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Injury Rates During Water-Based Wilderness Recreation

G. Dean Witman

This study came about after the author approached several people in the wilderness-recreation field about their risk-management practices, especially those related to training people who lead trips involving water exposure. The author was surprised that no widely accepted standards exist for training trip leaders or for the skills they need to deal with cases of water emergency. Some people even speculated that injury rates would increase if more water-safety training were conducted because injury rates during land-based activities were assumed to be greater. Although it was outside the scope of this effort to test all current opinions about wilderness water safety held by every practitioner in the field, the author hopes that this study will initiate more conversation about a topic that has not gotten much attention. The purpose of the study was to compare injury rates between water-based wilderness recreation and other backcountry activities and investigate whether more needs to be done to reduce the probability of injury during water-related backcountry activities.

Key Words: aquatic risk management, drowning, near drowning, lifeguarding, lifesaving, rescue and safety equipment, water-safety instruction

In a very basic sense, it is important for risk managers to understand the circumstances under which injuries occur during wilderness recreation so they can intelligently decide what resources contribute to higher levels of safety for participants. Research that helps professionals in the field determine which activities have higher rates of injury might also facilitate the formulation of prevention strategies, guide the training of trip leaders, assist in the selection of rescue equipment and first-aid supplies, and create more awareness of risk factors among participants in wilderness recreation. Although it might be impossible to design interventions that would be effective for every group entering the backcountry—for example, supervised versus unsupervised groups—fostering a dialog about the evidence is worthwhile to the extent that it points us in the direction of these solutions.

Review of the Literature

To date, little research has focused on aquatic injuries in a wilderness context. Numerous studies in the medical field (pediatrics, emergency medicine) have

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sought to establish the relationship between various demographic, behavioral, and environmental circumstances and submersion injuries.

Some studies have drawn distinctions between the risks associated with ponds, lakes, and rivers as opposed to swimming pools, bathtubs, or buckets (Brenner, Trumble, Smith, Kessler, & Overpeck, 2001; Quan, Gore, Wentz, Allen, & Novack, 1989) and the greater likelihood of injury in relatively uncontrolled aquatic settings. One British study made note that "a focus on the supervision of activities with schoolchildren" had a significant impact on "the reduction in river, lake, and canal drownings" over a 10-year period, 1988–89 through 1998–99 (Sibert et al., 2002, p. 1071). An Australian study looked at patterns of drowning and near drowning by location of residence and found that "people from remote regions were at higher risk of drowning and near-drowning" (New South Wales Injury Risk Management Center, 2000, p. 15). The pattern of rural versus urban differences was also recognized by a study in the Republic of Ireland that looked at mortality and hospital admission rates (Boland, Staines, Fitzpatrick, & Scallan, 2005). As the Australian study concluded, however,

> Without information on the location of the drowning episode it is not possible to determine whether this finding reflects increased risk of exposure to water-related hazards when they occur in remote areas or a lack of experience in dealing with water-related hazards by people from remote regions. (p. 15)

The New South Wales Injury Risk Management Center researchers suggested that further work is needed to clarify this issue and others raised by the research.

One study published in the *Annals of Emergency Medicine* (Newman, Diekema, Shubkin, Klein, & Quan, 1998) indicated that drowning accounted for most (55%) of the deaths of children participating in wilderness recreation. Although the scope of that research, confined to five counties in western Washington from 1987 to 1996, was fairly limited, the study indicated that water-based activities (swimming, river rafting, boating) do represent significant hazards to children between 12 months and 20 years of age who are engaged in recreation in a remote setting. A 13-year study in Pima County, AZ (Goodman, Iserson, & Strich, 2001), a region in which only 0.01% (1.1 of 9,241 square miles) is covered by water, pointed out that most of the deaths caused by unintentional trauma occurring in this wilderness setting were either drownings (31%) or falls into water resulting in drowning or fatal blunt trauma (25%). In this case, wilderness was defined as "a location remote enough so that standard ground-based emergency medical services units could not extract the body" (Goodman, p. 148).

Another study conducted over a 3-year period based on the case incident-report files from eight national parks in California found drowning to be the second most common cause of death among park visitors (12 of 78 fatalities, or 15.4%), with only one fewer incident than heart disease, at 16.7% (Montalvo, Wingard, Bracker, & Davidson, 1998). A similar study involving recreation in Washington State national parks, done by some of the same researchers as in Newman et al. (1998; Diekema and Klein were researchers in both studies) but with different research parameters, found that other causes of death—for example, falls, medical issues (heart disease)—occurred with greater frequency than drowning (5%), which happened at the same rate as suicide (Stephens, Diekema, & Klein, 2005). This low incidence of drowning might be because water-related activity (swimming and beach play) was the preinjury activity in only 3% of the cases, whereas hiking (55%), winter sports (15%), mountaineering (12%), and camping (6%) were much more common.

