This is the Formal Appeal submitted in 2020 to ICC on Proposal RB81-19 for the ICC International Residential Code (IRC)

by
Jake Pauls, BArch, CPE, HonDSc
Independent Consultant in Building Use and Safety
Silver Spring, MD & Toronto, Canada
www.bldguse-and-safety.com
bldguse@aol.com
Celebrating 53 years: filling-bldguse-and-safety-gaps™
assisted by
Tom Paris, Legal Counsel
Chicago, IL
tp@tomparislaw.com

Preview of Foundational Argument for Adoption of RB81-19

The case behind the appeal includes several evidential bases or foundations:

- **Precedent** (e.g., based on what is done—and accepted as necessary—for stair safety)
- **Ergonomics** (i.e., science of interactions of people and their environments)
- **Economics** (*all* benefits—including public health—and costs for individuals & society)
- **Parity** or equity among occupancy and building settings (required stairway handrails)
- **Survival** of society, organizations (e.g., ICC), and individuals (in terms of safety)

Requirements of ICC CP#1-03–Appeals: Key to required responses

"2.0 Right to Appeal: Any person may appeal an action or inaction in accordance with the policies of the ICC Board, excluding those beyond the control of ICC." **The subject of this appeal is within the control of the ICC.**

"3.1 An appeal (other than certification status-related appeals) shall be in writing, and shall be directed to and received by the ICC CEO within 30 days of notice of the action or inaction which forms the issue being appealed or no appeal shall lie." **The 30-day window for this appeal occurred on late April 2020 and ends on Friday, May 8, 2020 (according to ICC).**

"3.3 The appeal shall include the following:

3.3.1 A specific description of the issue being appealed; **See below.**

3.3.2 A statement describing precisely why the issue is being appealed; **See below.**

3.3.3 All appeals, except as to a staff action or inaction or certification status-related, shall also include the following:

3.3.3.1 A detailed description of how the issue being appealed will adversely affect the appellant. **See below.**

3.3.3.2 A statement indicating the requested remedial action; **See below.**

3.3.3.3 The names and mailing addresses of individuals and organizations that may have an interest in or be affected by the matter being appealed. Notice of the appeal will be provided to those parties in accordance with Section 6.1; **See below.**
and
3.3.3.4 A nonrefundable filing fee of $500." **This was sent by US Mail to ICC's Washington Office on 28 April 2020 in the form of a check, for $1,000.00 covering this appeal and one other, dealing with a separate proposal, RB81-19, which shares many background facts with this appeal on RB116-19.**

"3.3.1. Specific Description of the Issue Being Appealed" (with epidemiological background)

In relation to IRC proposal RB81-19—***on new home bathtub and shower grab bars***, submitted by the Appellant, the ICC process has badly failed hundreds of millions of people to whom the ICC owes a duty to provide reasonably competently produced, and timely model codes addressing critical issues, in this case, evidence-based model codes for usability and safety of buildings, *especially homes* for which families and others make their largest financial and other investments. ***The second-most dangerous and most problematic in terms of usability and safety (after stairways) are bathtubs and showers.***

Homes are the most likely place for occurrence of *medically-treated* injuries. See table below with *annual* estimates—by locale—for the period, 2010-2014 analyzed by the Pacific Institute for Research and Evaluation, PIRE, in Maryland. Of the recorded locales (89 percent of the total) 95.7 percent are homes and these total an estimated 955,723 *annually* during the period 2020-2014. Today that total would be well in excess of one million, home-related bathtub and shower-related injuries annually in the USA with an annual societal cost on the order of over 20 billion dollars annually.

Bathtubs & showers

	Locale of accident	Frequency	Percent
0	Not recorded	209,935.6	21.02
1	Home	754,831.6	75.57
2	Farm/ranch	25.3	0.00
4	Street/highway	756.9	0.08
5	Other public property	29,838.6	2.99
6	Mobile/manuf home	75.2	0.01
8	School	1,092.9	0.11
9	Place of rec/sports	2,293.3	0.23
	Total	998,849.3	100.00

In terms of available, code-addressable interventions to prevent and mitigate impact injuries with bathtub and shower facilities in homes, grab bars—more generically termed "points of control—are the easiest to implement—*at the time of original bathtub or shower installation*—and most

effective interventions that are highly cost-effective and relatively reliable (compared, for example, with permanent friction treatments of underfoot surfaces *which are only very partial interventions* for bathtub and shower-related injury events).

See Appendix A for a recent published paper for authoritative research findings—combined with empirical insights—on both the grab bar (points of control) provision aspect and very practical ways to solve the underfoot slipping aspect of the bathtub and shower safety issue. It was presented, by the Appellant, and published, at the most-recent Triennial Congress of the International Ergonomics Association in 2018. Dr. Daniel Johnson, both a Certified Professional Ergonomist (CPE) and a certified expert on slip resistance co-authored the paper.

Thus, it should be clear—right from the beginning of this Appeal application—that the focus on installation of grab bars, at the time of original construction, is the most appropriate measure to be addressed at this time in the IRC.

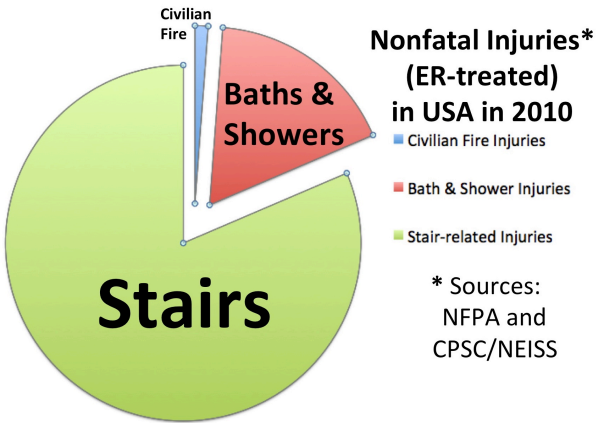
This appeal addresses only the grab bar portion of the interventions addressed in the paper for reasons that are clearly described in the Appendix A paper, *namely that very readily available interventions for the slipping issue—in or adjacent to bathtubs or showers—do not require, at this time, being addressed in the International Residential Code, IRC.*

"3.3.2. Statement Describing Precisely Why the Issue Is Being Appealed"

This will significantly reduce predictable, preventable injuries in people's use of bathtubs and showers, in homes. If not completely preventable, this will also mitigate—e.g., with functional grab bars as well as stanchions functionally equivalent to conventional grab bars—balance, trips (e.g., elevated shower water dams, thresholds or elevation changes for drainage, and bathtub walls) and underfoot slip-resistance conditions.

This has the potential of significantly reducing the 20 billion dollar annual toll in US societal injury costs from stair-related injuries, at least 95 percent of which happen in home settings. As an expert in the field, with knowledge of the relevant ergonomics, public health issues, economics, etc., the Appellant also has unmatched evidence at his disposal about the efficacy of various design and construction features in significantly reducing the injury toll while also improving usability.

This is a growing objective as our population ages and becomes more vulnerable in good times as well as during pandemics like we now endure—*largely in our homes.* Flaws in the *I-codes,* and earlier legacy codes, serve us very badly. We have over one million bathing/showering related injuries each year that receive professional medical attention in the USA alone—many times more than are injured in home fires. See pie chart (to right) which was provided also in proposal RB81-19.



