital.

Secondary/Primary Research
One of the best examples of exhaustive yet inadequate secondary research supplemented by primary research investigation appears In a journal article prepared under the primary supervision of Dr Gregory R Istre, Injury Prevention Center of Greater Dallas ("Childhood injuries due to falls from apartment balconies and windows," G R Istre, M A McCoy, M Stowe, K Davies, D Zane, R J Anderson and R Wiebe; Injury Prevention 2003; 9:349-352 BMJ Publishing Group Ltd) we see that an average of 33 falls per year with 13 resulting in hospital admission for children (defined as under 15 years). Window falls (39) outnumbered balcony falls (34). Two thirds of all balcony falls occurred between balcony rails, and all the rails inspected were more than 4 inches wide (an average of 7.5 inches, with all building sites being built earlier than 1984). The majority (75%) of all falls were from a second story height with 20% occurring from a height of three or more stories.

The geographic scope of this study was limited to Dallas County Texas, but it was notable for both its duration (a longitudinal study covering three full years) and the intensity of its resource commitment (collecting data from all area hospitals with cooperation from the state Department of Health). However, even a well conceived and executed study such as this helps to identify the weakness of relying on secondary data to help infer the dynamics of accidents and how to prevent them.

Limitations/Considerations in Primary Research Design

- Because there are many ways of estimating reliability, each influenced by different sources of measurement error, it is unacceptable to say simply, 'The reliability of text X is .90'. A generic term, reliability refers to the degree of consistency of the information obtained from an information gathering process.
- Far too many researchers incorrectly interpret statistical significance tests as evaluating the probability that the null is true in the population given the sample statistics for the data in hand. If *p ...* informed the researcher about the truth of the null in the population, then this information would directly test the replicability of results.
- "A one-tailed statistical significance test of an r (reliability coefficient) of roughly .94 even at an α=.01 level of statistical significant will be statistically significant with an n as small at 5!"

(Thompson, B. (1994) Guidelines for authors. *Educational and Psychological Measurement* 54(4), Sage Publications Inc. Page 841, 842, 844.)

Most researchers also test against a null hypothesis to test whether something is true. Typically the null hypothesis is something that is known to be untrue. In the case of studies evaluating the climbability of barriers, the null hypothesis from a NOMMA perspective would be that a comparison of the difference of mean actual fall rates for child subjects would be appreciably different from one another, at a reasonable significance level.

At the same time we must also take care to ensure that we upgrade the science of railing evaluation to an appropriate level. In a variety of fields the quality and professional, statistical literature is quite well developed. Psychology is one of the most advanced fields in this area, in part because they apply the inherent discipline and standards of the medical field when it comes to supporting or rejecting recommendations that might threaten lives if done improperly, coupled with the fact that they are measuring attitudes, beliefs, and other outputs of the human mind, a notoriously difficult environment for measurement.

Current Hypotheses: Railing Design and Child Accident Rates

Over time the following general assertions have been made justifying the implementation of new codes to reduce childhood accidents:

- There is a high volume of preventable accidents involving children falling from railings.
- Children are able to climb a variety of allowed railing designs under normal conditions that control for extraneous factors that contribute to their potential falls, but are unable to climb other railing designs that are allowed under alternative code recommendations.
- Similar accidents can be avoided in the future by altering the design of new construction through codes, reducing the accident rate to the extent that children fall from railings that have been built under current codes.
- Children's behavior will not adapt to new compliant designs.

These conditions collectively present us with testable hypotheses, but for ethical reasons cannot be actually tested. In reality, accident reports attest to the periodic tragedy of a child falling resulting in injury or fatality. Hospital emergency room reports document many visits.

D. Case Study: Research Supporting the 4" Opening
Below we cite the facts presented that supported the implementation of model codes with a 4" guardrail opening.

"The Silent and Inviting Trap," Elliott O. Stephenson, *The Building Official and Code Administrator*, November/December 1988.
This article advocates for a model code requiring a maximum allowable 4" standard guardrail opening, reduced from a 6" standard.

Specific evidence cited included studies conducted by the University of Michigan Highway Safety Research Institute (now Transportation Research Institute) for the U.S. Consumer Product Safety Commission:

- "Physical Characteristics of Children as Related to Death and Injury for Consumer Product Design and Use" May 1975
- "Anthropology of Infants, Children and Youth to Age 18 for Product Safety Design," May 1977.

