Injuries in West Virginia Commercial Whitewater Rafting (2011-2016)

Prepared for:

The West Virginia Division of Natural Resources
on behalf of the West Virginia Whitewater Commission

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EXECUTIVE SUMMARY

A total of 203 individuals (including 201 guests and 2 guides) were injured while rafting on rivers led by professional guides in the state of West Virginia for the six-year period 2011-2016. Over one-half (56.16%) of the injured were males. The injured were aged 10 to 72 years old with an average of 36.45 years. A large majority (65.50%) of the injured individuals had rafted at least once on rivers in the state or elsewhere.

Almost one-half (92 guests, 45.77%) of the injured occurred with ACE, followed by Adventures on the Gorge (43 guests, 21.39%). The overall incidence rate for the 15 licensed outfitters is 0.248 during the six-year period, ranging from the lowest of 0.059 for River Riders to the highest of 6.25 for WVU Outdoor Recreation Center, although this included only one injury out of 160 participants. Three fatalities, two females and one male, occurred on the Upper Gauley and the Lower New River during this time period. This translates to 0.00358 death per 1,000 users.

Nearly one-half (49.25%) of the injured occurred on the Lower New River, followed by the Upper Gauley (26.87%), while no injuries were reported on the Tygart River. A majority of injuries occurred at rapids with higher levels of river difficulty (57.72%, Class IV and V combined). A large number of incidents occurred at *Pillow Rock* (V) (20 injured guests, 9.95%), followed by *Jump Rock* (III) and *Lower Railroad* (III), each with 13 injured individuals.

Musculoskeletal injuries (sprains/strains, dislocations, and fractures) accounted for 51.30% of all injuries, followed by injuries to soft tissue (contusions, lacerations/punctures, and abrasions) (32.61%). Anatomically, knees, shoulders, and ankles were among the top three body parts that received most injuries, together accounting for 36.21%.

Injuries were more likely to occur in the water or on the raft than on shore. Fractures were more likely to occur on the raft than in the water while the opposite is true for dislocations. Injuries to arm/wrist/hand and injuries to the shoulder were significantly more likely to occur in the water than on the raft. However, injuries to eyes/nose/mouth/teeth were significantly more likely to occur on the raft than in the water.

Males tended to suffer dislocations more than females, who were more likely to have fractures than males. In addition, a significant difference existed between the two groups with regard to injuries on hip/leg/foot with females being more likely to get hurt than their male counterparts. In contrast, males were significantly more likely to injure their shoulders than females.

Recommendations include: 1) educate both guides and guests, particularly those experienced guests to know their limits, anticipate risks, and take appropriate prevention measures; 2) mark locations on Google Maps with embedded video clips for the most dangerous rapids and hazards; 3) pay special attention to *Pillow Rock* in summer; 4) improve injury reporting quality including differentiating injuries from swimming from injuries in the water as a result of falling out or boats flipping; and 5) illnesses that are not directly associated with rafting activities may need to be excluded from data analysis or analyzed separately in the future reports.

1. Introduction

This report is an analysis of the injuries reported to the West Virginia Division of Natural Resources on behalf of the West Virginia Whitewater Commission by the state's commercial rafting industry during the six-year period from 2011 to 2016. The information contained in this report is based on the requirement described in West Virginia Legislative Rule §58-12-11. No judgement was made in this analysis whether reported injuries follow the criteria for reporting established by West Virginia Legislative Rule §58-12-11.Therefore, all injury reports submitted by licensed outfitters during the time period are included and analyzed.

2. Demographics and Trip Characteristics

Fifteen outfitters submitted injury reports from 2011 to 2016. A total of 203 persons (including 201 guests and 2 guides) were injured during the six-year period. Over one-half (56.16%) of the injured were males (vs. 43.84% being females) (Figure 1). The injured were between 10 and 72 years old with an average age of 36.45 years. The age group with the highest percentage of injuries (32.51%) was between the ages 40 and 54 years, closely followed by the age group of 19 to 25 years (29.56%). Approximately 11% of the injured rafters were over 55 years, 13.30% were less than 18 years, and 13.79% were between 19 and 25 years (Figure 2).

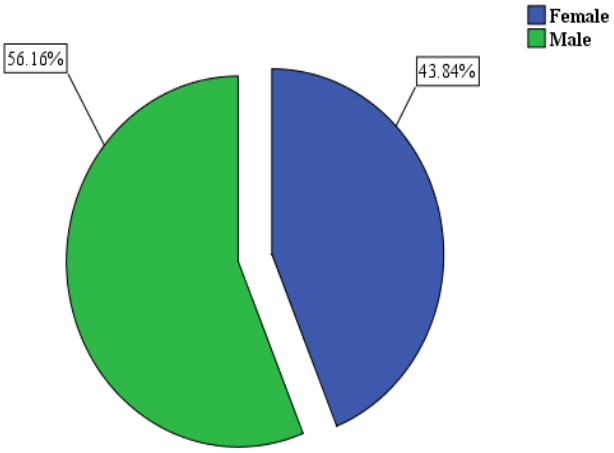

Figure 1. Reported injuries by gender

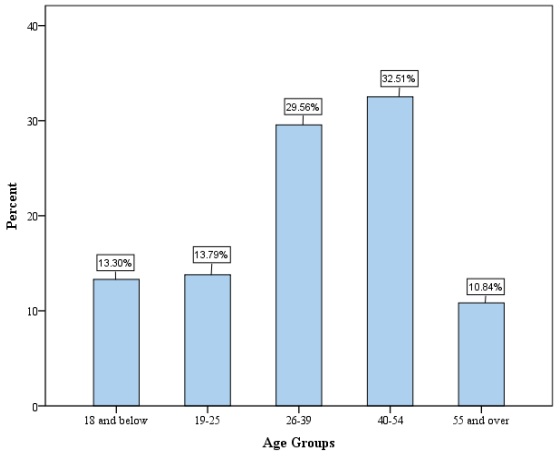

Figure 2. Reported injuries by age

A large majority (65.50%) of injured individuals had previous rafting experience (Figure 3), and overall, the injured had rafted an average of 21.53 times (Figure 4). Four outliers- 999, 999, 1000, and 1000 were excluded from the average calculation. A t-test analysis shows that females were not significantly different from males in how often they have rafted previously ($p > .05$). Females have rafted an average of 20.06 times prior to the current trip vs. 22.53 times for males. However, a Chi-square analysis indicates a greater proportion of male rafters (60.16%) have rafted at least once than their injured female counterparts (39.84%) ($p < .1$).

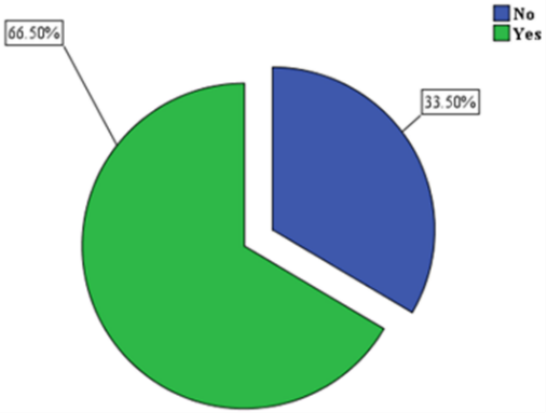

Figure 3. Reported injuries by past experience

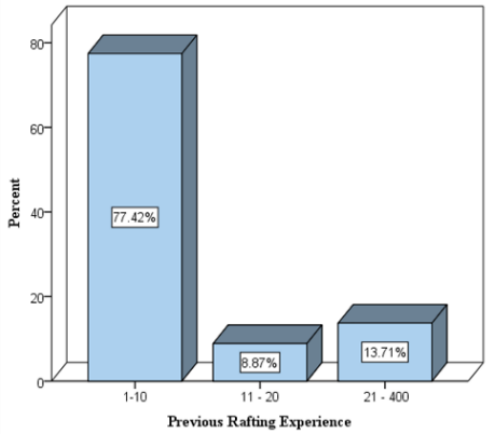

Figure 4. Previous rafting experience

3. River Usage

Table 1 presents the annual river usage for each of the 15 outfitters. As shown, Adventures on the Gorge had the highest total usage (275,434), followed by ACE (212,745), River Expeditions (83,660), River Riders (67,670), River and Trail Outfitters (44,765), and New and

Table 1. River usage by outfitter (2011-2016)

Outfitter	2011	2012	2013	2014	2015	2016	Total
ACE	36,431	39,593	38,431	34,575	34,189	29,526	212,745
Adventures on the Gorge	48,399	45,082	49,960	43,393	45,119	43,481	275,434
Alpine Ministries	2,097	2,062	2,018	2,133	2,018	1,983	12,311
Blackwater Outdoor Center	1,468	1,229	1,733	1,202	1,305	1,117	8,054
Cantrell Canoes and Rafts*	3,693	2,278	1,525	2,147	1,520	1,707	12,870
Cheat River Outfitters	1,736	1,300	2,038	1,961	1,520	1,566	10,121
Harpers Ferry Adventure Center	0	3,869	4,191	4,899	5,688	8,042	26,689
Laurel Highlands River Tours	362	247	281	138	34	151	1,213
New and Gauley River Adventures	7,202	7,313	6,299	6,407	6,372	6,928	40,521
River and Trail Outfitters	7,529	7,351	8,527	6,844	6,483	8,031	44,765
River Expeditions	17,502	16,925	13,984	11,654	12,032	11,563	83,660
River Riders, Inc	9,943	8,545	11,556	12,464	13,762	11,400	67,670
Songer Whitewater	4,574	2,997	0	0	0	0	7,571
West Virginia Adventures	1,634	740	753	732	1,792	2,457	8,108
WVU Outdoor Recreation Center	37	37	10	47	9	20	160
Total **	142,607	139,568	141,306	128,596	131,843	127,972	**811,892**

Note. *Usage for "Cantrell Canoes and Rafts" is compiled from "Cantrell" (2011 and 2012) and "Cantrell Ultimate Rafting" (2013, 2014, 2015, and 2015) from the Division's annual spreadsheet reports. **Total usage for all outfitters on all rivers is 837,183 for the six-year period.