The issue is too important to be dismissed in the manner the relevant ICC Committees has done this year after the Appellant works so hard last year, in Group A, to find the best place in the I-Codes to begin addressing the problem.

Finally this is a problem that NFPA addressed a few years ago (except for healthcare and detention occupancy settings) and the technical requirements (the starting point for the RB81-19 proposal for the IRC) are based, initially on what NFPA has adopted in 2018 and appearing, with minor changes, in 2021 editions. Notably, the core requirements for all occupancies ae currently "housed" in the One- and Two Family Dwelling Chapters of NFPA 101 and NFPA 5000. The opposition to this for the I-Codes, particularly the IRC, lacks a sound public health foundation as well as lacking evidence for ignoring the problem as the Committee action suggests.

"3.3.3.1 Detailed Description of How the Issue Being Appealed Will Adversely Affect Appellant"

It is not because I stand to gain financially or that I need a psychological "push" to install grab bars in the bathrooms of the two dwelling units I rent (in the USA and Canada). There are already "points of control"—*utilizing a total of four stanchions (grab bar equivalents)*—installed (by myself) in both of my *rented* apartments—*and none involved damage to apartment surfaces or structure*. Indeed if ICC responds to this Appeal in a responsible fashion, by making sure the 2021 edition of the IRC contains bathtub and shower grab bar requirements, I will have a reduction of huge responsibilities, *ethically*, to champion the installation of grab bars as part of original construction of homes. In and after my 88th year, I have much else to attend to.

With this Appeal, I am making the investment in seeking the improvement in the I-codes, particularly the IRC, because I am a professional imbued with social, ethical and moral responsibilities in public health, ergonomics and other aspects of my career. This is best reflected in the Honorary Doctor of Science degree in 2017 conferred on me by the University of Greenwich. I take, very seriously, this and other public service honors from academia and the two largest (national-scale and international) public health organizations in North America.

I share—with millions of Americans—a need to reduce my own, growing vulnerability to a life-changing fall, a legitimate concern in ones 78th year. My cohorts—*as well as many younger people*—deserve better than what ICC has done for us since its inception. See the age distributions in the following tables.

Bathtubs & showers			Hospital-admitted		
Age	Doc/Outp	ED	via ED	Direct	Total
00-09	37,209.4	43,339.8	1,331.7	666.4	82,547.3
10-19	35,633.2	23,065.4	550.0	193.0	59,441.6
20-29	69,977.6	35,853.2	1,362.6	482.8	107,676.2
30-39	111,103.0	36,699.4	1,497.8	444.1	149,744.3
40-49	128,478.0	37,743.3	2,339.7	706.7	169,267.6
50-59	122,562.0	37,817.5	3,806.7	1,332.2	165,518.4
60-69	70,334.1	24,507.2	4,954.2	1,648.5	101,444.0
70-79	50,248.3	18,727.5	5,880.1	1,832.0	76,687.9
>=80	49,813.7	23,342.6	10,501.9	2,864.2	86,522.4
Total	675,359.0	281,096.0	32,224.6	10,169.9	998,849.5

Toilets			Hospital-admitted		
Age	Doc/Outp	ED	via ED	Direct	Total
00-09	8,162.7	7,752.4	235.8	90.6	16,241.5
10-19	2,997.7	2,507.3	109.4	31.9	5,646.3
20-29	7,660.3	5,348.3	275.1	139.9	13,423.6
30-39	15,285.7	5,965.9	481.2	132.8	21,865.5
40-49	19,586.3	6,929.6	1,121.8	414.5	28,052.1
50-59	26,660.4	9,330.3	2,190.4	707.6	38,888.7
60-69	29,557.7	10,315.4	4,054.4	1,383.1	45,310.7
70-79	27,339.4	10,463.1	5,791.4	1,838.0	45,431.9
>=80	43,548.8	20,879.0	13,006.3	3,498.9	80,933.0
Total	180,799.0	79,491.3	27,265.8	8,237.2	295,793.3

These tables come from PIRE (Pacific Institute for Research and Evaluation, in Maryland) showing that bathtub and shower-related injuries affect all age groups; it is not just a problem older people have with bathing and showering. (Indeed, my first seriously injurious fall with a bathtub occurred nearly four decades ago when I was a young man, in a Las Vegas hotel, where I was for one of the many code-development meetings held at that time—1980s and 1990s—in Las Vegas. *That life-changing experience did not "stay in Vegas."* The memory of that is very persistent.

Note that, people over 80 have *only half* as many medically treated injuries for bathtubs and showers as middle age adult do but, for toilets, they have *twice as many*. Exposures differ! Older people choose—*likely out of concern for safety*—to forego showers and baths due to dangers posed by the current, typical dangerous conditions posed for everyone—at any age—by the bathtubs and showers the home building industry, callously (?) and thoughtlessly (?), delivers with new homes.

Thus my safety is endangered, not when I am in the dwelling units I rent and control—*with their installed points of control*—but every time I visit a home, as an overnight guest—and have to cope with relatively dangerous bathtubs or showers installed there—complying with the very deficient IRC. Clearly I am being adversely affected in this regard. This will only change when the home building industry—not able to do the right thing on their own—have to be constrained about what it does to everyone occupying one of its products.

Note, I am not alone in the foregoing views. AARP has, for decades, gotten similar results in surveys of people over 50; overwhelmingly—by more than 80 percent— they (like me) want to stay in their homes forever. Recent pandemic experience with hugely heightened risk of death in various types of retirement housing due to COVID-19 occurring in at least a few countries has added a new urgency to this need to have *homes for life*.

I have been given great skills, plus work opportunities, in my life and want to share the benefits, *particularly where these gifts have given me unusually important insights into how and why bad things happen to people using buildings of all sizes and types—including homes—in multiple countries.* It would be better for everyone if ICC and I can work together on this rather than being on opposing sides of impending legal procedures. In such procedures, I represent the public interest, especially, with superior evidence and safety experience that courts of law will recognize. ICC is the one now needing to change; this Appeal gives ICC a chance to do so—in time for the 2021 IRC.

"3.3.3.2 Statement Indicating the Requested Remedial Action"

The responsible Committee has to consider the evidence competently and do so impartially—not biased by their occupation, etc.—rather than "blow-off" a serious, well documented proposal with the weak Committee Reason statements provided such as provided last spring, e.g., "The dimensions are not sufficient for all medical conditions." The other two reasons, each also deeply flawed, were:

"These requirements should be optional" and

"It might be more palatable if only the blocking had to be installed."

One really has to question these "reasons" but, to do so, would require ICC to significantly improve its *Committee Action Hearings* (CAH) to allow more time for discussion of such huge safety issues—affecting largely predictable and preventable injuries to over five million people a year in the USA, *in their homes*, in the case of stairways and bathtub/shower facilities (both subject to appeals submitted by this Appellant at this time). But this has to go beyond addressing completely unrealistic time limits—particularly on issues as big as those addressed in this proposal, RB81-19 or others the Appellant is pursuing. (The latter include RB116-19, with a closely related RB112-19, both on home stairways and addressing over four million medically-treated, predictable and largely preventable injuries annually in the USA.)

