

## Original Article

# The effect of wilderness and medical training on injury and altitude preparedness among backcountry hikers in Rocky Mountain National Park

Michael D.T. Yue<sup>1</sup>, David W. Spivey<sup>1</sup>, Daniel B. Gingold<sup>2</sup>, Douglas G. Sward<sup>2,3</sup>

<sup>1</sup> University of Maryland School of Medicine, Baltimore, Maryland, USA

<sup>2</sup> Department of Emergency Medicine, University of Maryland School of Medicine, Baltimore, Maryland, USA

<sup>3</sup> Division of Hyperbaric Medicine, Program in Trauma, University of Maryland Medical Center, Baltimore, Maryland, USA

Corresponding Author: Douglas G. Sward, Email: dsward@som.umaryland.edu

**BACKGROUND:** The purpose of this study was to document the correlation between medical and wilderness training with levels of preparedness for acute mountain sickness (AMS), illness, and injury among backcountry hikers.

**METHODS:** We conducted a cross-sectional, convenience survey in Rocky Mountain National Park in July and August 2015. The study group consisted of 380 hikers who completed a written survey that collected information about demographics, wilderness experience, altitude experience, hiking equipment, communications devices, and trip planning.

**RESULTS:** Factors such as wilderness training (wilderness first aid [WFA], wilderness first responder [WFR], or wilderness emergency medical technician [WEMT]), wilderness experience, and altitude experience all affected hikers' emergency preparedness. Respondents with medical training were more prepared to avoid or respond to AMS (62.3% vs. 34.3% [ $P<0.001$ ]). They were also more prepared to avoid or manage injury/illness than hikers without medical training (37.7% vs. 20.7% [ $P=0.003$ ]). Participants with wilderness training were more likely to be prepared to avoid or respond to AMS (52.3% vs. 36.8% [ $P=0.025$ ]) but not significantly more likely to be prepared to manage illness/injury (31.8% vs. 22.0% [ $P<0.11$ ]). Adjusting for experience, wilderness training, age, and gender, we found that medical training was associated with increased preparedness for AMS (OR 2.72; 95% CI 1.51–4.91) and injury/illness (OR 2.71; 95% CI 1.5–4.89).

**CONCLUSION:** Medically trained hikers were more likely to be prepared to avoid or manage AMS, medical emergencies, and injuries than their non-medically trained counterparts. Wilderness training increased hikers' preparedness for AMS but did not significantly alter preparedness for illness/injury.

**KEY WORDS:** Hiking, wilderness; Acute mountain illness; Injury; Training

World J Emerg Med 2018;9(3):172–177

DOI: 10.5847/wjem.j.1920–8642.2018.03.002

## INTRODUCTION

Most injury-related deaths occur in wilderness areas before emergency medical services (EMS) are able to reach the patient.<sup>[1]</sup> Therefore, hikers should make every effort to avoid injuries and illnesses and must be prepared for treatment and stabilization when they occur. The most common mishaps in the wilderness are acute mountain sickness (AMS), asthma attacks, blisters, and sunburns,<sup>[2]</sup> which are all easily preventable.

Formal medical training used by first responders and emergency medical technicians is very useful in hiker preparedness. In fact, the incidence of such medical training in wilderness-goers has been increasing over time. In 2002, Gardner and Hill reported that <20% of hikers on the Long Trail in Vermont hadn't any medical training.<sup>[3]</sup> Five years later, the vast majority of a surveyed group of canyoneers had basic life support (BLS) or cardiopulmonary resuscitation (CPR), with more than

half reporting having more advanced first aid training.<sup>[4]</sup> Understanding the impact that medical training has on hiker preparedness could aid efforts to educate hikers on adequate safety and preparedness.

A few studies have examined the correlation between medical training with general hiker preparedness,<sup>[5,6]</sup> but none has linked training with levels of preparedness or preparedness for altitude exposure. Medical training may have an impact on altitude preparedness through potentially increased awareness of the physiological changes involved in altitude sickness. We hypothesize that higher levels of medical training and wilderness training will correlate with better levels of preparedness for AMS, injuries, and illness.