Source: Compiled from the annual river usage reports, WV Division of Natural Resources, Department of Commerce.

Gauley River Adventures (40,521). These six companies had a cumulative usage of 724,795, accounting for 89.27% of the total usage (811,892) reported from all 15 outfitters. Total annual usage from these outfitters ranged from the lowest 128,912 in 2014 to the highest 156,962 in 2011, with a mean of 135,315. WVU Outdoor Recreation Center had the lowest usage (only 160 participants in total), with an annual average of 26 individuals.

Annual river usage by river segments is presented in Table 2 and Figure 5. The Lower New River had the largest proportion of river usage (438,368), accounting for more than one-half (52.67%) of the total usage (832,206) on the seven river segments, with an annual average of 73,061 users. The Shenandoah River had the second highest proportion of users, with a total of 144,778 users, accounting for 17.39% of the total usage. River usages for the Upper New and Upper Gauley are somewhat close, with 95,477 users for the former and 84,303 users for the latter. Tygart River had only 43 users in total, averaging seven individuals for each reported year.

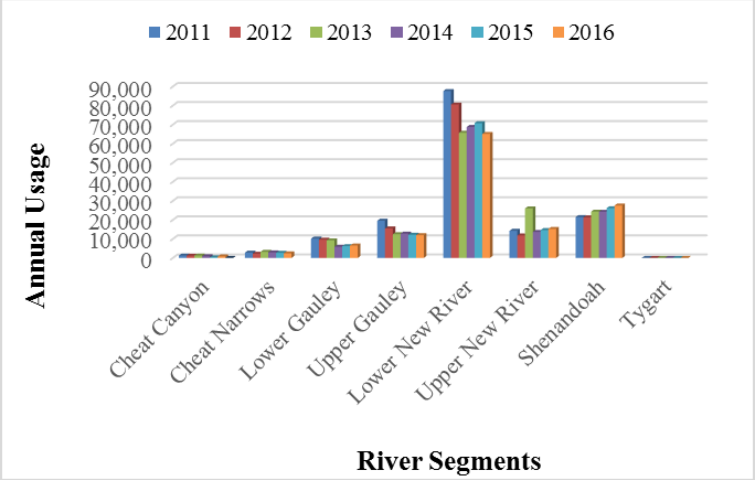

Figure 5. Annual river usage by river segments (2011-2016)

Table 2. River usage by river segments (2011-2016)

River segments	2011	2012	2013	2014	2015	2016	Total
Cheat Canyon	1,240	1,150	1,241	867	330	777	5,605
Cheat Narrows	2,797	2,219	3,186	2,875	2,674	2,405	16,156
Lower Gauley	10,145	9,589	9,220	5,842	6,185	6,495	47,476
Upper Gauley	19,524	15,467	12,461	12,731	12,164	11,956	84,303
Lower New River	87,593	80,519	65,704	68,736	70,718	65,098	438,368
Upper New River	14,243	11,809	25,972	13,654	14,609	15,190	95,477
Shenandoah	21,412	21,287	24,283	24,207	26,085	27,504	144,778
Tygart	8	20	0	0	15	0	43
Total*	156,962	142,060	142,067	128,912	132,780	129,425	**832,206**

Note. The total usage of 832,206 is slightly less than aforementioned 837,183 due to usage from other segments of the New River (i.e., 4,583 from Marathon Gauley, and 394 from Hawks Nest to Teays and Teays to Hawks Nest) being excluded.

Source: Compiled from the annual river usage reports, WV Division of Natural Resources, Department of Commerce.

4. Designated Whitewater Zone and Injury Rates

4.1 Injures by outfitters

Almost one-half (92, or 45.77%) of the injured guests rafted with ACE, followed by Adventures on the Gorge (43, or 21.39%), River Expeditions (24, or 11.94%), and New and Gauley River Adventures (12, or 5.97%). One (or 0.50%) injured guest was reported for each of the following five outfitters: Cantrell Canoes and Rafts, Harpers Ferry Adventure Center, Laurel Highlands River Tours, Songer Whitewater, and WVU Outdoor Recreation Center. The number of injured individuals for the remaining six companies ranged between 2 (1.00%) for Blackwater Outdoor Center and West Virginia Adventures and 9 (4.48%) for Alpine Ministries (Table 3).

While ACE had the largest injury rate, the incidence rate (IR) per 1,000 users is 0.442, not the highest among all outfitters. WVU Outdoor Recreation Center ranked the highest with an IR value of 6.25 (one participant out of 160) while Harpers Ferry Adventure Center had the lowest IR (0.037), followed by Cantrell Canoes and Rafts (0.078). The average IR is 0.248 for the 15 outfitters and 0.240 for the total river usage from all outfitters.

Table 3. Reported injuries by licensed outfitters (2011-2016)

Outfitter	Frequency	Percent	Total usage	Percent of total usage (per 1,000 users)
ACE	92*	45.77%	212,745	0.442
Adventures on the Gorge	43	21.39%	275,434	0.156
Alpine Ministries	9	4.48%	12,311	0.731
Blackwater Outdoor Center	2	1.00%	8,054	0.248
Cantrell Canoes and Rafts	1	0.50%	12,870	0.078
Cheat River Outfitters	3	1.49%	10,121	0.296
Harpers Ferry Adventure Center	1	0.50%	26,689	0.037
Laurel Highlands River Tours	1	0.50%	1,213	0.824
New and Gauley River Adventures	12	5.97%	40,521	0.296
River and Trail Outfitters	5	2.49%	44,765	0.111
River Expeditions	24	11.94%	83,660	0.287
River Riders, Inc	4	1.99%	67,670	0.059
Songer Whitewater	1	0.50%	7,571	0.132
West Virginia Adventures	2	1.00%	8,108	0.247
WVU Outdoor Recreation Center	1	0.50%	160	6.25
Total	201	100%	811,892	0.248
Total of river usage	201		837,183	0.240

Note. *The two injured guides were excluded from the calculations.

4.2 Injuries by river segments and rapids

Table 4 and Figure 6 present injuries by river segments. Nearly one-half (49.25%) of reported injuries occurred on the Lower New River, followed by the Upper Gauley (26.87%). No injuries were reported on the Tygart River. In addition, injury rates for Cheat Canyon and Cheat Narrows were also low, with 3 injured guests (1.49%) for the former and 4 (1.99%) for the latter. The average IR for all reported rivers is 0.242, ranging from 0 for Tygart, 0.069 for Shenandoah to 0.535 for Cheat Canyon, and to 0.641 for Upper Gauley (Figure 7).

Table 4. Reported injuries by river segments (2011-2016)

River Segment	Frequency	Percent	Total usage	Percent of total usage (per 1,000 users)
Cheat Canyon	3	1.49%	5,605	0.535
Cheat Narrows	4	1.99%	16,156	0.248
Lower Gauley	17*	8.46%	47,476	0.358
Upper Gauley	54*	26.87%	84,303	0.641
Lower New River	99	49.25%	438,368	0.226
Upper New River	14	6.97%	95,477	0.147
Shenandoah	10	4.98%	144,778	0.069
Tygart	0	0	43	0
Total	201	100%	832,206	0.242

Note. *The two injured guides were excluded from the calculations.

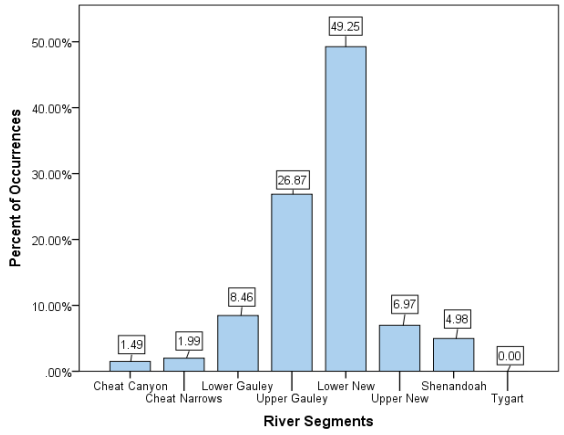

Figure 6. Reported injuries by river segments

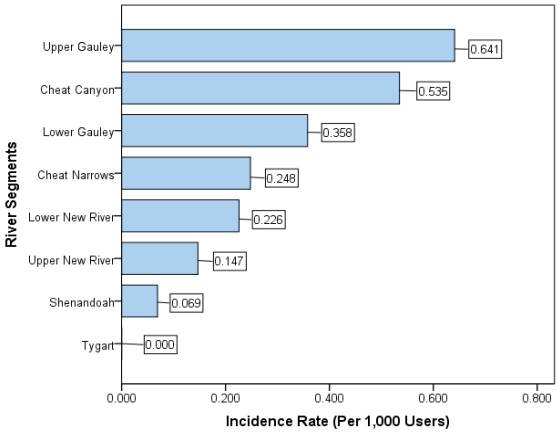

Figure 7. Incidence rate by river segments

Injuries were also reported by the location of rapids (Table 5). Injuries were most likely to occur at *Pillow Rock* (V) (20 injured guests, 9.95%) on the Upper Gauley. Other rapids such as *Jump Rock* (III) (13 guests, 6.47%), *Lower Railroad* (III) (13 guests, 6.47%), and *Surprise* (IV) (12 guests, 5.97%) on the Lower New River and *Sweet's Fall* (V) (12 injured guests, 5.97%) on the Upper Gauley also had a high likelihood of incidents (Table 5). A majority of incidents occurred at rapids with higher levels of river difficulty (57.72% IV and V combined), although a large number of incidents (34.33%) also occurred at Class III rapids (Figure 8).