The ICC Appeal process already includes a few components that are called for here—*if they are genuinely and seriously employed.*

Starting with formal reconsideration by the responsible Committee (International Residential Code Committee–Building), we need all its members to do their duty to consider the facts fully and without bias—blatantly an issue for the one-third of members formally representing NAHB. (Future ICC appointments should change that policy which exists due to a *quid pro quo* agreement between ICC and the NAHB dating back to the mid to late-1990s. That should send—to the courts of law—both of the parties to the agreement, the sooner the better. The agreement has proven to be very much against the public interest and it certainly makes ICC appear to be ethically challenged, if not also—eventually—legally vulnerable.)

There also should be the opportunity—*indeed a requirement*—for all those testifying on an issue to provide documentation for their assertions. This proposal (as well as the previously mentioned stairway proposals, RB112-19 and RB116-19) is an example of asymmetric debates with one side desperate to provide the available evidence to the debate, while the opponents too often appear more intent on "throwing rocks into the gearbox" and trivializing, if not killing, reasonable debate.

The assertions by Committee members and those testifying should also pass the 'laugh test' on claims such as such as grab bars "should be optional." That is akin to arguing that new automobiles do not require brakes or reliable steering systems, they should be optional. If such options are not chosen, would car drivers need to stick their foot out the door and drag it on the pavement to stop the car? No, there is a need for installed, reliable, effective brake systems for *all* cars and all drivers (plus passengers). Equally, there is a need for people entering or exiting a relatively dangerous shower interior or bathtub, with its high walls and slick surfaces, to have "points of control." Such "points of control," with upper limbs effectively employed in addition to having the single, unreliable under foot point of control (or contact). The single foot, carrying all their body weight, is necessary of course, but not sufficient. Having one grab bar available

within reach provides, with the single underfoot support, (only) two points of control unless there is a vertical bar or stanchion, for example, that can be simultaneously grasped by both hands. This works very well in the example (below), again from the proposal, of exactly such an installation, in one of my rental apartments.

Note that the installation has been augmented here, for demonstration purposes, to show alternative installations using conventional grab bars which would be attached to walls with screws, unlike both of the color-coordinated stanchions—both vertical and horizontal, neither of which has screws into a wall or the bathtub. Both stanchion installations meet the 250-pound load test. Moreover, to counter one of the industry opposition arguments that these would violate the tub manufacturer warranty, this is hardly the case as the tub shown is a 50-year old installation. More importantly, even if this were a new tub, the stanchion load—and load distribution—is no greater than imposed by an adult stepping on or sitting on the tub rim. Countless women "violate" such claimed warranty limitations as they sit on the tub wall or rest much of their body weight on the tub wall while shaving their legs, to say nothing about the huge forces of water on tub walls when filled to the overflow limit for a full bath.

Proposal RB 81-19 dealt with the whole issue of "points of control"—particularly in relation to "Grab Bar Equity" in the table presented on the 2019 Public Comment Agenda, page 713 as well as, better reproduced, in the Committee Action Hearing Agenda (CAH). (page 2290). It is shown below as it was submitted to ICC.

Gab Bar Equity with Stair Handrails

Number of Points of Control Via Hands or Feet	≤1	1	2	3	3-4
Standard walker for older adult with altered gait.					✔
Occupational settings with risk of worker falls from heights. Also, stairs where users can use two handrails simultaneously, one on each side.				✔	
Stairs where users have only a single handrail. ***Grab bar(s) usable for bathtub/shower entry/egress.***			✔ ★		
Bathtubs/showers with slip resistant underfoot surfaces when wet.		✔			
Bathtubs/showers without slip resistant underfoot surfaces when wet, the common condition currently.	✔				

Perhaps not surprisingly, once the Committee had come up with three (albeit weak) reasons, they proceeded to the vote, rather than addressing each issue on its full set of merits and defects. An examination of all the responsible Committee's actions on the 27 disapproved proposals up to about RB130-19 (i.e., preceding and including the Appellant's issues) revealed that the Committee gave an average of 2.93 reasons for each disapproved proposal. The three relatively major proposals by the Appellant each had 3 reasons despite their much greater need and justifications.

Perhaps, in some future world of more-responsible code development, ICC committees would give each proposal the time and effort commensurate with its complexity and societal importance. ***That could still happen in 2020 as one outcome of this appeal.*** As one kind of evidence of the very large nature of the problem RB81-19 addresses—and the immense amount of evidence on the problems and solutions, consider the bibliography of about 50 items referred to in the CAH proposal as provided in last year's Group A proposals on grab bars (that could be obtained from cdpAccess archives as well as from the proponent. It is again provided with this Appeal request, in Appendix B.

Committees have a high duty. This committee apparently has failed to deliver on its duty. As a member of many NFPA committees—including the TC on Residential and, since 1978, the TC responsible for stairway requirements—(with 230 committee-years of committee memberships overall), I have learned well what we are taught about addressing proposals. If we do not think a proposal is "ready for prime time," it is our duty to set out *all* the reasons that, *if addressed by the proponent in the public comment process*, this should result in the proposal's acceptance. My suggestion to ICC: please respond to well-developed proposals specifically and in detail: i.e., what are the specific aspects of the proposal that have errors or weaknesses, so that instead of wasting yet more years, ICC can finally get the codes that befit its lofty ambitions and use of "SAFE" in its Web URL.

More practically, ICC, its committee, and members recognize that some proposals take more work and mental effort than the majority of proposals or comments on the agenda. First of all,

recognize which ones address really significant safety and regulation issues (rather than market share skirmishes—especially when millions of injuries must be mitigated, if not prevented—and address them accordingly. RB81-19 is one of those issues, along with RB116-19 (plus RB112-19) on home stairways—the site of over four million medically treated injuries annually in the USA. These deserved more thoughtful Committee Reason statements, particularly when relatively well-justified, much-needed proposals are "Disapproved."

Hopefully, the full ICC Appeal process will make up for the perfunctory treatment given by the Committee. Otherwise, the next option is to take this matter to the courts where evidence is treated with more respect.

"3.3.3.3 Names and mailing addresses of individuals and organizations that may have an interest in or be affected by the matter being appealed." (Notice provided per Section 6.1.)