## METHODS

We conducted a cross-sectional survey of hikers on backcountry trails in Rocky Mountain National Park (RMNP) in July and August 2015. The RMNP was chosen because of its relatively high elevation and the popularity of the location, ensuring adequate power of the study. We approached hikers in four areas of the park: Wild Basin (4 days), Bear Lake Area (5 days), West Side (3 days), and Longs Peak (2 days). These regions were selected to provide a representative sample of hikers through high volume, location, and difficulty level. Hikers were informed of the study objectives and asked if they would be interested in participating. Those who were interested and who met our inclusion criteria (age  $\geq 18$  and competent in written English) consented by filling out the survey. This study was approved by the institutional review board of the academic medical center with which the authors are affiliated.

Most survey questions required binary or spectrum responses; open-answer responses were required to document demographic information and to assess knowledge of AMS. Subjects selected their own level of wilderness experience (none, little, some, experienced). The survey asked their number of days of wilderness experience per year and their years of wilderness experience to document their perceived level of experience. Similarly, subjects' altitude experience was based on self-selection (none, little, some, experienced).

Because there is no accepted convention for determining hiker preparedness for AMS, we developed our own four-point scale to assess altitude preparedness. Subjects who scored three or more points were categorized as "altitude prepared". One point was awarded for each of the following: having an altimeter

or equivalent (topographic map + compass or a GPS device), taking or considering pharmacologic altitude illness prophylaxis, self-reporting a safe ascent plan, and knowing at least two of the major symptoms of AMS (headache, emesis, fatigue, difficulty sleeping, tachycardia, irritability, dyspnea, and dizziness). Experience provides the most concrete knowledge of a person's altitude tolerance; this four-point system is flexible enough to allow experienced hikers who know they do not need prophylaxis and do not carry an altimeter to be "altitude prepared". It also classifies the less experienced as prepared if they have given sufficient thought to the issue of altitude illness. This system, while imperfect, encompasses the basics of high-altitude safety. Hikers who did not consider prophylaxis but who have a safe ascent plan, carry an altimeter, and know how to recognize AMS are generally recognized as prepared for altitude. Similarly, hikers with prophylaxis, an altimeter, and knowledge of AMS symptoms would be considered prepared. Symptoms more exclusive to altitude illnesses such as high altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE) (e.g., ataxia, altered mental status, dyspnea on rest) were not scored, because it was our intention to ask hikers about AMS, which is much more common than HAPE and HACE, especially in the RMNP, where the altitude maximum is around 14,000 feet.

Similarly, there is no universal convention for determining hiker preparedness for illness and injury. Subjects were categorized as prepared for illness and injury ("wilderness prepared") by having 7 of the 10 hiking "essentials,"<sup>[7,8]</sup> a map or equivalent, and either two rescue devices or 9/14 of recommended first aid items. The rationale for this system is that prepared hikers should carry the "essentials" of hiking, should be able to orient themselves in the world, should be able to signal for help, and should be able to administer basic first aid in the event of injury. We chose 9/14 first aid items as the cutoff, given that hikers should be able to improvise a splint, hemorrhage control, and tourniquets; should have sunscreen and blister care; should carry acetaminophen and ibuprofen; and ought to carry at least two of the other items. Cell phones counted as rescue devices but not GPS devices.

Subjects with medical training more advanced than cardiopulmonary resuscitation, and wilderness first aid (WFA) were considered "medically trained". Those who had earned National Outdoor Leadership School qualifications in wilderness first aid (WFA), as a wilderness first responder (WFR), or as a wilderness

emergency medicine technician (WEMT) were considered “wilderness trained”. WFA is an introductory course to wilderness medicine, consisting of 16 hours of training over the course of 3 days. WFR is a more advanced course aimed at wilderness guides, search and rescue teams, and others in the outdoor industry; the course consists of 70 hours of training over 9 or 10 days. The WEMT curriculum qualifies trainees as EMTs with wilderness specialization and consists of 200 hours of training over 5 weeks.