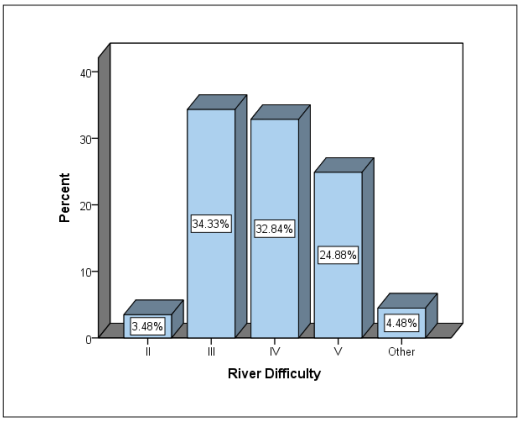

Figure 8. Reported injuries by river difficulty

Table 5. Reported injuries by location of rapids (2011-2016)

River Segment	Location	Class level	Frequency	Percent
Lower New River	Jump Rock	III	13	6.47%
	Lower Railroad	III	13	6.47%
	Surprise	IV	12	5.97%
	Middle Keeney	IV	11	5.47%
	Greyhound	IV	10	4.98%
	Millers Folly	IV	10	4.98%
	Double Z	IV	9	4.48%
	Lower Keeney	IV	5	2.49%
	Swimmers	II	4	1.99%
	Upper Railroad	III	4	1.99%
Lower Gauley	Pure Screaming Hell	V	4	1.99%
	Koontz Flume	IV	4	1.99%
Upper Gauley	Pillow Rock	V	20	9.95%
	Sweet's Fall	V	12*	5.97%
	Lost Paddle	V	5	2.49%
	Others		65*	32.34%
	Total		201	100%

Note. *The two injured guides were excluded from the calculations.

Rapids where injuries occurred are also mapped on Google Maps (Figures 9-12). This mapping of occurrences allows for a visual and spatial observation of injuries across the reported river segments (https://drive.google.com/open?id=19DA70S6qZfh-j4TGXrRf9YCyFJtK-xGG&usp=sharing). The following are screenshots of mapped rapids (note, points on the map only indicate the location of occurrences, not the frequency of occurrences).