The main conclusion one can draw from this review is that a number of researchers, with diverse perspectives and a variety of methods, have generally found that there is a high risk of injury when water exposure occurs in a remote setting. This study provides an approach to demonstrating whether this is the case in the specific context of wilderness recreation.

Methods

This study retrospectively reviewed incident data reported by the Wilderness Risk Managers Committee (WRMC) for 1989–2000 as published in the 2004 Wilderness Risk Management conference proceedings. Because this study was based on historical-data analysis, the precision and accuracy of the incident data reported could not be verified.[1] The study established whether the relationship between injury rates (and near misses[2]) for water-based activities and other backcountry activities was significant at a selected confidence interval.

This study tested two hypotheses regarding injury rates for participants in wilderness recreation and recommends that action be taken, including additional investigation, to reduce the probability of injury during water-related activities. Rejecting the null hypothesis in either of the cases studied here would indicate that water-based wilderness recreation activities have higher injury rates than other backcountry activities.

Hypothesis 1. The injury rate for water-based activities is higher than for other backcountry activities

Hypothesis 2. The rate of near misses for water-based activities is higher than for other backcountry activities

The study also attempted to compare an estimate of WRMC drowning deaths per participation day with 2002–2006 United States Lifesaving Association (USLA) statistics for drowning deaths per visit to guarded beaches using two different methods. One method attempted to estimate a WRMC drowning-death rate by using a widely accepted relationship between drowning and near drowning.[3] The other method assumed that a drowning death had occurred and that WRMC data would be used retrospectively to determine whether the death could have been predicted. This would have provided an indication of the extent to which legal liability could be established.

This part of the study highlighted some of the difficulties of retrospectively comparing across incident-reporting databases. In order to compare WRMC with USLA incident data, several assumptions, such as that a participation day as defined by WRMC (see Table 1)[4] is substantially the same as a visit to a guarded beach as defined by USLA,[5] would have had to be made. After considering the obvious drawbacks of this approach, I decided to exclude this analysis from the study. Nonetheless, other researchers might able to develop a method of comparing incident data for wilderness recreation with larger data sets with more widely accepted injury-rate benchmarks.

Table 1 Profile of Total Activity Hours

Activity	1989–1990 total hr	1991–1997 total hr	1998–2000 hr	1998–2000 participation days
Camping (general)	2,576,434	1,358,303	6,647,371	276,974
Climbing (rock, ice, and rappelling)	164,380	45,241	979,041	40,793
Backpacking	641,498	159,791	616,341	25,681
Canoe (flat water)	75,347	124,656	197,324	8,222
Mountaineering	5,120	1,320	76,284	3,179
Solo	0	56,208	73,819	3,076
Hiking (day, orienteering)	53,918	7,982	72,327	3,014
Work projects	47,613	47,229	70,363	2,932
Skiing (touring)	91,993	3,242	68,129	2,839
Kayaking (white water and sea)	37,103	18,496	54,521	2,272
Canoeing (white water)	18,286	11,204	33,833	1,410
Horseback riding	0	0	28,762	1,198
Rafting	17,333	27,872	20,919	872
Sailing	23,765	16,800	14,136	589
Biking (mountain)	14,767	750	10,970	457
Snowshoeing	1,528	0	10,852	452
Water (swim, wade, snorkel)	89,977	6,361	9,853	411
Winter camping	0	2,760	6,840	285
Biking (touring)	29,623	2,160	2,201	92
Marathon	0	1,440	1,260	53
Cave	9,873	54	924	39
Boating (power, row)	144,358	0		
Skiing (downhill/telemark)	76,826	772		
Scuba	1,920	0		
Total backcountry	**4,121,662**	**1,892,641**	**8,986,083**	**374,837**
Climbing (walls)	—	—	7,794	974
Initiatives team challenges	1,715,821	73,518	1,220,880	152,610
Ropes course (high and low element)	314,604	72,032	668,234	83,529
Transportation (to activity)	98,897	43,249	894,945	37,289
Sports and recreational games	104,992	5,1010	19,900	2,488
Total nonbackcountry	**2,234,314**	**193,900**	**2,811,753**	**276,890**
Combined total	**6,355,976**	**2,086,541**	**11,807,836**	**651,727**

Because the events being studied (injuries and near misses) are fairly rare and recorded as a function of time instead of the number of outcomes, the study approximated the rate of occurrence by a Poisson distribution. It used commercially available statistical software, SPC XL 2000, for all calculations and the following five-step procedure for hypothesis testing:

Step 1: State the hypotheses to be tested:

H_0: $\lambda \leq$ expected number of occurrences within the specified period.