Our data were stored and analyzed using Microsoft Excel 2010 (Microsoft Corp, Redmond, Washington) and SAS University Edition 3.4 (SAS Institute, Inc., Cary, North Carolina). We planned to enroll more than 300 hikers, as this number would provide sufficient sample size to find a 15% absolute difference in the proportions of hikers who are well prepared between groups using chi-squared single-variable analysis, with extra power for multivariate logistic regression. This calculation used standard parameters, alpha 0.05 and beta 0.2 (power: 0.8). We performed multivariate logistic regression to assess which types of experience independently predict wilderness or altitude preparedness. The explanatory variables that we included are medical training, wilderness training, wilderness experience, age, and gender.

## RESULTS

We collected data from 380 individuals: 184 in Wild Basin, 89 in the Bear Lake Area, 38 in West Side, and 69 at Longs Peak. We approached hikers at least half a mile from trailheads. Data were collected at altitudes ranging from 7,800 feet (Wild Basin) to 12,760 feet (Longs Peak boulder field). Participants’ levels of training are presented in Table 1. Half of them ( $n=190$ ) were day hikers, and the remainder planned to spend one or more nights in the park. Sixty-nine subjects (18.2%) had medical training more advanced than CPR. Sixty-six (17.4%) had wilderness training (certified in WFA, as a WFR, or as a WEMT). Fourteen (3.7%) had both wilderness and medical training, representing an overlap of about 20%.

Respondents with wilderness training were not significantly more likely to be prepared for illness and injury than participants without such training (31.8% vs. 22.0% [ $P<0.11$ ]). Unadjusted, those with wilderness training were more likely to be prepared for AMS (52.3% vs. 36.8% [ $P=0.025$ ]) (Table 2), but this effect did not persist when controlling for other variables such as

medical training. Adjusting for experience, wilderness training, age, and gender, we found that medical training was associated with increased preparedness for injury and illness (odds ratio [OR] 2.71, 95% CI 1.5–4.89) and AMS (OR 2.72, 95% CI 1.51–4.91) (Table 3).

For all levels of altitude or wilderness experience, medically trained hikers had a higher proportion of preparedness for AMS than those without such training (62.3% vs. 34.3% [ $P<0.001$ ]) (Table 4). Although this difference is not statistically significant in the population with no or little wilderness experience (only 12 subjects in this category), the trend of increased preparedness among the medically trained continued. In every category, the medically trained hikers had a substantially higher likelihood of being prepared compared with the non-trained. As expected, individuals with more altitude or wilderness experience were more likely to be prepared for AMS than less experienced individuals. Specifically, wilderness-experienced individuals were more likely to be prepared for AMS than less experienced individuals (41.6% vs. 25%). Altitude-experienced subjects were more likely to be prepared for AMS than subjects with no or little altitude experience (42.9% vs. 30%). Similarly,

**Table 1.** Highest level of training

Parameters	Number
Medical training (379 total responses)	
None	134
Cardiopulmonary resuscitation (CPR)	177
Medical assistant (MA)	3
Certified nursing assistant (CNA)	3
Combat life saver (CLS)	2
Physical therapist (PT)	3
Emergency medical technician (EMT)	13
Wilderness-EMT (WEMT)	4
Registered nurse (RN)	21
Licensed practical/vocational nurse (LPN/LVN)	2
Physician assistant (PA)	2
Medical doctor (MD)	13
Doctor of pharmacy (Pharm D)	1
Doctor of dental medicine (DMD)	1
Wilderness training (378 total responses)	
None	315
Wilderness first aid (WFA)	52
Wilderness first responder (WFR)	7
Wilderness EMT (WEMT)	4
Sex (379 responses)	
Male	221 (58.3%)
Female	158 (41.7%)
Age groups (379 responses)	
18–30	112 (29.6%)
31–40	66 (17.4%)
41–50	58 (15.3%)
51–60	90 (23.7%)
61+	53 (14.0%)
Consecutive days in wild (373 responses)	
Day hike	190 (50.8%)
2–3 days	90 (24.1%)
3+ days	94 (25.1%)