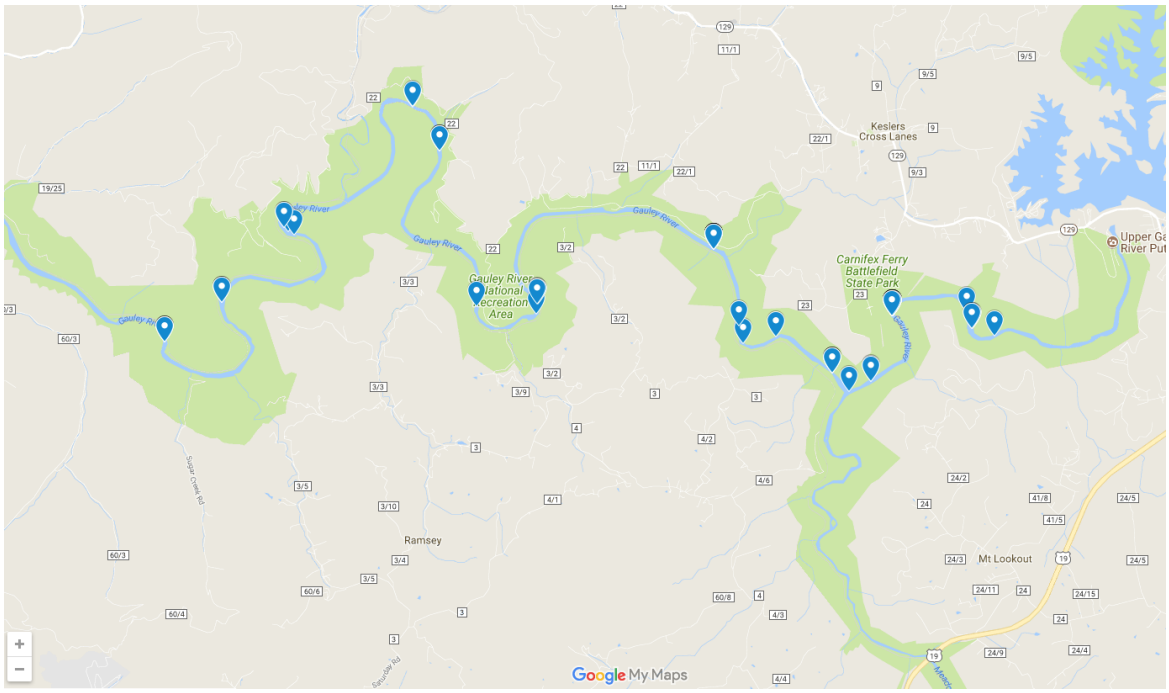

Figure 9. Google map screenshot: Gauley River

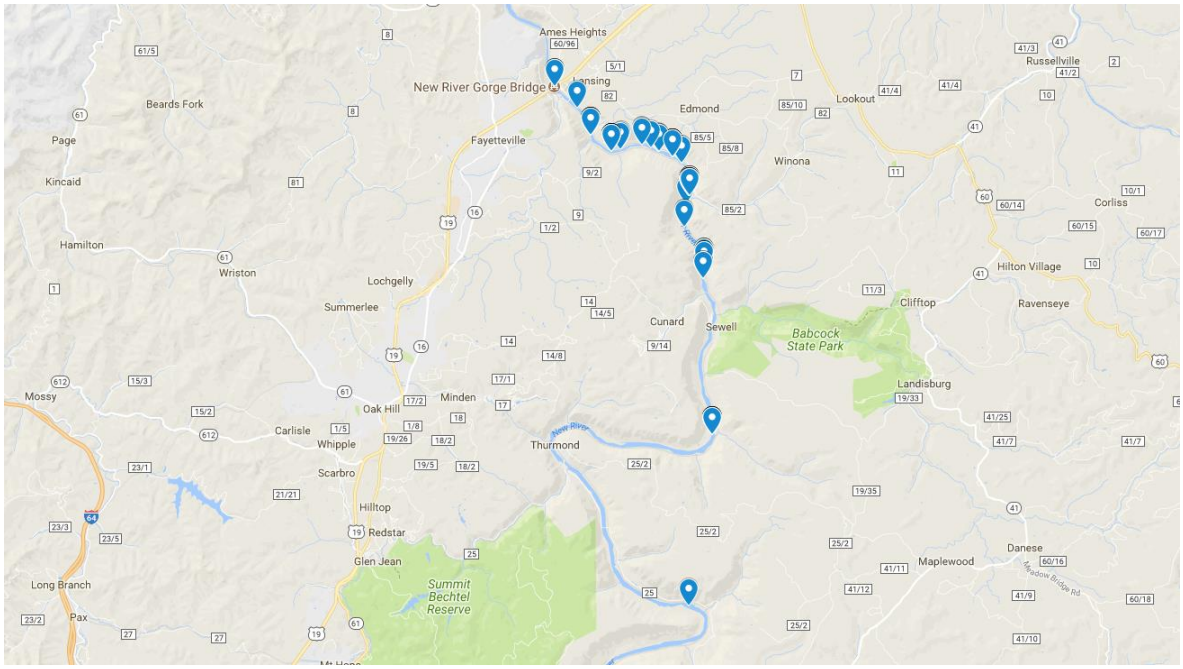

Figure 10. Google map screenshot: New River

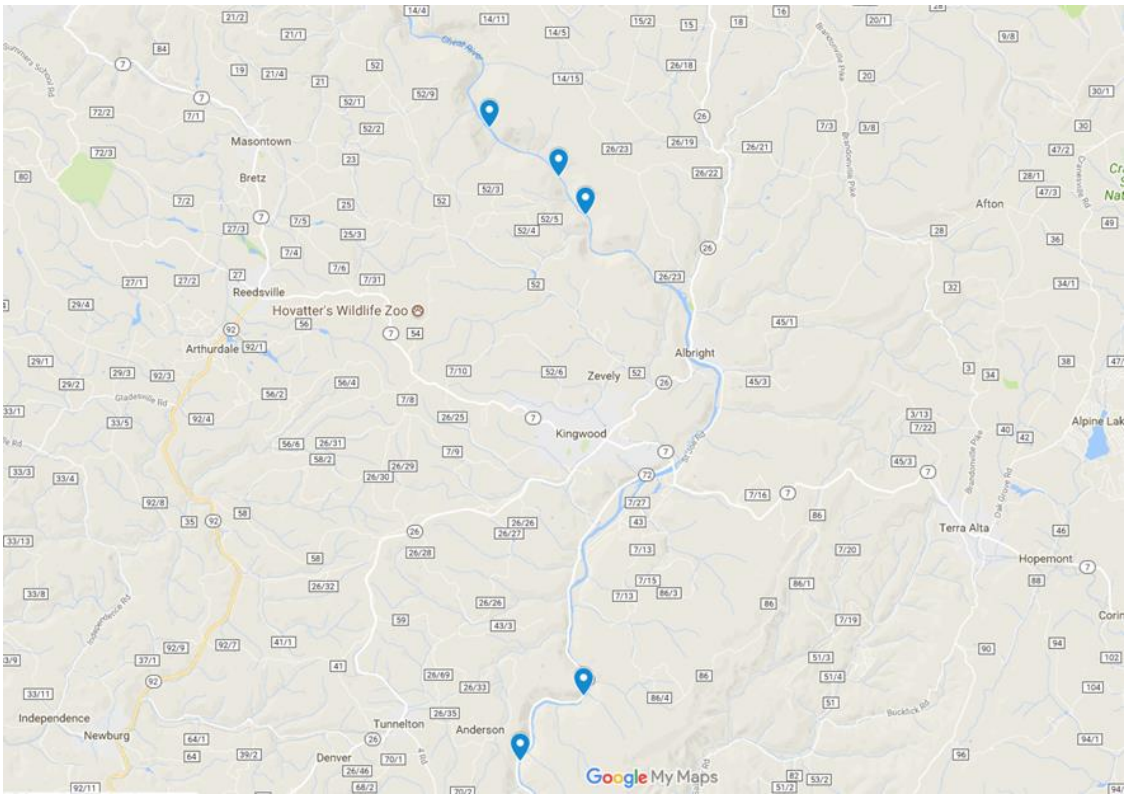

Figure 11. Google map screenshot: Cheat River

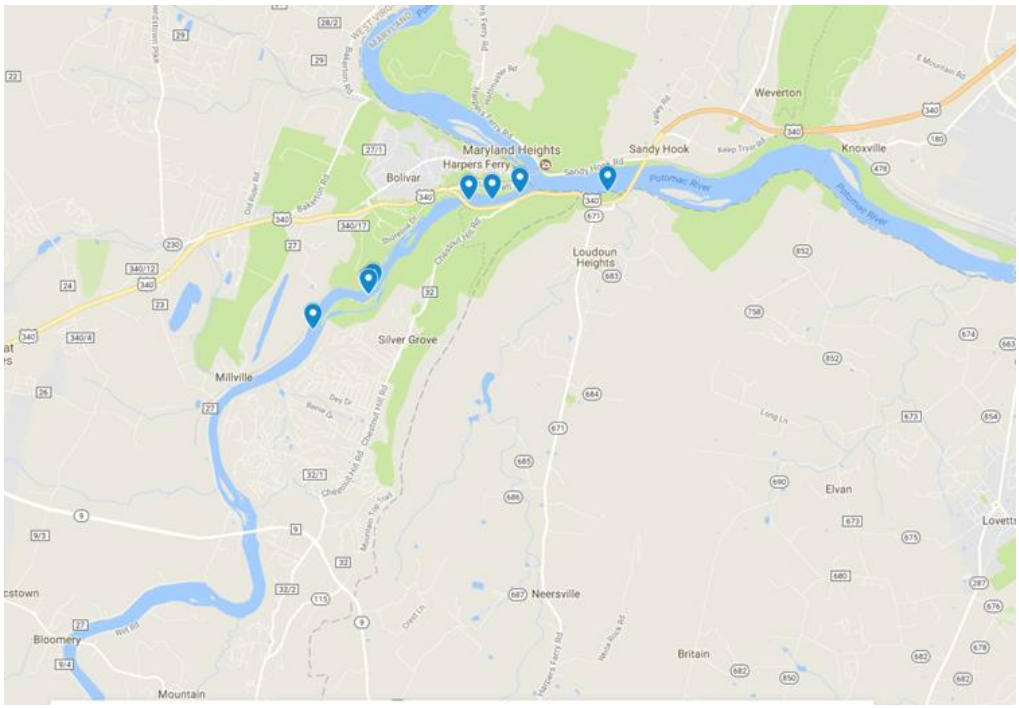

Figure 12. Google map screenshot: Shenandoah River

5. Time and Season of Injuries

Figure 13 presents time of injuries by percent. Over one-third (38.42%) of rafters were injured between 12:01 pm and 2:00 pm. A small percent of injuries occurred before 10:00 am (9.85%) or after 4:01 pm (3.45%), while the percent of injuries occurred between 10:01 am and 12:00pm (24.63%) is close to that occurred between 2:01 pm and 4:00 pm (23.65%). Similar findings were reported in the 2001-2010 report (Attarian, 2011). For example, 39% and 5% of guests were injured between 12:01 pm and 2:00 pm, and after 4:01 pm in the 2001-2010 report as opposed to 38.42% and 3.45% in this report, respectively.

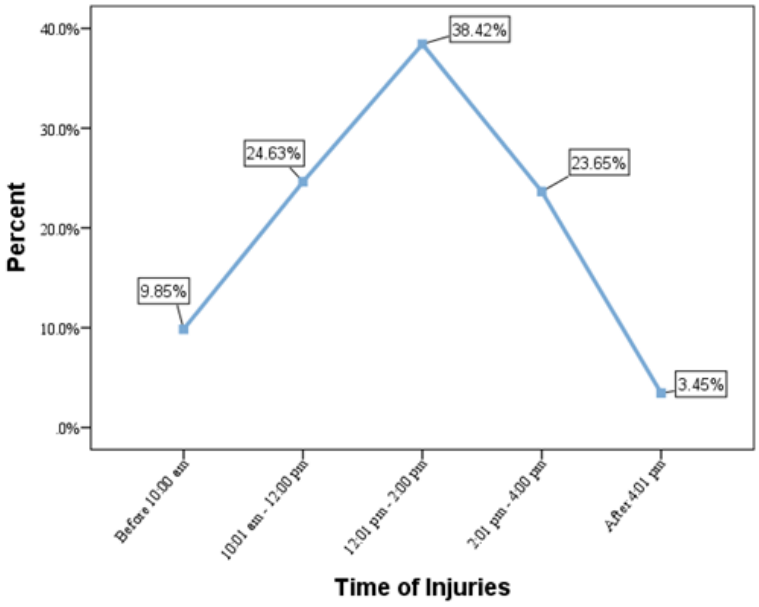

Figure 13. Percent of injuries by time

Figure 14 presents season of injuries by percent. Over a half (55.67%) of injuries occurred in summer, and over one-third (35.96%) of rafters were injured in fall. Spring is the season with the least percent of injuries (8.37%). This finding shows that summer is the high season for injuries and more attention should be paid to the risk and safety management in the summer season.

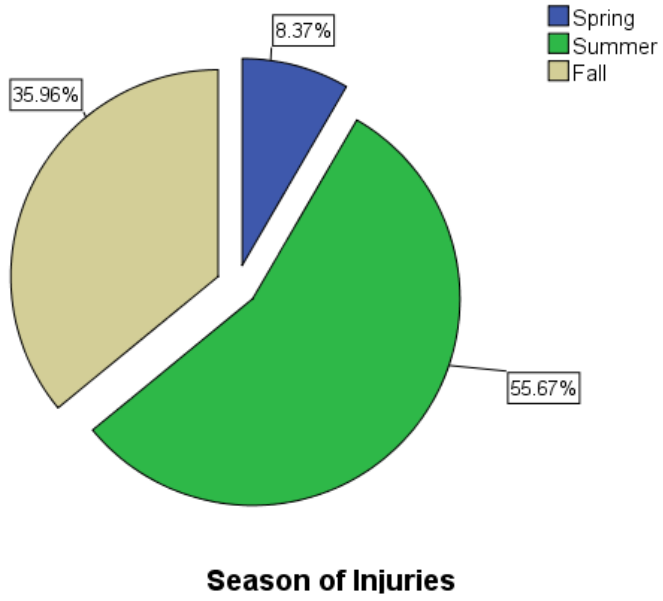

Figure 14. Percent of injuries by season

6. Cause of Injuries

Whitewater injures can happen by: 1) striking an object in the river, a participant, or piece of equipment, 2) through traumatic stress by interaction of the paddler's position in relationship to the equipment and the forces generated by moving water, 3) overuse injuries, and 4) submersion and environmental injuries (Fiore, 2003, as cited in Attarian, 2011, p. 8). Many of the injuries reported over the six-year period fall into one of these categories.

The "Accident Description" of the injury reports submitted by each rafting company provides the source for determining the cause of injuries. As Figure 15 shows, over one-third (34.48%) of incidents occurred in boats mainly due to collisions between paddlers (i.e., body contacts among passengers; being hit by other rafters' helmets or paddles while surfing or hit by a rafter's own paddle/helmet). Nearly one-third (29.56%) of incidents occurred during or after falling out of a boat (i.e., foot got caught under thwart or leg/foot did not release from the tube, shoulder dislocated by grabbing the strap while falling out; hit rocks in the water after being ejected into water). Approximately 11% of guests were injured due to boats flipping (i.e., two guests were drowned to death after their rafts being capsized). A small number of rafters

slipped and were injured while walking on rocks (1.97%), or were injured while jumping between rocks or off a rock into water (4.43%), or injured while swimming (5.91%) (i.e., hit a rock underwater, foot became caught in between rocks). Finally, 7.39% of guests were injured for other reasons including snake bites, reactions with hives, and boating accidents, among others. It should be noted some injuries occurred during the rescue (i.e., cut finger as being pulled into the raft).

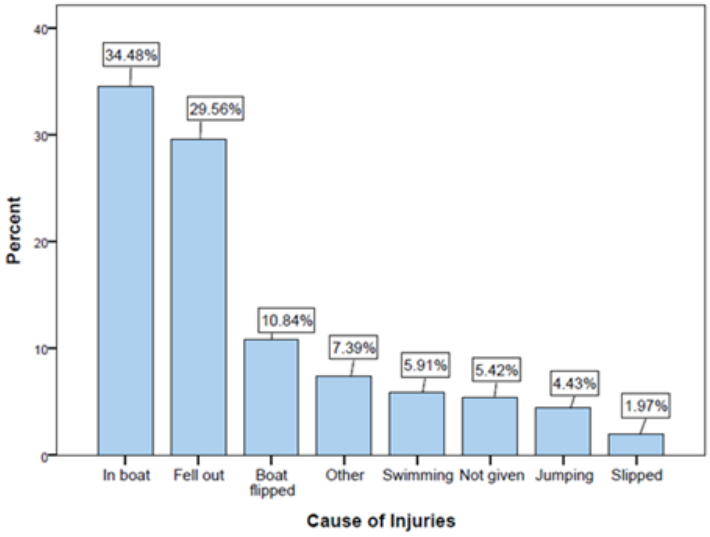

Figure 15. Cause of injuries

7. Type of Injuries

7.1 Fatalities

Three fatalities occurred during the six-year period 2011-2016, accounting for 1.49% of all 201 reported incidents and equivalent to 0.00358 per 1,000 users. This fatality rate is close to the 0.004 reported for the ten-year period 2001-2010 (Attarian, 2011), and is lower than 0.0055 reported for the period 1984-1999 (Fiore, 2003). The national incidence of commercial rafting fatalities is estimated to range from one death per 400,000 person visits (IR = 0.0025) to one death per 250,000 person visits (IR = 0.004) (American Whitewater, 2007).