H_1: $\lambda >$ expected number of occurrences within the specified period.

Step 2: Determine a planning value for α (.05 in all cases).[6]

Step 3: Compute $\lambda = p$ (number of occurrences in the population/specified period for the population) $\times$ n (specified period for the sample).

Compute the standardized test statistic, z, using x = number of occurrences observed in the sample.

Step 4: Compute the one-sided p value.

Step 5: If $p \geq \alpha$, then fail to reject H_0.

If $p < \alpha$, then reject H_0 with $(1 - p)100\%$ confidence in H_1.

This investigation also determined which water-related activities have the highest injury rates. It would be interesting to determine what injury profiles and contributory factors are the most prevalent in these cases, but such research was beyond the scope of the current effort. An example of a contributory factor that was not examined but that might warrant additional research is the impact of supervision and the training level of supervising staff members. Although injury profiles within the scope of the study varied (e.g., sprains and strains, soft-tissue damage, near drowning), it was impossible from the way the data were presented to associate injury profiles with specific activities, water based or otherwise.

Results

The data from the WRMC incident-reporting database showed that 277 injuries (see Table 2) occurred during a total of 10,878,724 participation hours, 1991–2000. Seventy-one injuries occurred during water-based activities, compared with 206 for other backcountry activities. The injuries associated with water-based activities occurred during a total of 535,975 participation hours, compared with 10,342,749 hours for other backcountry activities. Fifty-eight near misses (see Table 3) were recorded during 8,986,083 participation hours, 1998–2000. Three activity categories as defined by WRMC, flat-water canoeing, white-water/sea kayaking, and water (swimming, wading, snorkeling), accounted for 92% of all injuries during water-based activities (65 of 71 injuries; see Figure 1).

Hypothesis 1

Hypothesis 1 was that the injury rate for water-based activities would be higher than for other backcountry activities.

The 206 injuries that occurred during other backcountry activities were divided by 10,342,749 participation hours for these activities and then multiplied by the

Table 2 Injuries and Injury Rates by Activity

	1991–1997 Injuries		1998–2000 Injuries	
Activity	***n***	**Rate**	***n***	**Rate**
Backpacking	29	4.36	39	1.52
Camping (general)	32	0.57	33	0.12
Canoe (flat water)	16	3.08	28	3.41
Hiking (day, orienteering)	10	30.07	10	3.32
Biking (mountain)	2	64.00	10	21.87
Kayaking (white water and sea)	4	5.19	8	3.52
Climbing (rock, ice, and rappelling)	7	3.71	7	0.17
Skiing (touring)	3	22.21	7	2.47
Horseback riding	0	—	5	4.17
Water (swim, wade, snorkel)	6	22.64	3	7.31
Solo	0	0.00	1	0.33
Work projects	0	0.00	1	0.34
Winter camping	1	8.70	1	3.51
Biking (touring)	3	33.33	0	10.90
Mountaineering	1	18.18	0	0.00
Canoeing (white water)	1	2.14	0	0.00
Rafting	2	1.72	0	0.00
Sailing	1	1.43	0	0.00
Snowshoeing	0	—	0	0.00
Marathon	1	16.67	0	0.00
Cave	2	888.89	0	0.00
Boating (power, row)	2	0.00	0	0.00
Skiing (downhill/telemark)	0	—	0	0.00
Total backcountry	**123**	**1.56**	**154**	**0.41**
Sports and recreational games	17	79.98	18	7.24
Initiatives team challenges	10	3.26	16	0.10
Ropes course (high and low element)	8	2.67	8	0.10
Transportation (to activity)	2	1.11	6	0.16
Climbing (walls)	—	—	1	1.03
Miscellaneous	22	—	0	—
Total nonbackcountry	**59**	**7.30**	**49**	**0.18**
Combined total	**182**	**2.09**	**203**	**0.31**

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Table 3 Backcountry Near-Miss Profile