Dr. Ben Barkow	dr.ben@bteam.com
Dr. Peter Barss	peter.barss@gmail.com
James Benya	sasquake@access4less.net
David Collins	dcollins@preview-group.com
Sean DeCrane	Sean.DeCrane@ul.com
Chris Dubay	cdubay@NFPA.org
Richard Duncan	rduncan@udinstitute.org
Dr. Nancy Edwards	Nancy.Edwards@uottawa.ca
Dr. Nigel Ellis	Nigel@fallsafety.com
Dr. Geoff Fernie	Geoff.fernie@uhn.ca
Dr. John Fruin	frujack522@gmail.com
Roger Gervais	gervais.roger.p@gmail.com
Stanley Harbuck	he@xmission.com
Dr. Glenn Hedman	ghedman@uic.edu
Donald Henning	dhenning888@gmail.com
Gina Hilbery	gina@cohenhilberry.com
Wayne Jewel	jewellwayne@ecodecycle.com
Byron Johnson	byron.johnson@bell.net
Dr. Daniel Johnson	dajinc1@mac.com
Roger Johnson	R.Johnson@koonz.com
Dr. Satoshi Kose	skose@gakushikai.jp
Dr. Rani Leuder	raniergo@gmail.com
Marsha Mazz	m.mazz@verizon.net
Dominic Marinelli	dmarinelli@accessibility-services.com
Dr. Ted Miller	miller@PIRE.org
Dr. Ian Noy	i.noy@outlook.com
Dr. Alison Novak	Alison.Novak@uhn.ca
Tom Paris	tp@tomparislaw.com
Mike Roys	mike.roys@riseandgoing.co.uk
Jonathan Rubes	jrubes@rubescodes.com
Tim Ryan	t.ryan36421@gmail.com
Ken Schoonover	schoonkm@gmail.com
Dr. Gary Smith	Gary.Smith@nationwidechildrens.org
Dr. Rebecca Spicer	rspicer@impactresearchinc.com
Dr. Ed Steinfeld	arced@buffalo.edu
Linda Strobl	str.linda@gmail.com
Keith Vidal	keithvidal@vidaleng.com
Dr. Leon Vinci	lfv6@aol.com
Carolyn Williams	ethx77@gmail.com

On the following pages are Appendices A and B consisting of the following:

Pauls, J. and Johnson, D.A. (2018). **Applying Ergonomics to Bathing Safety: Including adoption of unorthodox practices for slip-resistant underfoot surfaces of bathtubs plus showers and provision of effective points of control.** *Proceedings of the 20th Congress of the International Ergonomics Association (IEA2018),* Vol II, Springer, pp. 486-500.

Bibliography of about fifty items collected originally for a Public Policy of the American Public Health Association (APHA) on bathroom grab bars. Notably, currently, both APHA and the Canadian Public Health Association (CPHA) have policies, dating back at least a decade, recommending that model codes—including ICC's—have requirements for all new homes to be provided with bathtub and shower grab bars. NFPA has heeded those formal recommendations, indeed going beyond this being only for homes.

Applying Ergonomics to Bathing Safety: Including adoption of unorthodox practices for slip-resistant underfoot surfaces of bathtubs plus showers and provision of effective points of control

Jake L. Pauls[1] and Daniel A. Johnson[2]

[1] Jake Pauls Consulting Services, Toronto, Canada
bldguse@aol.com
[2] Daniel A. Johnson, Inc., Olympia, WA, USA
dajinc1@mac.com

Abstract. Of four key factors in bathing safety, related to fall prevention and mitigation, slip resistance is relatively easily addressed. However, in the field of underfoot slip resistance, water is not typically considered as a "friend." Surprisingly, when applied to an underfoot terry cloth towel, water dramatically improves slip resistance in otherwise slippery dedicated showers and in bathtubs used for standup showers. This is now empirically established but, as it defies convention and occurs in a relative research vacuum, there is reticence about adopting the practice of simply having a wet—*or even better*—damp towel underfoot while entering, using and exiting a shower facility. This paper presents what is known and what remains to be learned about the extent to which—*plus why*—water and terry cloth are a potent slip-resistance combination that, qualitatively, solves one-quarter of the shower safety problem with conventional bathtubs and even more with dedicated showers. Regarding potency, we have learned that thin towels are more effective than thick ones and contaminants such as shampoo appear not to affect slip resistance. Combined with code-required improvements to another factor—*effective points of control through the addition of grab bars or stanchions,*—a new, cost-effective practice can greatly reduce the large injury toll.

Keywords: Bathing Safety, Slipping, Points of Control.

1. Introduction to Epidemiology, Etiology and Economics of the Problem

US injury statistics, including national annual estimates of hospital emergency department (ED) visits, from the US Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) provide a useful picture of the size and nature of the injury problem with bathtubs, bathtub-shower combinations and showers. For example, using US CPSC NEISS data for 2010 (a year for which there are other useful data, noted below), an estimated 263,000 ED visits occurred due

to bathtub and shower-related injuries. Note that NEISS deals separately with injuries associated with hot water scalds. (For convenience, the generic terms “bathing” and “bather” are used in this paper in relation to use of these facilities generally.) Examination of a convenience sample of short narratives available for the over 7,500 documented ED visits, on which such national estimates are based, revealed that falls are a typical mechanism leading to injuries, many of which occurred with bather movement before, during and after bathing when combinations of four key dangers are present:

1. Geometry of the impediments over which one must transfer (e.g., bathtub walls and high sills for dedicated showers)
2. Hard, unforgiving surfaces
3. Insufficient, effective points of control
4. Slippery underfoot surfaces.

Most dangerous are activities entailing transfers, both ambulatory—stepping in and out of a bathtub or dedicated shower—and stand-to-sit plus sit-to-stand transfers when horizontal forces underfoot increase relative to vertical ones.

Indeed, if bathing-related falls are compared to falls occurring on stairs, the exposure time-corrected risk of falls associated with bathing exceeds such risk for stairs. In other words, a single step into or out of a bathtub imposes a higher risk of a misstep and fall than occurs in a person’s typical single step on stair flight—which entails moving ones foot the height of two risers. Each entails traversing about 400 mm vertically on a typical home stair.

Stairs accounted for the largest number of ED-treated injuries associated with consumer products typically found in buildings, according to the US CPSC NEISS data, with most occurring in homes. For 2010 in the US, stairs accounted for an estimated 1,232,000 visits to hospital EDs. Such stairs would likely be used for on the order of 100 steps per day per person, on average, versus on the order of one transfer step per person daily, on average, associated with bathing.

The relative growth of bathing-related falls versus those associated with stairs is also notable. Bath and shower-related injuries in the US grew in the two decades between 1991 and 2010 by a factor of two for those resulting in an ED visit and by a factor of three for those resulting in hospital admission after first going to the ED. For 2010, in the USA, there were about 263,000 ED-treated injuries associated with bathtubs and showers and about one million treated by medical personnel in all settings. Generally for all ages, stair-related injuries grew by about 65 percent over all ages for hospitalized cases between 1991 and 2010. Although outside the scope of this paper, toilet use involves some similar transfer issues to bathing with comparable mitigation measures, namely improving points of control. The vulnerability of older adults and their inability to forego toilet use, contrasted with bathtub and shower use, leads to larger proportions of older person injuries from toilet use. Thus dual use—for both bathing and toileting—of some points of control discussed below, is very important.

Most of the foregoing epidemiological and etiological data come from the author’s own analyses using, , the readily accessible US CPSC NEISS Web site (https://www.cpsc.gov/cgibin/NEISSQuery/ last accessed 2018/05/27) and his own

survey of hotel bathing facilities and bathing experiences during extensive, world-wide travels.

There also are more-formal literature resources. A listing of 50 documents is available directly from the first author; these were examined in the course of preparing a bathroom usability and safety policy statement for the American Public Health Association in 2016.

A smaller set of references was examined in 2015 for a set of proposals to the National Fire Protection Association (NFPA) for new requirements covering all new bathing facilities within the scope of NFPA's model building code, NFPA 5000 and NFPA's *Life Safety Code*, NFPA 101.