The three fatalities, two females and one male, all occurred in water (one occurred during swimming and the other two drowned because of rafts flipped). Two of them occurred with Adventures on the Gorge (at *Pillow Rock* on Upper Gauley and at *Middle Keeney* on the Lower New River) and one with Alpine Ministries (at Upper Railroad on Lower New River) (Table 6).

Table 6. Reported fatalities (2011-2016)

Fatality	Outfitter	Gender	Age	Prior rafting	Cause of fatalities	River	Rapid	River Difficulty
1	Alpine Ministries (07/16/2011)	Female	64	Yes	Swimming	Lower New River	Upper Railroad	III
1	Adventures on the Gorge (09/26/2011)	Female	40	Yes	Raft flipped	Upper Gauley	Pillow Rock	V
1	Adventures on the Gorge (08/13/2013)	Male	16	No	Raft flipped	Lower New River	Middle Keeney	III

7.2 Injury type, count, and percent by river segments

Table 7 presents type, count, and percent of injuries by river segments. Almost one-half (47.39%) of the injuries occurred on the Lower New River, followed by the Upper Gauley (26.96%). No injuries were reported on the Tygart River. Overall, musculoskeletal injuries (sprains/strains, dislocations, and fractures) accounted for 51.30% of total 230 injuries (vs. 45% for the ten-year period 2001-2010), followed by injuries to soft tissue (contusions, lacerations/punctures, and abrasions) (32.61%) (vs. 39% for the ten-year period 2001-2010).

Table 7. Type of injuries by river segments (2011-2016)

Type	Cheat Canyon	Cheat Narrows	Lower Gauley	Upper Gauley	Lower New	Upper New	Shenandoah	Tygart	Total	Percent
Sprain/Strains	1	2	4	13	25	4	2	0	51	22.17%
Contusion/ Bruise	0	0	1	10	14	2	4	0	31	13.48%
Abrasion	0	0	3	2	2	0	1	0	8	3.48%
Hypothermia	0	0	0	0	0	0	0	0	0	0.00%
Concussion	0	0	1	4	9	1	0	0	15	6.52%
Dislocation	2	1	4	9	13	2	1	0	32	13.91%
Fracture	1	0	2	9	19	2	2	0	35	15.22%
Laceration/ Puncture	0	2	4	10	16	4	0	0	36	15.65%
Heat	0	0	0	0	1	0	1	0	2	0.87%
Illness	0	0	0	0	0	0	0	0	0	0.00%
Others	0	0	2	5	10	1	2	0	20	8.70%
Total	4	5	21	62	109	16	13	0	230	100.00%
Percent	1.74%	2.17%	9.13%	26.96%	47.39%	6.96%	5.65%	0.00%	100.00%	

7.3 Injury type by gender

Table 8 and Figure 16 depicts the type of injuries by gender. Overall, males (55.22%) tended to be more likely to be injured than did females (44.78%). In regard to specific types of injuries, males (23 counts, 10.00%) were more likely to suffer dislocations than females (9 counts, 3.91%), while the opposite is true for fracture injuries—females had 21 counts (9.13%) and males had 14 counts (6.09%). These differences are statistically significant with the absolute value of adjusted residual > 2.0 (Table 9). However, both groups had very similar percentages of injuries for sprains/strains (10.43% for females vs. 11.74% for males), contusions (6.09% for females vs.

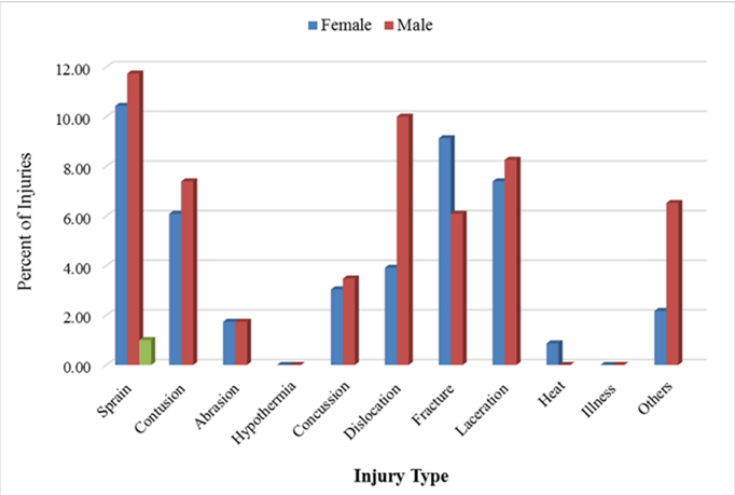

Figure 16. Type of injuries by gender

7.39% for males), abrasions (1.74% for each), concussions (3.04% for females vs. 3.48% for males), and lacerations (7.39% for females vs. 8.26% for males).

Table 8. Type of injuries by gender (2011-2016)

	Female		Male		
Type	**Count**	**Percent**	**Count**	**Percent**	**Total**
Sprain	24	10.43%	27	11.74%	51
Contusion	14	6.09%	17	7.39%	31
Abrasion	4	1.74%	4	1.74%	8
Hypothermia	0	0.00%	0	0.00%	0
Concussion	7	3.04%	8	3.48%	15
Dislocation	9	3.91%	23	10.00%	32
Fracture	21	9.13%	14	6.09%	35
Laceration	17	7.39%	19	8.26%	36
Heat	2	0.87%	0	0.00%	2
Illness	0	0.00%	0	0.00%	0
Others	5	2.17%	15	6.52%	20
Total	103	44.78%	127	55.22%	230

Table 9. Chi-square analysis of type of injuries by gender

Type of injuries		**Gender**				
		Female	Male	**Total**	χ^2	**Φ**
Sprain/Strain	Count	24	27	51	10.24*	0.216
	Percent	47.06%	52.94%	100.0%		
	Adjusted residual	0.49	-0.49			
Contusion/Bruise	Count	14	17	31		
	Percent	45.16%	54.84%	100.0%		
	Adjusted residual	0.13	-0.13			
Concussion	Count	7	8	15		
	Percent	46.67%	53.33%	100.0%		
	Adjusted residual	0.21	-0.21			
Dislocation	Count	9	23	32		
	Percent	28.13%	71.87%	100.0%		
	Adjusted residual	-2.00	2.00			
Fracture	Count	21	14	35		
	Percent	60.00%	40.00%	100.0%		
	Adjusted residual	2.07	-2.07			
Laceration/Puncture	Count	17	19	36		
	Percent	47.22%	52.78%	100.0%		
	Adjusted residual	0.41	-0.41			
Other	Count	5	15	20		
	Percent	25.00%	75.00%	100.0%		
	Adjusted residual	-1.82	1.82			
Total		97	123	220		
		44.09%	55.91%	100.0%		

Note. Eight abrasion injuries and two heat incidents are not included in the Chi-square analysis due to their cell size less than 5.

*p > .05.

** Absolute value of adjusted residual > 2.0.

7.4 Injury type by location of occurrences

Type of injuries by location of occurrences is presented in Table 10 and graphically depicted in Figure 17. As shown, injuries occurred almost equally in the water (44.80%) and on the raft (46.61%), while a small percent of injuries (8.60%) occurred on shore. Sprain/strain injuries accounted for the largest percentage (11.31%) of all injures on the raft, followed by fracture injuries (9.95%), and laceration/punctures (8.60%). For injuries in the water, sprains/strains and dislocations each accounted for 9.05%, followed by contusions (7.69%), and lacerations/punctures (6.79%). A Chi-square test shows that fractures were significantly more likely to occur on the raft (22 counts, 9.95%) than in the water (5 counts, 2.26%) ($p < .01$) (Table 11). In contrast, dislocations occurred in the water (20 counts, 9.05%) more frequently than on the raft (9 counts, 4.07%) ($p < .01$) (Table 11). No significant differences were found for other types of injuries between the two locations of occurrences (Table 11).

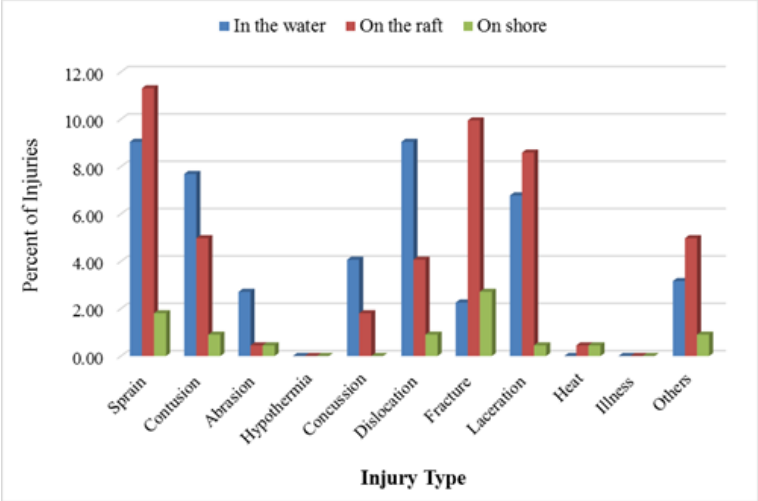

Figure 17. Type of injuries by location of occurrences

Table 10. Type of injury by location of occurrences* (2011-2016)

	In the water		On the raft		On shore		
Type	Count	Percent	Count	Percent	Count	Percent	Total
Sprain	20	9.05	25	11.31	4	1.81	49
Contusion	17	7.69	11	4.98	2	0.90	30
Abrasion	6	2.71	1	0.45	1	0.45	8
Hypothermia	0	0.00	0	0.00	0	0.00	0
Concussion	9	4.07	4	1.81	0	0.00	13
Dislocation	20	9.05	9	4.07	2	0.90	31
Fracture	5	2.26	22	9.95	6	2.71	33
Laceration	15	6.79	19	8.60	1	0.45	35
Heat	0	0.00	1	0.45	1	0.45	2
Illness	0	0.00	0	0.00	0	0.00	0
Others	7	3.17	11	4.98	2	0.90	20
Total	99	44.80%	103	46.61%	19	8.60%	221

Note. *For reasons of parsimony, nine locations of occurrences not reported or reported as "others" were excluded.