Activity	Wilderness Risk Managers Committee, 1998–2000
Canoe (flat water)	15
Canoeing (white water)	11
Camping (general)	8
Climbing (rock, ice, and rappelling)	5
Backpacking	4
River crossing	3
Hiking (day, orienteering)	2
Solo/independent student	2
Water (swim, wade, snorkel)	2
Kayaking (sea)	1
Kayaking (white water)	1
Mountaineering	1
Snowshoeing	1
Rafting	1
Total	**58**

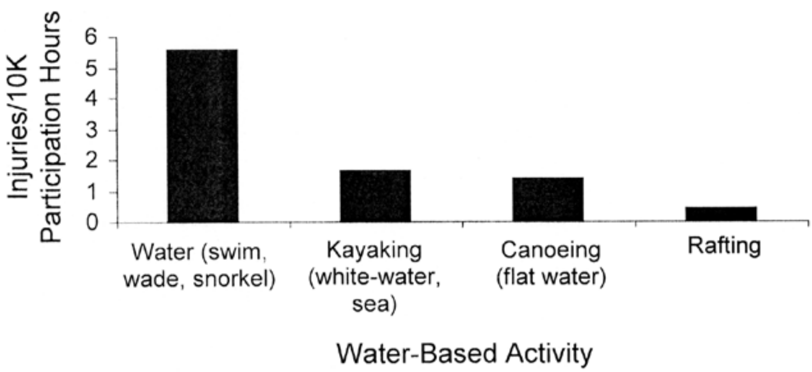

Figure 1 — Wilderness Risk Managers Committee injury rates by water-based activity.

sample size of 535,975 participation hours. This calculation yields the expected number of injuries within the amount of participation hours associated with water-based activities. This expected value was then compared with the observed number of 71 injuries for water-based activities. A value for p was then computed and a decision made to reject or fail to reject the null hypothesis.

The value of p was so small that the statistical software used computed it as zero, signifying a p value of less than .00001 (Table 4). In other words, there was

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an imperceptibly small likelihood that the observed value of 71 or more injuries during water-based activities occurred by chance.

Hypothesis 2

Hypothesis 2 was that the rate of near misses for water-based activities would be higher than for other backcountry activities.

In this case, the 24 near misses that occurred during other backcountry activities were divided by 8,655,497 participation hours for these activities and then multiplied by the sample size of 330,586 participation hours. This calculation yields the expected number of injuries within the amount of participation hours associated with water-based activities. This expected value was then compared with the observed number of 34 near misses for water-based activities. A value for p was then computed and a decision made to reject or fail to reject the null hypothesis.

Again, the value of p was so small that the statistical software used computed it as zero, that is, $p < .00001$ (Table 5). Again, this means that, based on the rate of near misses for non-water-based backcountry activities, the probability of having 34 or more near misses happen by chance was imperceptibly small.

Table 4 Poisson-Distribution Hypothesis Testing, Hypothesis 1: Injuries

User-defined parameters	
M (lambda)	10.6751938
number of occurrences	71
Probabilities	
$p(x = 71)$	0
$p(x < 71)$	1
$p(x \leq 71)$	1
$p(x > 71)$	0
$p(x \geq 71)$	0

Table 5 Poisson-Distribution Hypothesis Testing, Hypothesis 2: Near Misses

User-defined parameters	
M (lambda)	0.916650309
number of occurrences	34
Probabilities	
$p(x = 34)$	0
$p(x < 34)$	1
$p(x \leq 34)$	1
$p(x > 34)$	0
$p(x \geq 34)$	0

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Discussion

In the case of Hypothesis 1 (injuries), the null hypothesis (H_0) was rejected with a high degree of confidence. Our confidence in the alternative hypothesis (H_1) is therefore greater than 95% as computed by $(1 - p)100\%$. This means that the testing of this hypothesis suggested that water-based activities have a higher actual injury rates than other activities. As such, water-based activities might require more carefully developed injury-prevention strategies.

In the case of Hypothesis 2 (near misses), the null hypothesis (H_0) was also rejected with a high degree of confidence. Our confidence in the alternative hypothesis (H_2) is therefore greater than 95% as computed by $(1 - p)100\%$. Although near-miss rates are challenging to quantify and might be reported with proportionately greater (or lesser) frequency than other activities, near-miss data supported the results found for actual injuries.

The attempts to compare WRMC incident data for water-based activities with the USLA fatality rates suggested that, based on a rough calculation, WRMC fatality rates would be higher than those at guarded beaches, further indicating the need for more effective interventions.

In general, this research indicated that more effective strategies need to be developed so that injuries occurring during exposure to water in remote environments can be prevented. It might also suggest the need for more conservative approaches to water-based activities than for others.