the medically trained hikers were more prepared for illness and injury than hikers without medical training (37.7% vs. 20.7% [ $P=0.003$ ]). As before, surveying only 12 subjects with no or little wilderness experience renders the results for the category statistically insignificant ( $P=0.42$ ). The raw numbers show a smaller proportion of prepared hikers in the experienced group (Table 4).

Wilderness training (WFA, WFR, WEMT) did not affect hiker preparedness for AMS or illness and injury as robustly as medical training. Although individuals of all experience levels with wilderness training

were more likely to be prepared for AMS (52.3% vs. 36.8% [ $P=0.025$ ]), this difference was not statistically significant within experience categories ( $P=0.07$ ,  $P=0.13$ ,  $P=0.06$ , and  $P=0.12$ ). As for preparedness for illness and injury, the effect of wilderness training was not statistically significant ( $P=0.11$ ). However, the trends do suggest that more wilderness-trained hikers than non-trained hikers are prepared to respond to illness and injury (31.8% vs. 22% [ $P=0.11$ ]) (Table 2).

Taking into account other variables (age, experience, gender, and medical training) with a regression model, we found that wilderness training did not significantly increase preparedness for AMS (Table 4). While the odds ratio of 1.41 reflects an overall trend toward increased preparedness in wilderness-trained hikers, the 95% *CI* (0.76–2.62) does not inspire confidence in the significance of this finding. Similarly, the regression model for altitude experience (*OR* 1.18, 95% *CI* 0.6–2.31) did not indicate a significant role for altitude experience in determining hiker preparedness for AMS. Age (*OR* 1.0, 95% *CI* 0.98–1.02) was convincingly a non-factor in determining hiker preparedness for AMS. Interestingly, wilderness experience (*OR* 0.75, 95% *CI* 0.32–1.3) trended in the direction of reducing

**Table 3.** Regression tables

Parameters	OR Ratio	Full model	
		95% CI	
Wilderness prepared			
Wilderness experience	0.80	0.37	1.71
Wilderness training	1.45	0.79	2.70
Age	1.00	0.98	1.02
Male	2.71	1.57	4.69
Medical training (2–5)	2.71	1.50	4.89
Altitude prepared			
Altitude experience	1.18	0.60	2.31
Wilderness experience	0.75	0.32	1.73
Wilderness training	1.41	0.76	2.62
Age	1.00	0.98	1.02
Male	2.74	1.57	4.78
Medical training (2–5)	2.72	1.51	4.91

**Table 2.** Altitude and wilderness preparedness stratified by medical training and experience, *n* (%)

Altitude/wilderness experience	Total	All ( <i>n</i> =375)	Not medically trained ( <i>n</i> =306)	Medically trained ( <i>n</i> =69)
		Altitude prepared		
Altitude: none/little	90	27 (30)	17 (23.3)	10 (58.8)
Altitude: some/experienced	280	120 (42.9)	87 (38.0)	33 (64.7)
Wilderness: none/little	48	12 (25)	8 (21.6)	4 (36.7)
Wilderness: some/experienced	327	136 (41.6)	97 (36.1)	39 (67.2)
All	380	148 (39.5)	105 (34.3)	43 (62.3)
		Wilderness prepared		
Wilderness: none/little	49	12 (24.5)	8 (21)	4 (36.4)
Wilderness: some/experienced	331	78 (23.6)	56 (20.6)	22 (38.0)
All	380	90 (23.8)	64 (20.7)	26 (37.7)

Some data fields total less than 380 because not all participants answered all questions on the survey. Values in parentheses represent the percentage prepared. “Altitude prepared” was defined as at least three of these four elements being true: having an altimeter, taking/considering AMS prophylaxis, having a safe ascent plan, knowing at least two symptoms of AMS. “Wilderness prepared” was defined as having 7 of 10 hiking “essentials” and either 2 of 5 rescue devices or 9 of 14 recommended first aid items.