Table 11. Chi-square analysis of type of injuries by location of occurrences

Type of injuries		Location		Total	χ^2	Φ
		In the water	On the raft			
Sprain/Strain	Count	20.00	25.00	45	17.23*	0.31
	Percent	44.44	55.56	100.0%		
	Adjusted residual	-0.30	0.30			
Contusion/Bruise	Count	17.00	11.00	28		
	Percent	60.71	39.29	100.0%		
	Adjusted residual	1.65	-1.65			
Dislocation	Count	20.00	9.00	29		
	Percent	68.97	31.03	100.0%		
	Adjusted residual	2.66**	-2.66**			
Fracture	Count	5.00	22.00	27		
	Percent	18.52	81.48	100.0%		
	Adjusted residual	-3.15**	3.15**			
Laceration/Puncture	Count	15.00	19.00	34		
	Percent	44.12	55.88	100.0%		
	Adjusted residual	-0.30	0.30			
Other	Count	7.00	11.00	18		
	Percent	38.89	61.11	100.0%		
	Adjusted residual	-0.67	0.67			
Total		84.00	97.00	181		
		46.41%	53.59%	100.0%		

Note. Thirteen concussions, eight abrasions and two heat incidents are not included in the Chi-square analysis due to their cell size less than 5.
*p < .01.
** Absolute value of adjusted residual > 2.0.

8. Injuries by Anatomical Region

About one-half (50.35%) of the injuries occurred on the left side of a body and 45.45% on the right side. Injuries reported as "both" and "multiple" accounted for a very small percentage, with 2.80% for the former and 1.40% for the latter. Figure 18 depicts the percent distribution of injuries by body sides.

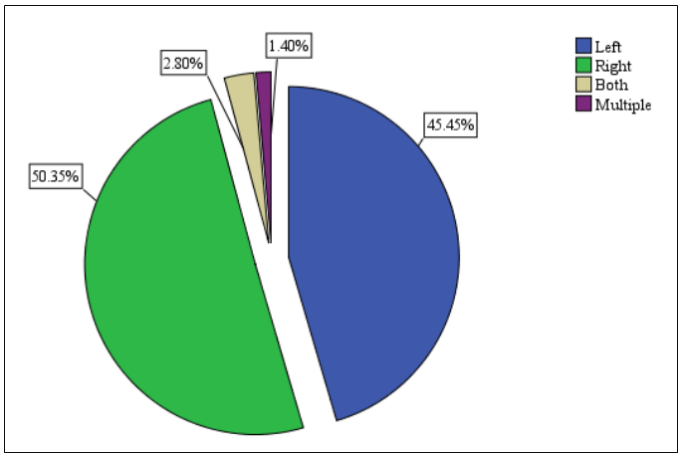

Figure 18. Type of injuries by body sides

Figure 19 and Figure 20 display injured body sides by gender and by location of occurrences, respectively. Both females and males had the similar chance of being injured on the left side (23.36% for females vs. 24.09% for males) while males were more likely to get hurt than females on the right side (21.17% for females vs. 31.39% for males). In terms of injuries by location of occurrences, both the left and right sides of the body were injured at the similar rate both in the water and on the raft (Figure 20).

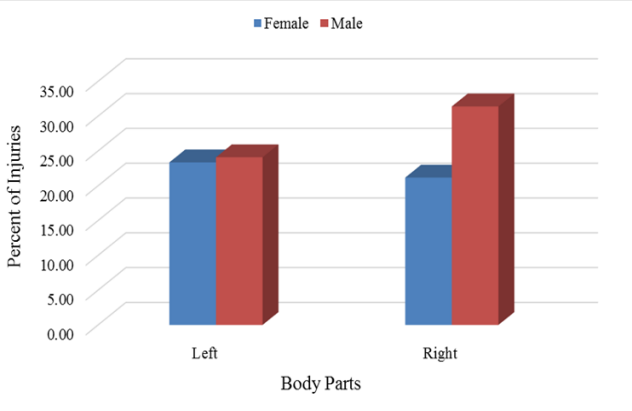

Figure 19. Side of body injuries by gender

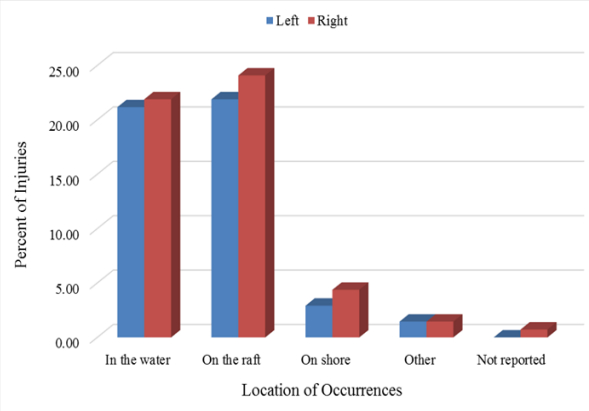

Figure 20. Side of body injuries by location of occurrences

Table 12 presents the frequency and percent of injuries by anatomical region. A total of 232 injuries were reported (excluding injuries recorded as “left”, “right”, “both”, and “multiple” as

Table 12. Frequency and percent of injuries by anatomical region

Body parts	Frequency	Percent
Abdomen	1	0.43%
Ankle	27	11.64%
Arm	11	4.74%
Back	4	1.72%
Chest	6	2.59%
Eye	8	3.45%
Face	14	6.03%
Foot	6	2.59%
Hand	16	6.90%
Head	16	6.90%
Hip	4	1.72%
Knee	29	12.50%
L Leg	11	4.74%
Mouth	12	5.17%
Neck	2	0.86%
Nose	8	3.45%
Other	7	3.02%
Shoulder	28	12.07%
Teeth	15	6.47%
U Leg	3	1.29%
Wrist	4	1.72%
Total	232	100.0%

analyzed in the earlier section of this report). Knee, shoulder, and ankle were the three body parts that had the most injuries, each accounting for 12.50% (29 counts), 12.07% (28 counts), and 11.64% (27 counts), respectively. An abdomen injury was reported only once, representing 0.43% of total reported injuries. Other body parts such as neck, upper leg, back, hip, and wrist were among the least injured, ranging between 2 (0.86%) and 4 (1.72%) injuries. A graphic display of injuries by anatomical region is shown in Figure 21.

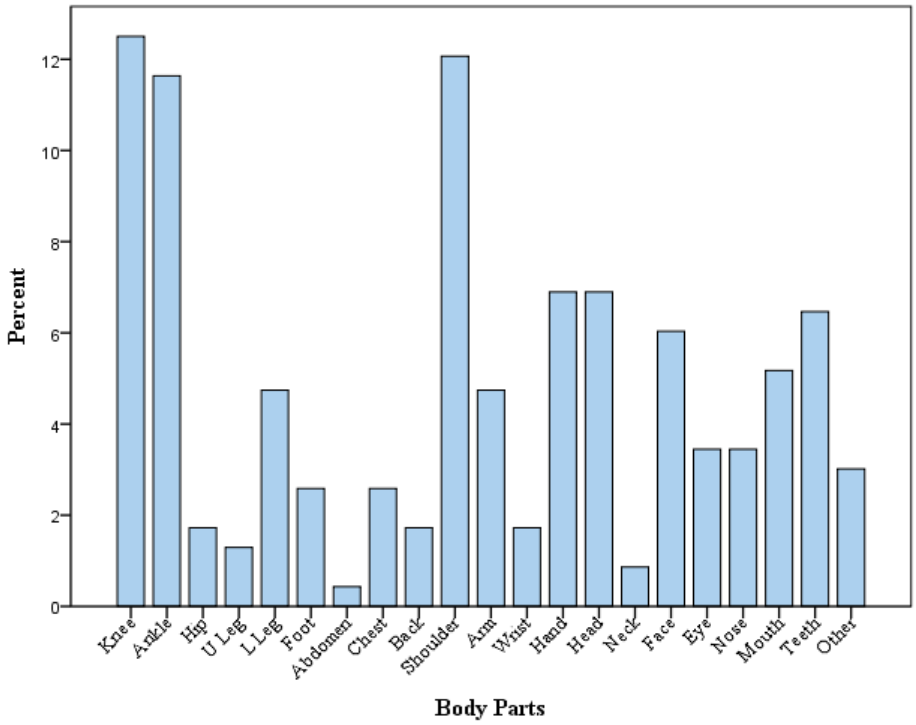

Figure 21. Injuries by anatomical region

Injured body parts were further analyzed by gender and by location of occurrences. For reasons of parsimony and to be consistent with previous reports, several types of injuries are lumped together, including hip/leg/foot, abdomen/chest/back, head/neck, eyes/nose/month/teeth, and arm/wrist/hand. The percent of injuries by body parts for females and males are presented in Table 13 as well as graphically shown in Figure 22. Overall, more injuries occurred to males (52.59%) than to females (47.41%). While females had 18.97% of injuries occurred to the lower extremities (hip/leg/foot, knee, and ankle) and 9.92% to the upper extremities (arm/wrist/hand, and shoulder), males had exactly same percentage (15.52%) of injuries to either the lower or upper extremities.