Key findings of these studies were drawn from samples that each consisted of at least 4,000 individuals under 13 years and under 18 years:

- The average (mean) head breadth ranges between 4.88" and 5.35" and mean chest depths range between 4.21" and 4.84" for children in age cohorts ranging from 10-12 months up to 43-48 months.
- The minimum head breadth ranges between 4.37" and 4.95" and chest depth ranges from 4.07" and 4.87" for children in those same age cohorts using a 99% confidence interval.
- The distribution of actual head breadth and chest depths have a relatively narrow variance so that few small children are able to pass completely between a 4" wide opening.
- The data regarding distribution of the physical size of children at various ages is then linked to their physical ability to pass through openings of various widths, primarily 4", 4.5", and 6".
- The distribution shows that almost 100% of children under four years of age can pass through a 6" opening; 5% of children 10-12 months old and 1% of children 13-18 months old can pass through a 4.5" opening.

These facts are linked to observations regarding common climbing behavior among children passing through narrow spaces—most specifically the breadth of the head and possibility of a child passing only part of their body through leading to potential strangulation.

There are also discussions of the total injuries using NEISS (National Injury Surveillance System) data for 1978-1988 documenting an average of 340 falls annually for children under 10 years of age, including 21% causing dislocations or lesser injuries; 63% causing fractures, lacerations, or concussions; and 17% causing concussions, fractured necks, crushed arms or other serious injury. An average of three children per year under 10 years of age would die of their injuries.

The findings were interpreted in this article with the addition of secondary research and findings that present use of the final recommendation of a 4" opening. Among them were:

- Citing endorsements of trade groups (such as National Spa and Pool Institute) for maximum openings in pool enclosures.
- Codes including *South Florida Building Code* and *National Building Code of Canada*.
- Citations from the Australia building code.

The article also discussed anecdotal information including voluntary remodeling undertaken by a commercial retail property owner, several accident reports, and citation of several cases leading to litigation including one large settlement.

E. Recommended Experimental Study Design
One of our primary considerations is that all of these studies revolve around consideration of product design and its effect on accident rates. With various code considerations under evaluation, the existing hypothesis underlying all proposed code changes are that product design effects varied outcomes in a positive direction—in the form of reduced accident rates and/or reduced severity of the outcome of an accident when it occurs.

The data that we need to collect to validate or disprove this hypothesis is relatively simple to structure, and a brief discussion of that data should be sufficient to demonstrate why past data collected has been inadequate to support these hypotheses.

The structure of this test must be a mix of "product focused" and "subject focused." Because the policy prescription entails changes in product design, we must test a mix of designs that comply with current code, designs that no longer comply with current code but which exist in significant numbers throughout the US housing stock, and designs that are advocated for the future.

To keep the study design at a reasonable level of complexity and to avoid having to divide the sample across a large number of cohorts (which will either reduce statistical significance of the observed results and cross-design comparisons with a fixed budget, or require a larger budget to oversee a more comprehensive testing strategy), we recommend testing the following three or four specific designs:
#1) A design with 7"-8" horizontal spacing with vertical toe holds, scrolls or horizontal balusters up to at least 50% of the vertical height of the railing.
#2) A design with 4" horizontal spacing with vertical toe holds, scrolls or horizontal balusters up to at least 50% of the vertical height of the railing.
#3) A design with 4" horizontal spacing and vertical pickets with no toe holds.
#4) (Possibly) A design with far more restrictive design features, presumably an outright barrier with some vertical spacing (at the top of a 36" railing perhaps) that is not in any proposed code changes to date but which would represent the most extreme design suggested to promote child safety.

In each of these tested designs we have certain behavioral assumptions that are not hypotheses to be tested in the study, but which represent postulated opportunities for behavior that has empirically led to the accidents that has been documented in the past and cited as evidence supporting the implementation of progressively more stringent code.
#1) A child will remain on the base (ground) level to observe that they want to see beyond the barrier, with a primary desire for visual contact overruling any desire to climb to get a better or less obstructed view.
#2) A child will use the available toe holds with some frequency to climb the guard so that their center of gravity at least approaches the top of the railing.
#3) A child will attempt to climb the guard with less frequency (corresponding to an increased difficulty assessed before attempting to climb, or reassessed while in the dynamic act of attempting to climb).
#4) A child will occasionally attempt a far more difficult maneuver to observe external stimuli and face far greater risk once in place based on the relationship of their center of gravity to the top of the barrier, presenting lower likelihood of climbing behavior but a higher overall probability of accidental falls.