US government epidemiological analyses are somewhat more dated than those presented here; e.g., US Centers for Disease Control and Prevention (2011). The best etiological studies are also dated; e.g., Aminzadeh, *et al.,* (2000); Kira (1966); Stone, Blackwell and Burton (1975).

Especially recommended are synopses focused on both epidemiology and economics: e.g., Lawrence, Spicer, Miller (2015); Miller (2016). Miller (2016) provides some of the basic information needed to make the cost-benefit case for improved bathroom safety. In a later presentation, Miller (2017) provides more detail on cost-benefit analysis which was used by Pauls (2017) in a presentation video, focused on home bathroom safety. The economic bottom line of this is a close match in the annual societal cost per household, of bathing and toileting-related fall injuries in the US, and the cost of installing points of control, such as grab bars and, as a cost-effective more versatile innovation, stanchions. The latter, especially, could serve users of both the home bathing and toileting facilities that, in many small bathrooms, are often adjacent (as shown in Fig. 1).

2 Practice Innovations Addressing 3 of the 4 Types of Dangers

2.1 Points of Control to Mitigate Transfers over Impediments

See Fig. 1 for a two-option, demonstration installation in a traditional, small (2.1-meter by 1.5-meter) bathroom with bathtub-shower combination, a toilet and a lavatory (off the right side of the photo).

Unlike the conventional grab bars, wall-to-wall horizontal and tub-to-ceiling vertical stanchions do not require screws into the structure behind the ceiling, tiled walls or tub wall. They are not cantilevered out from walls but are held *between* wall, ceiling and other surfaces including, as in Fig. 1, the bathtub rim. Stanchions are typically seen on buses and trains, especially those used for commuting, and are typically within easy reach of most passengers, whether seated, standing or moving from one position to the other. The innovation here is to use stanchions in bathrooms.

In a typical small bathroom, the stanchion (the vertical one, with its bottom fixing on the bathtub rim, in Fig. 1) serves toilet plus shower and immersion bathing users. Either of options would meet the new NFPA requirements for locations of grab bar for new bathtub-shower combinations.

Fig. 1. Two options, one with stanchions (informally referred to as "poles," usually straight lengths of graspable tubing) and the other employing conventional grab bars providing two points of control.

Although included as an option, as effective as conventional grab bars, stanchions are not required by the new NFPA rules where, in the 2018 edition of two codes, they are referred to as "poles" (NFPA 2018a, b). Stanchion-type bars are a relatively straightforward, cost-effective, NFPA-complying installation on existing bathtub-shower combinations, even in rental apartments. They can be easily installed and removed without wall, ceiling or tub damage as they can be held in place by special (automotive-grade) adhesives rather than screws into walls. The structural criterion applied is performance-based—a load of at least 250 pounds must be sustained through the life of the installation. Similar requirements are currently being processed through two other national model building code organizations in both the US and Canada.

The costs of installing the two points of control (horizontal or diagonal and vertical) are comparable to the average USD280 societal cost of bathing and toileting-related injuries—expressed on an average, per-household basis—over a one-year period. Even a relatively expensive installation cost, say double the USD280 (e.g., for retrofitting conventional grab bars), would still make the cost-benefit very acceptable given the years of service possible with the two points of control.

The foregoing information deals with the points of control involving ones hands although the vertical pole can also provide support at ones back, for example when standing on one leg and drying the other leg with a towel. Feet typically provide

one or two points of control. Table 1 shows options for points of control dealing with gravity and lateral loads. For bathing, we need two or three points of control for comfort and safety; hence the need for proper handholds for transfers.

Table 1. Minimum number of points of control currently provided with typical practices or imposed design rules.

Number of Points of Control	≤1	1	2	3	3-4
Standard walker for older adult					√
Occupational settings with risk of worker falls from heights				√	
Stairs			√		
Bathtubs with slip resistant underfoot surfaces when wet		√			
Bathtubs with slippery underfoot surfaces when wet	√				

2.2 Hard, Unforgiving Surfaces, Including Those of Impediments

The first two of the key dangers listed above are relatively difficult to prevent and, thus, mitigation approaches are needed. These dangers are geometry of the impediments one must traverse by stepping over (e.g., bathtub walls and high sills for shower enclosures) and hard, unforgiving surfaces (e.g., enamel surfaces of rigid tub walls, ceramic tiles on walls and floors, and metal water controls plus spouts). An additional complication affecting step-over of the tub wall is the difference between floor and bathtub bottom elevations; this can be as much as 100 mm. Retrofit cutouts of tub walls are one partial solution and another expensive solution is a purpose-designed, walk-in tub. These pose operational complications and do not entirely eliminate elevation differences and step-over dangers. Hence points of control are still important.

With the best dedicated showers, the step-over danger can be eliminated through design and construction of a water-draining shower pan and attention to confining water spray, including fixed enclosures (e.g., use of safety glass). Such showers offer additional benefits to users requiring a roll-in design. Some hotels have begun retrofit programs, replacing conventional combination shower-bathtubs with walk-in / roll-in showers.

Many newer showers are delivered in one or a few pieces with resilient material for walls (instead of hard tiles) providing some cushioning in case of impact as well as controls and water spouts that would not be contacted so injuriously in a loss of balance or fall. However, even with newer materials, such showers share the danger posed by underfoot surfaces.

Showers require careful attention to underfoot slip resistance that is often inherent in wet conditions, even with certain tiles and surface roughness treatments underfoot. Adequacy of slip resistance should be confirmed, by competent expertise, in design and operation of such facilities. Unfortunately, for conventional bathtubs

with their smooth surfaces, another approach to slip resistance is needed and this is the largest focus of this paper, especially as the recommended intervention is somewhat unorthodox, even heretical to some objecting to a virtually no-cost, simple solution to a complex problem.

3. Provision of Effective Underfoot Slip Resistance

3.1 Recent and Current Safety Standard Situation

Efforts to deal with slippery underfoot surfaces of bathtubs with manufactured surface treatments have not been successful (in the view of many safety professionals). An early effort to specify a minimum slip resistance criterion for new bathtub surfaces has floundered for multiple reasons including (as only several of many problems):

- Highly questionable minimum slip resistance (SR), also called static coefficient of friction (COF) of 0.04 originally specified in a ASTM standard, F462—79 (ASTM 1979) using a NIST-Brungraber portable slip-resistance tester.
- Application only to *new* bathing surfaces, for the duration of the warranty.
- Discontinued production of the single specified tester.
- Withdrawal, without replacement, of ASTM F462.
- The test foot material, used for original testing with the tester to simulate a bare foot, no longer being available.

As recently as early 2017, the situation was confused among bathtub manufacturing representatives and slip resistance experts (at the meeting of ASTM F15.03 committee responsible for safety standards for bathtub and shower structures). It was noted that the original decision on the 0.04 COF or SR threshold for "safe traction" was based on twice the traction from the best tested, untextured (wet) surface—which was also twice the traction of the worst textured surface. The threshold was *not* based on reasonable safety as determined with human subject testing, for example, to determine actually utilized (needed) slip resistance when stepping in and out of a bathtub (as discussed below).