Table 14 presents the Chi-square test of injured body parts by gender. Results show that females (17 injuries, 7.33%) were significantly more likely to be injured on the hip/leg/foot than were males (7 injuries, 3.02%) ($p < .05$) , while males (21 injuries, 9.05%) were significantly

more likely to injure their shoulder than were females (7 counts, 3.02%) ($p < .05$). No significant differences were found in injuries occurring on other body parts between the two groups.

Table 13. Body part injuries by gender (2011-2016)

	Gender				
	Female		Male		Total
Body parts	Counts	Percent	Counts	Percent	counts
Hip/Leg/Foot	17	7.33%	7	3.02%	24
Knee	11	4.74%	18	7.76%	29
Ankle	16	6.90%	11	4.74%	27
Abdomen/Chest/Back	3	1.29%	8	3.45%	11
Shoulder	7	3.02%	21	9.05%	28
Head/Neck	8	3.45%	10	4.31%	18
Face	9	3.88%	5	2.16%	14
Eyes/Nose/Mouth/Teeth	21	9.05%	22	9.48%	43
Arm/Wrist/Hand	16	6.90%	15	6.47%	31
Others	2	0.86%	5	2.16%	7
Total	110	**47.41%**	122	**52.59%**	**232**

Table 14. Chi-square analysis of injured body parts by gender

Body parts		Gender: Female	Gender: Male	Total	χ^2	Φ
Knee	Count	11	18	29	17.14*	0.276
	Percent	37.93%	62.07%	100.0%		
	Adjusted Residual	-1.16	1.16			
Ankle	Count	16	11	27		
	Percent	59.26%	40.74%	100.0%		
	Adjusted Residual	1.25	-1.25			
Hip/Leg/Foot	Count	17	7	24		
	Percent	70.83%	29.17%	100.0%		
	Adjusted Residual	2.37**	-2.37**			
Shoulder	Count	7	21	28		
	Percent	25.00%	75.00%	100.0%		
	Adjusted Residual	-2.60**	2.60**			
Arm/Wrist/Hand	Count	16	15	31		
	Percent	51.61%	48.39%	100.0%		
	Adjusted Residual	0.43	-0.43			
Head/Neck	Count	8	10	18		
	Percent	44.44%	55.56%	100.0%		
	Adjusted Residual	-0.31	0.31			
Face	Count	9	5	14		
	Percent	64.29%	35.71%	100.0%		
	Adjusted Residual	1.26	-1.26			
Eyes/Nose/Mouth/Teeth	Count	21	22	43		
	Percent	48.84%	51.16%	100.0%		
	Adjusted Residual	0.12	-0.12			
Total	Count	108	117	225		
	Percent	48.00%	52.00%	100.0%		

Note. Injuries on abdomen/chest/back and injuries reported as "others" are not included in the Chi-square analysis due to their cell size being less than 5.

*$p < .05$.

** Absolute value of adjusted residual > 2.0.

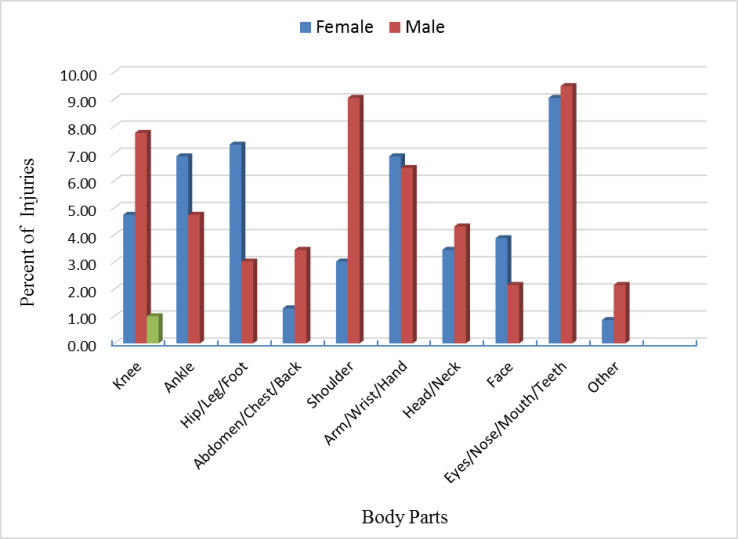

Figure 22. Body part injuries by gender

Table 15 presents the frequency and percent of body part injuries by location of occurrences. The graph on the percent of injuries is presented in Figure 23. Similar to the distribution pattern related to the type of injuries, injuries by body parts occurred least likely on shore, accounting for 9.33%, while the odds were similar for injuries occurring in the water (44.40%) and injuries occurring on the raft (46.47%).

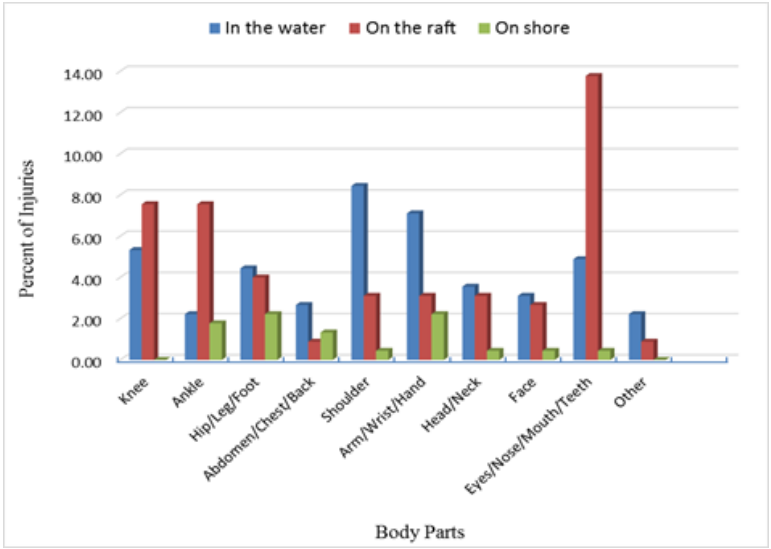

Figure 23. Body part injuries by location of occurrences

A further analysis using Chi-square indicates that injuries to the arm/wrist/hand were significantly more likely to happen in the water (16 counts, 7.11%) than on the raft (7 counts, 3.11%). So too were injuries to the shoulder (19 counts, 8.44% in the water vs. 7 counts, 3.11% on the raft). However, a significantly greater proportion of injuries to eyes/nose/mouth/teeth (31 counts, 13.78%) and to ankles (17 counts, 7.56%) occurred on the raft than in the water (11 counts, 4.89% for eyes/nose/mouth/teeth and 5 counts, 2.22% for ankles). No significant differences existed for other injuries between the two locations.

Table 15. Body part injuries by location of occurrences (2011-2016)

Body parts	Location						Total counts
	In the water		On the raft		On shore		
	Counts	Percent	Counts	Percent	Counts	Percent	
Hip/Leg/Foot	10	4.44%	9	4.00%	5	2.22%	24
Knee	12	5.33%	17	7.56%	0	0.00%	29
Ankle	5	2.22%	17	7.56%	4	1.78%	26
Abdomen/Chest/Back	6	2.67%	2	0.89%	3	1.33%	11
Shoulder	19	8.44%	7	3.11%	1	0.44%	27
Head/Neck	8	3.56%	7	3.11%	1	0.44%	16
Face	7	3.11%	6	2.67%	1	0.44%	14
Eyes/Nose/Mouth/Teeth	11	4.89%	31	13.78%	1	0.44%	43
Arm/Wrist/Hand	16	7.11%	7	3.11%	5	2.22%	28
Others	5	2.22%	2	0.89%	0	0.00%	7
Total	99	44.00%	105	46.67%	21	9.33%	**225**

Table 16. Chi-square analysis of injured body parts by location of occurrences

Body parts		Location		Total	χ^2	Φ
		In the water	On the raft			
Knee	Count	12	17	29	25.41*	0.367
	Percent	41.38%	58.62%	100.0%		
	Adjusted Residual	-0.61	0.61			
Ankle	Count	5	17	22		
	Percent	22.73%	77.27%	100.0%		
	Adjusted Residual	-2.38**	2.38**			
Hip/Leg/Foot	Count	10	9	19		
	Percent	52.63%	47.37%	100.0%		
	Adjusted Residual	0.56	-0.56			
Shoulder	Count	19	7	26		
	Percent	73.08%	26.92%	100.0%		
	Adjusted Residual	2.92	-2.92			
Arm/Wrist/Hand	Count	16	7	23		
	Percent	69.57%	30.43%	100.0%		
	Adjusted Residual	2.36**	-2.36**			
Head/Neck	Count	8	7	15		
	Percent	53.33%	46.67%	100.0%		
	Adjusted Residual	0.55	-0.55			
Face	Count	7	6	13		
	Percent	53.85%	46.15%	100.0%		
	Adjusted Residual	0.55	-0.55			
Eyes/Nose/Mouth/Teeth	Count	11	31	42		
	Percent	26.19%	73.81%	100.0%		
	Adjusted Residual	-3.00**	3.00**			
Total	Count	88	101	189		
	Percent	46.56%	53.44%	100.0%		

Note. Injuries on abdomen/chest/back and injuries reported as "others" are not included in the Chi-square analysis due to their cell size being less than 5.

*p = .001.

** Absolute value of adjusted residual > 2.0.

9. Treatment by Health Care Provider

Evacuations to an outfitter base camp or medical facility may occur when an individual was injured on the rafting trip. During the six-year period 2011-2016, a majority (78.82%) of the injured were evacuated (Figure 25) and nearly one-half (46.91%) of the evacuated were taken to a hospital, followed by an outfitter base camp (29.01%) (Figure 26). The evacuation rate of 78.82% is much higher than an average of 52% for the period 2001-2010, but comparable to 81% in 2006 (Attarian, 2011).