**Table 4.** Altitude and wilderness preparedness stratified by wilderness training and experience, *n* (%)

Altitude/wilderness experience	Total	All ( <i>n</i> =375)	Not wilderness trained ( <i>n</i> =310)	Wilderness trained ( <i>n</i> =65)
		Altitude prepared		
Altitude: none/little	90	27 (30)	22 (27.2)	5 (55.6)
Altitude: some/experienced	285	120 (42.9)	91 (40.6)	29 (51.8)
Wilderness: none/little	49	12 (25)	10 (21.7)	2 (100)
Wilderness: some/experienced	331	136 (41.6)	104 (39.4)	32 (50.8)
All	380	148 (39.5)	114 (36.8)	34 (52.3)
		Wilderness prepared		
Wilderness: none/little	49	12 (24.5)	10 (21.3)	2 (100)
Wilderness: some/experienced	331	78 (23.6)	59 (22.2)	19 (29.7)
All	380	90 (23.8)	69 (22.0)	21 (31.8)

Some data fields total less than 380 because not all participants answered all questions on the survey. Values in parentheses represent the percentage prepared. “Altitude prepared” was defined as at least three of these four elements being true: having an altimeter, taking/considering AMS prophylaxis, having a safe ascent plan, knowing at least two symptoms of AMS. “Wilderness prepared” was defined as having 7 of 10 hiking “essentials” and either 2 of 5 rescue devices or 9 of 14 recommended first aid items.

preparedness for AMS, although not significantly. Continuing with the regression models in Table 4, we see that male gender (*OR* 2.74, 95% *CI* 1.57–4.78) noticeably increased preparedness for illness and injury. Although wilderness training failed to appreciably affect preparedness for AMS when taking into account other variables (age, experience, medical training, gender), medical training noticeably increased AMS readiness (*OR* 2.72, 95% *CI* 1.51–4.91) (Table 3).

The regression model results for preparedness for illness and injury were quite similar to those for AMS preparedness. Wilderness training (*OR* 1.45, 95% *CI* 0.79–2.7) did not appear to affect readiness for illness and injury. Age still appeared to be a complete nonfactor (*OR* 1.0, 95% *CI* 0.9–1.02). Wilderness experience similarly trended toward decreasing preparedness for illness and injury (*OR* 0.8, 95% *CI* 0.37–1.71). Male gender also increased preparedness for illness and injury (*OR* 2.71, 95% *CI* 1.57–4.69). As before, medical training (*OR* 2.71, 95% *CI* 1.5–4.89) noticeably increased preparedness for illness and injury when adjusting for age, experience, wilderness training, and gender (Table 3).

## DISCUSSION

We surveyed hikers in RMNP to determine how medical and wilderness training affects preparedness for AMS, injury, and illness. We hypothesized that medical training above the level of CPR would correlate with level of preparedness for both altitude and injury, which our results strongly support. Across all experience levels (except no or little wilderness experience), we found 20% to 30% greater preparedness in the medically trained group. This difference could be due to greater experience applying medical training to wilderness issues. It could also be due to greater awareness of potential bodily harms that may occur in general; medical training of all levels teaches the learner to think critically about mechanisms and treatment of injury. Thus, while pharmacists and physical therapists possess a limited background in first aid, the nature of their medical training would increase their awareness of potential dangers in the backcountry.

Surprisingly, wilderness training, once controlled for other factors, did not affect hiker preparedness for AMS or illness/injury. This could be due to the very brief nature of WFA training, the level attained by most of the wilderness-trained group.