The foregoing points and others, such as the summation that "F462 is only barely better than nothing," were presented within an ASTM's F15.03 Committee on January 31, 2017. One authority on the topic stressed what a replacement for F462 should be based on and how it should be employed to improve bathing safety from slip-related falls.

3.2 Study of Utilized Slip Resistance

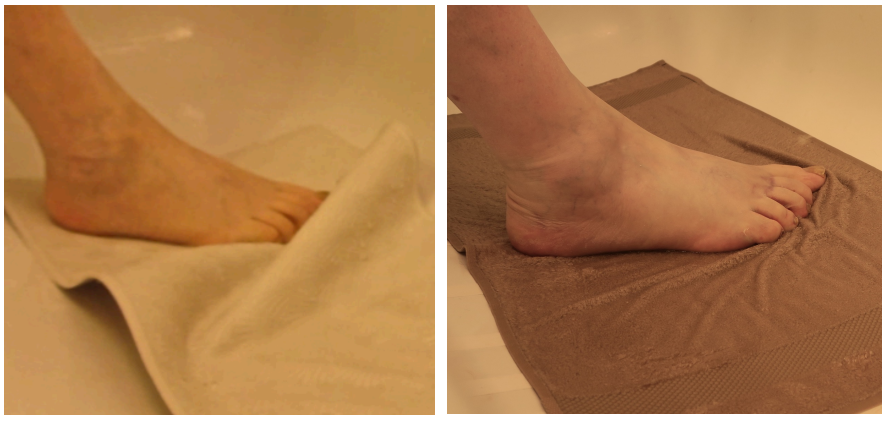
Siegmund, *et al*. (2010) performed a study to "quantify the friction used by barefoot subjects entering and exiting a typical bathtub/shower enclosure under dry and wet conditions." The study involved 60 subjects, equally divided by gender, from three age ranges, younger, middle age and older adults. Force plates with slip-resistant surfaces (with SR of 0.55 to 0.90) provided data to derive utilized friction which was lower, by about 0.06, in wet conditions than in dry conditions. Older subjects used less friction than young subjects (p=0.01 to p=0.001 depending on complexity of the

required movement*)*. The range of utilized friction was 0.102 to 0.442, with a median of 0.23. Between the highest and lowest mean plus/minus one standard deviation, the range of utilized friction was 0.13 to 0.36. Utilized friction was lower, by 0.058 ± 0.04, for wet conditions than for dry conditions. There were differences among age groups only for exiting the bathtub when young subjects used more friction. These results were significant at p =0.001 and 0.006. The only grab bar provided was on the back wall and subjects were instructed to only use it in case of a slip or loss of balance (which did not occur); so, generally, it was not reported as a factor in stepping in and out of the bathtub during the testing.

Selected 'take home messages' from the paper's conclusions (with the following quotes taken out of order): "Overall, these findings suggest that subjects entering and exiting a bathtub adjust their utilized friction based on a perception of surface slipperiness." Referring to the outdated standard (described in the prior section) governing bathtub stipulating a "minimum friction of 0.04" [ASTM, 1979], this is much "less than the friction subjects used here when entering a dry or wet bathtub." The authors also noted "the importance of using mats, textured or etched surfaces to increase the friction of smooth bathtubs."

3.3 Unreliable, Yet Widely Recommended Slip Resistance Interventions

The advice given in the quote above, regarding "mats, textured or etched surfaces" is questionable based on the authors' personal experience with many bathtubs and showers worldwide. Some of the consumer-purchased mats, including those relying on suction cups, are relatively unreliable (compared to wet terry cloth towels addressed in this section), even if installed and used in accordance with product instructions. See Fig. 2.



A **B**

Fig. 2. Failure of (A) properly installed rubber suction cup mat, compared to a (B) wet terry cloth towel, during entry to wet bathtub with smooth enamel surface with relatively similar foot forces exerted.

Unreliability of both bathtub surface treatments and consumer-installed stick-on friction strips or rubber or vinyl mats relying on suction cups has been the expectation of the lead author for many years, buttressed by his many experiences with on the order of a hundred different bathtubs, combination bathtub-showers, and dedicated showers annually in the course of extensive international travel. Moreover, no relationship (except perhaps an inverse one) has been noted between price or opulence of a hotel room and the safety of its bathing facilities. This included one serious, injurious fall, he suffered decades ago, when attempting to get out of a bathtub, in a posh hotel room bathroom.

Only rarely—on the order of a few out of a hundred times—has a sufficiently slip-resistant, underfoot, bathtub surface been encountered in the daily showering experience, most notably with typical bathtub-shower combinations. When wet, etched surfaces and textures (which can be compromised with abrasive cleaners) almost always provide no better perceived slip resistance than does smooth enamel; i.e., with provided slip resistance less than a tenth of what is required for utilization (SR or COF in the 0.1 to 0.44 range) as discussed above in the subsection on utilized slip resistance.

Other solutions to achieving slip resistance, not relying on ineffective industry treatments of underfoot surfaces, were clearly needed (at least in the authors' view).

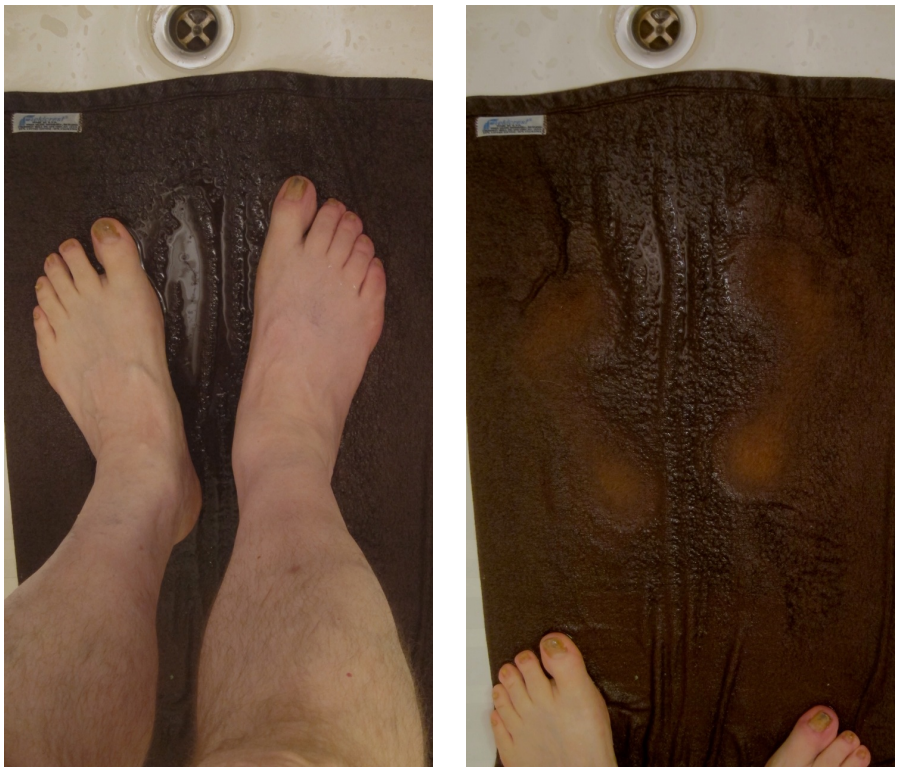
3.4 Underfoot—Dry, Damp and Sopping Wet—Terry Cloth Towels

The idea about use of wet terry cloth towels for bathtub mats likely came to the lead author from the usual hotel room mat for use on the floor outside a shower or bathtub. On smooth ceramic or stone flooring, such mats—often of somewhat thicker terry cloth construction, usually slide easily underfoot except when, if some water was splashed outside the tub or shower, the mat was thrown or placed on top of the wet floor. Result: the terry cloth mat no longer slid on the smooth floor. As soon as ones weight began to be applied to the mat, it stayed in place, *very reliably!* The water film under the mat had an adhesion effect. Soon the practice moved to insuring that there was some water on the floor before such a mat was set in place.