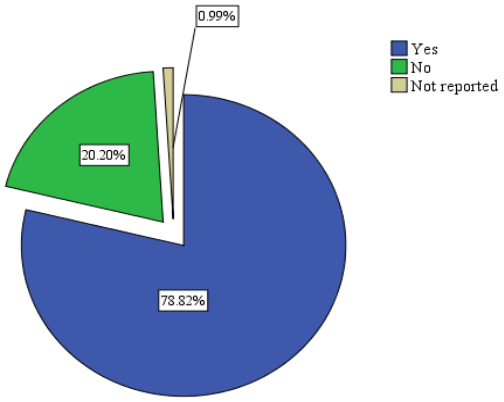

Figure 24. Injuries requiring evacuation by percent

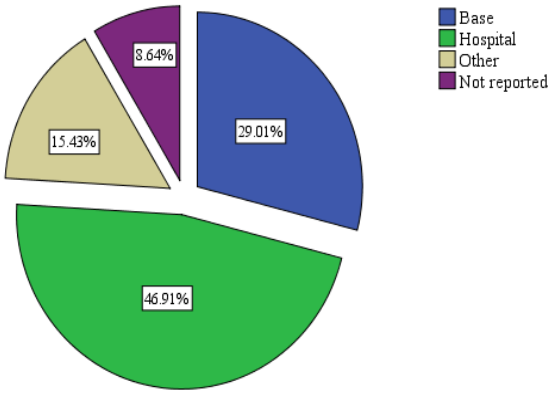

Figure 25. Evacuation location of treatments

Legislative rule on injury reporting (§47-27-11 [Accident Reports]) specifies that injuries that "require medical treatment by a licensed health care provider, excluding diagnostic analysis" must be reported to the West Virginia Division of Natural Resources (cited in Attarian, 2011, p. 12). Approximately 39% of the evacuated guests were evaluated by a medical or osteopathic doctor (MD or DO), 13% by an EMT or paramedic, 3% by a registered nurse, and 13% by a physician assistant. It should be noted that a large percent (28.22%) of the evaluation was reported as "other" and 3.68% were not reported.

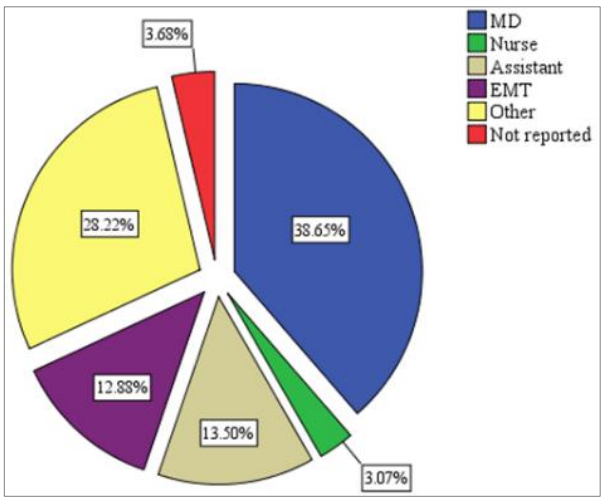

Figure 26. Treatment by professional health care provider

A majority (66%) of the injured guests received some form of treatments, including a splint or cast (17.24%), stitches (7.88%), medication (6.90%), surgery (2 guests, 1%), or other unspecified treatment (13.79%). In addition, 25.12% of the injured received a diagnosis only.

10. Conclusions and Recommendations

Findings from this report are comparable to some extent with previous studies/reports in West Virginia and elsewhere. For example, the overall injury incidence rate of 0.240 per 1,000 users is lower than 0.263 for the three-year period 1995-1997 in West Virginia (Whisman & Hollenhorst, 1999) while a little higher than 0.234 reported in 1997 for a Colorado river (Colorado State Parks, 1997). That said, the incidence rate of 0.242 for the five rivers (Cheat river, Gauley River, New River, Shenandoah, and Tygart) is much lower than 0.309 for the same rivers for the period 2001-2010 (Attarian, 2011).

Fatal injuries were rare and three fatalities occurred during the reporting period. This translates into 0.00358 per 1,000 users, which is close to 0.004 reported for the ten-year period 2001-2010 (Attarian, 2011), and lower than 0.0055 reported for the period 1984-1999 (Fiore, 2003). It falls within the typical range for whitewater rafting of between 0.0025 and 0.004 estimated by American Whitewater (2007).

It appears that participating in white water rafting is much safer than participating in many other outdoor recreational/adventure activities (Table 17). For example, the incidence rate for skiing/snowboarding ranges from 0.6 (Austria) to 16.0 (Canada) worldwide, with a rate between 2 and 7 in the USA, much higher than 0.240 for white water rafting in this report. A study in New Zealand shows that commercial horse riding (20.1), mountain biking (11.0), and surfing (9.7) has the highest claim incidence, while the claim incidence for white water rafting is ranked lower (17 out of 26 activities) (Bentley, Page, & Macky, 2007). It is worth noting that independent recreationists tended to be more likely to sustain injuries from outdoor adventure activities than those with a commercial guide (Bentley, Meyer, Page, & Chalmers, 2001; Bentley et al., 2007).

Incidents occurred more frequently on the Upper Gauley and Lower New River at *Pillow Rock*, *Sweet's Fall*, *Jump Rock*, *Lower Railroad*, and *Surprise*. These five locations accounted for about 35% of all incidents. Similar findings were also reported for the period 2005-2010 (Attarian & Siderelis, 2013). Thus, priorities on education and resource allocation should be placed on these locations in terms of risk management and injury prevention.

Some injuries differ by gender and by location of occurrences as well. For example, males tended to suffer dislocations more likely than females, while females were more likely to get injured on the hip/leg/foot than their male counterparts. In contrast, males were significantly more likely to hurt their shoulders than were females. Fractures were more likely to occur on the raft than in the water. Injuries to the arm/wrist/hand and injuries to shoulders were significantly more likely to occur in the water than on the raft, while injuries to eyes/nose/mouth/teeth were significantly more likely to occur on the raft than in the water. Whisman and Hollenhorst (1999) also reported that injuries to the face were more likely to occur on the raft than in the water (note, face in their study includes eyes/nose/mouth/teeth

while injures on face were separately described and analyzed from injuries to eyes/nose/mouth/teeth in this report).

Table 17. Incidence rates of outdoor adventure activities (per 1000 user days)

Sources	Activities	Incidence rate	Country/ region	Year	Note
North America					
Davidson & Laliotis (1996)	Skiing	2.6	USA	1983-1992	Alpine skiing (California)
Johnson, Ettlinger, & Shealy (2008)	Skiing	2.53	USA	1972-2006	Vermont ski area
UnofficialNetworks (2017)	Skiing	2.0	USA	2017	Nationwide
National Ski Areas Association (2012)	Snowboarding	6.97	USA	2001	Nationwide
Abu-Laban (1991)	Snowboarding	8.0-16.0	Canada	1988-1990	Banff National Park
Europe					
Stenroos & Handolin (2014)	Skiing	1.97	Finland	2006-2012	Levi Ski Resort
Ruedl et al. (2014)	Skiing	0.6	Austria		Alpine skiing, nationwide
Ekeland & Rodven (2008)	Skiing/ Snowboarding	1.4	Norway	1996-2006	Nationwide
Zacharopoulos, Tzanakakis, & Douka (2008)	Skiing Snowboarding	6.1 4.1	Greece	2005-2006 2007-2013	Nationwide
Bianchi, Brugger, & Niemann (2017)	Skiing	2.8	Switzerland	2008-2010	Nationwide
Médecins de Montagne (2015)	Skiing Snowboarding	2.5 2.9	France	2012-2013	Nationwide
Oceana					
Bentley, Meyer, Page, & Chalmers (2001)	Recreational/adventure activities	0.084 (hospitalized)	New Zealand	1982-1996	Based on injury claim counts
Bentley, Page, & Macky (2007)	Motor vehicle traffic accident	0.12 (Hospitalized)		1982-1996	
	Horse riding	20.1		2003-2004	
	Mountain biking	11.0		2003-2004	
	Surfing	9.7		2003-2004	

While the Upper Gauley and Lower New River continue to be the river segments involving a majority of incidents for the period 2001-2010 and for the period 2011-2016, it seems that incidence rates per 1,000 users have decreased from 0.309 from the period 2001-2010 to 0.242 for the current period—a good sign for the whitewater industry in the state. Having said this, there are no reasons to be complacent. More efforts should be taken to determine the cause of injuries, and to educate both guides and participants, particularly experienced rafters so as to keep injuries as minimal as possible. It is worth noting that experienced individuals tended to be more likely to get hurt than novices.

Attarian (2011), in his ten-year period report, has provided useful recommendations for injury prevention from the perspectives of education, engineering, and enforcement. Injury prevention may also be achieved using Google Maps or other means. For example, specific rapid locations where severe injuries had occurred can be marked on the Google Maps with embedded videos describing potential risks at each location. In so doing, prospective customers may have a chance to visualize possible hazards associated with those locations and get well prepared, mentally and physically, before taking a rafting trip.

Finally, previous studies have emphasized the need for consistent, accurate, and complete reporting of injuries to ensure a high quality analysis. An analysis based on incomplete and inaccurate injury reporting may lead to misleading results and associated interpretations (Attarian; 2011, Whisman & Hollenhorst, 1999; Wilson, McDermott, Munir, & Hogervorst, 2013). Therefore, more efforts are needed to improve the quality of injury reporting. Specifically, illnesses (i.e., reactions with hives) that are not directly a result of rafting activities may need to be excluded from injury analysis and reporting in the future. In addition, under the "Accident Description" of the injury report, if a guide was the injured party, then the injury should be separately reported under a subhead "injured party" with two checking boxes: guests and guides, for the convenience of data entry and data analysis. Moreover, it is worth noting that most injuries as a result of falling out into water or boats being capsized were reported as "swim" under the subhead "Injury Occurred." This created confusion with injuries resulted from an actual swimming. More detailed reporting may be needed to discern injuries with swimming from injuries in the water because of falling out or flipped boats so that the cause of injuries can be easily identified and analyzed.

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