Among the interventions to be considered by practitioners, and backed up by future research, is the training of trip leaders in water safety and rescue. The impact of education on participants' awareness of hazards should also be investigated. Policies should be considered for, and evidence-based methods used to evaluate the effectiveness of, assessing participants' ability to avoid incidents during water-based activities (for example, verifying swimming skills) and providing remedial training where appropriate. Similar research should be undertaken to guide the selection of equipment for performing a water rescue in a backcountry setting and the use of improvised techniques.

I decided that investigating the injury profiles and contributory factors associated with incidents occurring during water-based wilderness recreation was beyond the scope of this study. Nevertheless, it would be valuable to know whether the injuries incurred were sprains and strains or head trauma. It is also important to understand what demographic, behavioral, environmental, and other factors were present when an incident occurred. More research is needed so that risk managers can provide a better standard of care for participants in wilderness recreation.

It should also be mentioned that Leemon (2004) reported on injuries, illnesses, and near misses but not on fatalities. The WRMC incident-report form calls for type of injury to be reported, including choices for fatality in addition to injury, illness, and near miss.

Because in general terms the 1-year odds of dying from an accidental drowning and submersion injury are 3 times greater than exposure to forces of nature (natural heat or cold, lightning, etc.; National Safety Council, 2006), and fatalities have actually occurred from time to time during water-based backcountry programs (King, 1979), the WRMC incident-reporting database should definitely be used to investigate fatalities.

The difficulties of retrospectively making comparisons across incident-reporting databases indicate that there might be a need for a national or international surveillance system that defines the circumstances surrounding an incident resulting in an injury well enough to enable the development of effective prevention, rescue, and treatment methods.

Finally, this study was conducted in a manner that would allow the research to be repeated and the results to be reproduced—no steps were taken to validate the data. Based on these considerations, additional research using a similar approach, as well as studies using alternative data sets and research methods, is warranted.

Conclusion

The results of this study suggest that more resources should be devoted to mitigating the risks associated with water-based wilderness recreational activity. Although it was beyond the scope of this study to evaluate the effectiveness of specific interventions, I recommend that future research be conducted to scientifically investigate the benefits of risk-management practices currently in use or available. These investigations would foster more discussion of the evidence surrounding injuries during these activities and provide for more targeted solutions than the traditional trial-and-error approach.

Evidence-based methods could be used to explore the merits of the following prospective interventions:

- The extent to which training trip leaders in water-safety skills enables them to better safeguard the people they lead
- Whether creating awareness among participants of the risk factors reduces the rate of injury
- The impact that assessing and improving the ability of participants to avoid an incident has on injury rates
- The extent to which developing improvised techniques for performing a swimming rescue would reduce the risk of injury

Endnotes

1. According to Leemon (2004), WRMC incident reports are submitted voluntarily or as a condition of Association for Experiential Education (AEE) accreditation by 20 different organizations that carry out organized trips into backcountry settings. Contributing organizations are asked to submit reports in accordance with reporting criteria established by WRMC, including the use of WRMC-designed report forms. The forms are submitted to the AEE and kept on commercially available database software, FileMaker Pro, by Drew Leemon, chairman of the WRMC and risk-management director for the National Outdoor Leadership School. The methodology cited in Leemon (2004) also indicates that some organizations collect participation in the form of participation days and that some conversion of the units of measure is reflected in the published data.

2. Leemon defines a near miss as a "potentially dangerous situation where safety was compromised but did not result in injury. Like an accident, it is an unplanned and unforeseen event" (2004, p. 117).

3. Safe Kids Worldwide (www.usa.safekids.org) reported that within a specified period 2,700 children were treated for near drowning for every 859 children who died as a result of unintentional drowning.

4. WRMC asks data contributors to account for the specific activities occurring in 1 day of participation. Some contributors view all activities together as 1 day of participation. In converting hours to days, some data are probably counted twice, which might result in inaccuracy.

5. Beach attendance as defined by USLA is normally people recreating in the water or on the sand and at adjacent picnic areas, parking lots, recreation concessions, and bike paths. It does not include people who merely transit on bikes or in cars. It is an estimate by lifeguards on duty. A drowning death in a guarded area is one that occurs under the protection of lifeguards, as determined by the lifeguard provider, or within the designated swimming area.

6. I set α at a minimum level and selected .05 because it is most commonly used in academia, the social sciences, and business. For hospital tests and other areas of testing, other values (.001, .01) are more common.

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