The full *Eureka* moment came when a standard hand-size, terry cloth towel was thrown into the wet, smooth enamel-finish bathtub being used for a shower. It was easy to position and smooth out the sopping wet towel with a light touch from one foot. As soon as (half) body weight was applied underfoot, there was no movement of the towel under wet conditions even when a horizontal force was exerted at about a 60-degree angle of one leg and the underfoot surface.

Experimenting with combinations of horizontal and vertical forces with one foot revealed what happens in the fraction of a second when the bare foot compresses the terry cloth towel. This expels excess water from underneath the ball and heel of the foot (as shown in Fig. 3B) so that the foot moves horizontally 1 to 3 cm before locking in place with no slipping between foot and towel as well as between towel and smooth bathtub surface. A similar effect is shown in Fig. 4 where the vertical force from the bather's body weight is applied to a curved portion of the bathtub so

that there are both tangential and normal forces on the surface which varies in slope, underfoot, from 5 to 45 degrees from horizontal (equivlent, as the angle tangent, to SR of 0.09 to 1.0).



A B

Fig. 3 Sequential views of (A) feet compressing the sopping wet terry cloth towel and (B) immediately after the feet are repositioned, the compressed towel—while briefly only damp—has visible impressions of the feet.

Testing with Variably-inclined Surfaces. Subsequent, systematic testing of wet towels on a polished glass ramp surface of variable inclination confirmed that the wet towel, underfoot, is stable to nearly a 30-degree inclination. (See Fig. 5) At such high slopes the towel moves slowly, in a creep fashion (at about one cm per second), not precipitously. Note, unlike in the European Ramp Test (discussed by Di Pilla, 2003), subjects here do not walk on the sloping surfaces; they stand in place. Effective SR up to about 0.5 can be tested with the adjustable slope available to the lead author.

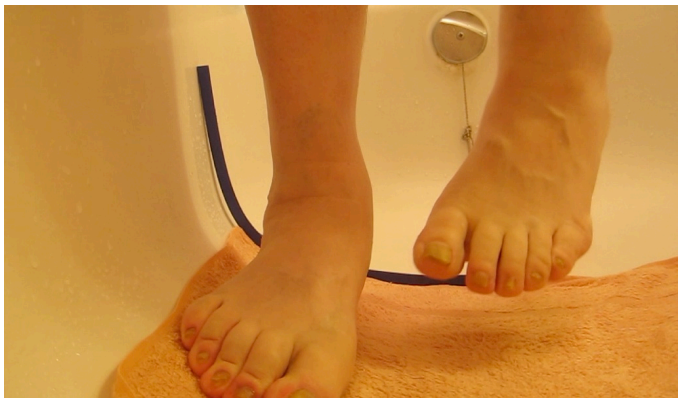


Fig. 4. Foot carrying all of bather's weight on the curved portion of the bathtub, where the slope ranges from 5 to 45 degrees with a damp terry cloth towel interface. Note that the towel has only shifted less than a centimeter.

Fig. 5. 27.5-degree (tan 0.52) slope glass ramp surface with damp terry cloth towel showing slow creep just beginning.

Further testing, with an adjustable glass surface, as well as a polished surface comparable with plastic tub construction, is contemplated to provide more quantitative data, with multiple subjects, and to video record (in high-definition) the underside of the clear glass ramp to understand better the mechanism based on intimate interface of smooth glass, a film of water and the compressed, highly fibrous towel under bare foot pressure. But first, it is important to describe findings by the second author to complement the first author's empirical findings reported here.

Testing Slip Resistance of Terry Cloth Towels with a Tribometer. The second author of this paper, who is certified in the use of a tribometer (the Variable Incident Tribometer, VIT) has, independently been testing comparable terry cloth towel sam-

ples with a smooth granite surface as well as a calibrated test tile of known slip resistance (SR) comparable to what a glazed enamel tub provides under dry, damp and sopping wet conditions. As demonstrated in the following findings, these standard measurements corroborate what has been found in field settings with actual bathtub and shower surfaces and standard, hotel-supplied terry cloth towels (that are similar to towels used very widely in other residential settings, among others). The tribometer studies also considered the effect, to slip resistance, of various thicknesses, measured as weight per unit area, of terry cloth towels in addition to fiber composition, which is typically cotton but could include other materials such as bamboo and some synthetics.

One relatively early tribometer consisted of a weighted object being pulled across a dry, flat, horizontal surface. Slip resistance (SR) was simply the ratio of the horizontal force needed to start the object in motion divided by the weight of the object. But if there is moisture between the weight and the surface, then adhesion, called "stiction", can cause erroneous readings so that this method does not give valid readings (English, 1996). Stiction appears to result when there is some residence time after the weight is placed on the surface and the horizontal force is applied.

Variable Incident Tribometer. An alternate method is to determine the tangent of the angle at which a force is applied to an object to just start the object sliding over the surface. If, for example, the object starts to slide when a force is applied at an angle of 26.6°, the slip resistance = tan 26.6° = 0.5 (Templer, 1992). If the force is applied to a wet surface in such a manner so that no stiction is allowed to form, the readings of slip resistance are consistent with human experience (English, 1996).

The English XL, commonly referred to as the Variable Incident Tribometer (VIT) (see Excel Tribometers), overcomes this problem and was used in subsequent tests reported below.

Slip Resistance Criteria. Slip resistance of a walkway can range from a theoretical zero up to and sometimes greater than 1.0. A slip resistant surface for those who do not expect to be walking on a slippery surface is generally considered to be one that provides a slip resistance of 0.5 or higher (Ekkebus and Killey, 1973; Sacher, 1993; Nemire et al., 2016). But one can walk without falling on a surface with a somewhat lower slip resistance, especially if one knows or expects the surface to be slippery.

Most dry surfaces provide adequate slip resistance while some of those same surfaces are dangerously slippery when wet (Templer, 1992).

Initial Test of Concept with Smooth Granite Surface. A smooth granite counter top was initially tested both in a dry and wet condition, and with and without a towel between the VIT test foot and the granite. A VIT, recently calibrated by the manufacturer, was used for all tests.

Not surprisingly the wet granite exhibited a low SR (0.188) compared to the dry granite (SR = 0.864). The difference was highly significant (t test, $p<.01$). This result is consistent with reports that smooth hard surfaces, such as granite and marble, when wet, are slippery and associated with falls (e.g., Di Pilla, 2003, p.128).