For the purposes of this test, we will need to establish an acceptable level of stimulus to serve as the "reward" or "incentive" for the child to be more curious to pursue investigation of the forward facing environment (i.e. beyond the railing) rather than their immediate surroundings.

We will also need to eliminate the presence of visible or discernable adult observers or supportive personnel. This will ensure that the environment more closely represents the conditions that most closely correspond to the settings cited in most accident reports—an unsupervised child who presumably is driven by curiosity to investigate an unfamiliar setting from the vantage point of a familiar one. Because virtually all past investigative work has featured the presence of one or more adults behind or in front of the child, judging from the photographic evidence and experiment descriptions cited in past articles, we need to eliminate this source of bias.

The experimental design we would recommend that would best simulate an appropriate external environment for which existing and future proposed codes are meant to influence accident outcomes would include the following features:

1) A well simulated exterior or an open exterior (i.e. windowless access) that presents a residential/street environment with appropriate sounds to ensure sufficient "incentive" to provoke child curiosity and lead them to investigate.
2) An interior with simple features and minimal stimuli to provide the child with comfort and a sense of being in someone's home, and with the child has sufficient time to become familiar and perhaps bored.
3) A flooring beyond the railing that features a real drop of at least the height of the railing, perhaps 4' with cushioning that is not readily identifiable as such. Ideally this can be configured to record the actual point of impact on the child's body in the event of a fall.
4) Concealed cameras recording child activity at regular intervals during a period of observable time, perhaps 15 minutes to an hour.
5) Ability to rotate the child through at least two barrier scenarios in a single study observation period.
6) Sufficient standardization of child subjects to ensure that they are of comparable height, weight, gender, and other relevant physical attributes, with a distribution across the targeted age groups sufficient to ensure a representative grouping of average ages within each segment.
7) Ability to repeat this experiment once more but with more powerful incentives to demonstrate climbability so that the analysis records a much higher number of climbing incidents and allows us to measure falls as a proportion of total climbing incidents. .

This study design would allow us to determine the approximate frequency with which children feel compelled to climb and then use their surroundings to aid them in that activity. One of the major overlooked features of the secondary research/accident reports that have been analyzed through various syndicated sources and academic studies is the simple fact that codes can only affect individuals residing in or exposed to new construction compliant with specific codes.

In fairness, we must consider the possibility that households with a high risk of serious accidents (due to the child's personality, level of existing supervision, and the potential vertical drop) may in effect be substituting one specific fall/injury dynamic for another, with wide vertical railing spacing allowing a child to fall between railings rather than pursuing the more arduous task of climbing a railing and falling over.

The analysis of this study would consist of a simple ANOVA (analysis of variance) across the various regimes for each of the three or four design options, with appropriate descriptive statistics demonstrating the comparability across the observations from each sample. The analysis would be distinct for the "low incentive" and "high incentive" environments, allowing us to draw conclusions regarding the likelihood of an accident occurrence under test conditions, and the physical impact for a sufficiently high number of accidents to expand the discussion of safety to cover the most important consideration—demonstrating that existing designs are equal to or superior to proposed designs in minimizing serious injury to children.

F. Conclusions

We have outlined above limitations to the conduct of any research, a critique of existing research in our field, and outlined the parameters for a research project that would more reliably address the issues that have been attempted previously through primary and secondary research.

These notions may seem radical and perhaps dispassionate—taking a highly emotionally charged issue and moving into an accident rate/'parts per million' perspective.

However, this is the true nature of the phenomena we seek to understand, evaluate, and affect through enforcement of existing codes and consideration of prospective new model codes.

To accomplish this we must attempt to master some of the unfamiliar tools of psychological research and risk management, to ensure that we are responsibly promoting product safety as it occurs in the real world. Out of the millions of times that collectively all individuals within a population are in a specific circumstance that exposes them to risk, what is the proportion of times they might be injured? To what degree are these negative outcomes avoidable? And what can we do collectively to ensure that they are avoided, if they can be avoided through alternative railing designs?