The corner of a thin towel was inserted between the VIT foot and the granite. When a slip occurred, it was noted that the towel slipped on the granite rather than the test foot slipping on the surface of the towel. Distilled water was applied to the surface of the granite, or the top of the towel. The SR of the towel on the granite under dry and wet conditions is recorded in Table 2.

Table 2. Effect of towel, wet or dry, on slip resistance of smooth granite counter top

Surfaces	**No Towel**	**No Towel**	**With Towel**	**With Towel**
Condition	**Dry**	**Wet**	**Dry**	**Wet**
	0.86	0.2	0.2	0.35
	0.86	0.16	0.24	0.41
	0.9	0.18	0.25	0.41
	0.85	0.21	0.26	0.4
	0.85			0.41
				0.4
Means	**0.864**	**0.188**	**0.238**	**0.387**

The difference between the towel on the dry granite vs towel on the wet granite was highly significant: t test: p=8.13 E-.06. The difference between the Wet condition, with and without towel, was also highly significant: t test: p=6.12 E-.07. The relatively higher SR on the wet vs the dry surface confirmed what Pauls had demonstrated; the foot did not readily slide when it was on a wet towel on a smooth hard surface.

SR Testing on a Calibrated Test Tile. Further testing on towel density as well as when there were likely contaminates was conducted. A recently calibrated Certified Test Foot Calibration Tile from (Excel Tribometers, Tile #219) was used as a base upon which a portion of each towel was placed during testing. When tested wet without any towel the tile exhibited a SR of 0.188, a value within the range of 0.17 (+/- 0.03) that was consistent with the range reported by Excel Tribometers for that calibrated tile.

With Soap and Shampoo Contaminants. Though expecting some effect on SR when the towels were contaminated with soap and shampoo, it was found that there was no significant effect on SR when testing towels that had been placed on a tub surface following bathing and the bather used either soap (Ivory® hand soap) or hair shampoo (Suave®). The testing was not done in that shower but, instead, on the calibrated test tile.

Towel Thickness. According to the Turkish Towel Company (2016) plushness is associated with its density, its weight and size. A towel's grams per square meter (GSM, or g/m^2) represents how many grams the dry towel weighs per square meter:

> "The higher the grams per square meter (GSM), the denser the fibers of the towel are, making it softer and more absorbent. A GSM between 300 and 400 makes for a thinner towel, whereas a GSM of 450 to 600 is plush. A GSM of 700 or higher is considered luxury hotel quality." (Turkish Towel Company, 2016)

The granite counter top was then tested with a thin hand towel (GSM = 406 g/m^2). SR with the dry towel (0.238) was relatively slippery but when distilled water was applied to the towel a SR of (0.397) was recorded. The difference was highly significant (t test, $p<.01$). It was decided to evaluate the concept using towels with characteristics, similar to those found in hotels and other commercial establishments, and to study any effect that contaminants (i.e., soap or shampoo) or how the use of thicker towels might affect the results.

Two towels of similar size (~ 410 mm by 460 mm) were measured with a tape measure and weighed on a digital scale so that the plushness of each towel could be calculated. Both towels had a GSM > 600 and so are considered "plush".

The SR of both towels on the certified test tile was ascertained under dry**,** damp and sopping wet conditions. The "damp" condition occurred when distilled water was applied to the towel but the water did not appear to pool above the base of the threads. The "sopping wet" condition was when the water was visible above the base of the fibers at the start of the test (see Table 3).

Table 3. Slip Resistance of Thin vs Plush Towels When Dry, Damp, and Sopping Wet on Test Tile

	A	**B**	**C**	**D**	**E**	**F**
GSM	643	683	643	683	643	683
Conditions	Dry	Dry	Damp	Damp	Sopping	Sopping
Thickness	Thin	Thick	Thin	Thick	Thin	Thick
	0.18	0.21	0.36	0.28	0.27	0.21
	0.17	0.2	0.33	0.26	0.26	0.23
	0.17	0.2	0.32	0.28	0.28	0.24
	0.19	0.19	0.31	0.31	0.29	0.24
				0.34		
				0.31		
Means	**0.1775**	**0.200**	**0.33**	**0.297**	**0.275**	**0.23**

Significance:

A vs B Thin vs Thick - Dry: significant i.e., $p<.05$ (t test, $p = 0.0117$)

C vs D Thin vs Thick - Damp: not significant (t test, $p = 0.085$)

E vs F Thin vs Thick - Sopping: significant (t test, $p = 0.003$)

Dry vs Wet Towels Data pooled: Thin vs Thick (Damp & Sopping Pooled)

C+D vs E+F not significant (t test, $p = 0.092$)

Wet vs Dry highly significant (t test $p <<.001$)

Tests in Porcelain Tub. Damp and sopping wet towels did not exhibit a statistically significant difference ($p=0.26$) when tested in a nine-year-old bath tub that had been used almost daily. When data were pooled the damp and sopping wet towels had a higher SR (Mean = 0.296) than the wet tub with no towel underfoot (SR mean = 0.24). The difference was statistically significant ($p < 0.004$). The 95% Confidence Interval for the porcelain tub with a wet towel (damp or sopping wet); $SR = 0.26<0.3<0.34$.

4. Conclusions

Generally, the practice of using ordinary terry cloth towels to solve one of the main problems with bathing safety, along with installation of effective points of control—for example, using stanchions that integrate well with bathroom décor at low cost—should make bathing a less dangerous activity, at modest cost and low installation complexity in both new bathrooms and existing ones.

One bottom line is somewhat unorthodox, even heretical. Whereas in much of the work on slip resistance, water is considered an "enemy, it turns out that for slip resistance of smooth, wet surfaces typically found underfoot in a bathtub or shower, the combination of ordinary terry cloth towels and water is your "friend." Towels are ubiquitous and readily available in bathrooms in most homes and hotels. If people were advised to place damp towels on the floor of tubs and showers, as well as on the floor outside of the tub in a location where they would expect to be stepping when entering or exiting the tub, the probability of slips and related missteps could be greatly reduced.

Solutions to the slipping and other problems for bathing—especially showering—can be elegant, counterintuitive, inexpensive and immediately at hand (or should we say also "at foot") in every bathroom. Such solutions are addressed in freely accessible videos and, increasingly, those requiring structurally adequate installation of points of control are being enshrined in North American safety standards and building codes. Thus improved bathing safety could be a success story in applying ergonomics to heretofore inadequately addressed public health problems.

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Approximately 50 internationally-produced scientific and technical references, on bathing/showering safety, were compiled by the proponent, in 2016, for an American Public Health Association (APHA) draft policy highlighting, especially two Canadian research studies that also are addressed in video presentations by Principal Investigators (Dr. Nancy Edwards, Dr. Alison Novak) for the research and posted, for free streaming viewing at, https://vimeo.com/164239941 Accessed January 8, 2018. Additional videos covering technical aspects of bathing and showering safety (including cost impact and benefit issues*) are found at the following links (all of which are available, with descriptions, at www.bldguse.com, the proponent's Professional Practice Website, Accessed January 8, 2018.).

- https://vimeo.com/237294479
- https://vimeo.com/239276202 *
- https://vimeo.com/197742277
- https://vimeo.com/193507768
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