Our data also show a strong correlation between

gender and preparedness: males were 2.74 times more likely to be prepared than females. We observed that males in mixed-gender parties tended to carry more gear than the females. Because of this imbalance, females might not have been aware of the items their party members were carrying when they filled out the survey. This would especially apply to day hikers sharing one backpack between two people. Thus, if the male was carrying the pack, then the female would seem unprepared since she would not be carrying any of her “individual” items. Although this might seem like an artefactual result, it has a practical application, in that, if a party member relies on another to carry everything, the one without the pack has no equipment if the two get separated. This common arrangement could explain the apparent gender difference in hikers’ preparedness for illness and injury, but it does not explain the disparity in altitude preparedness, since our evaluation of this topic was based on knowledge, planning, and the possession of an altimeter (or altimeter equivalent) by the group rather than an individual.

Past studies found that older hikers were more likely to be prepared than younger hikers,<sup>[7]</sup> but our data show no such association (Table 3). Age might be a proxy for experience, in that older hikers might carry more equipment than younger hikers because they know what can happen in the wilderness. However, this effect is likely to be diminished in the RMNP since many hikers view the park as a “destination wilderness” and thus bring along equipment they would not bring on ordinary hikes. The abundance of wilderness experience in our study population might have drowned out the effect of age on preparedness. A recent survey of climbers summiting 14,000-foot peaks in Colorado found preparedness increased with age. The investigators did not account for differences in experience within age groups and did not define levels of “prepared” versus “not prepared”. The same study examined the effects of medical training on knowledge and preparedness and found that medical knowledge increased with medical training, looking primarily at first aid, first responder, and EMT certifications. This finding did not apply to preparedness scores.<sup>[9]</sup>

Many previous investigators collected data through online surveys or at trailheads, whereas we collected data on trails in the backcountry, increasing the accuracy and immediacy of our data. By collecting information on site, we eliminate the inaccuracy of recall-based surveys. We selected Rocky Mountain National Park as our study location due to its 3.5 million annual visitors on trails of

varying difficulty and altitude, allowing us access to a large and diverse sample population.

One limitation of our study is its low number of subjects with no or little wilderness experience. This is likely the result of our selection of study locations; it seems unlikely that people who have never been hiking would select RMNP, especially the deep backcountry areas, unless they were with a group of more experienced hikers. Similar studies conducted in state parks and more urban regions would probably involve hikers with less experience. It is also noteworthy that Coloradans as a whole are more active compared with residents of other states and have the lowest rate of obesity.<sup>[10]</sup> Another limitation is that we encountered relatively few hikers with wilderness training. While we estimate that response rates were high, potential subjects who were not surveyed represent a possible source of selection bias. Although the effect of wilderness training on preparedness was not statistically significant, we are confident that a higher-powered study would confirm that wilderness training makes one more likely to be prepared for illness and injury.

Further studies are needed to determine the effect of training and preparedness on actual rates of injury, as we have only assumed there is a direct link. Understanding the training that hikers have would be useful as we refine educational programs in an effort to reduce activating local EMS systems. Furthermore, studies designed to identify the subpopulation of hikers who activate the EMS system most frequently would be very useful in determining what kind of training should be targeted to whom.

## CONCLUSIONS

Medically trained hikers were more likely to be prepared for altitude, medical emergencies, and trauma than their non-trained counterparts. Wilderness-trained hikers were similarly more prepared for altitude sickness. These relationships likely reflect hikers' awareness of hazards in the wilderness and the steps that can be taken to avoid them. Future data on actual injury rates and population makeup would clarify these relationships.

## ACKNOWLEDGMENT

The manuscript was copyedited by Linda J. Kesselring, MS, ELS, the technical editor/writer in the Department of Emergency Medicine at the University of Maryland School of Medicine.

**Funding:** None.

**Ethical approval:** This study was approved by the institutional review board of the academic medical center with which the authors are affiliated.

**Conflicts of interest:** None to declare.

**Contributors:** Study concept and design: DGS, MDY, DWS; Obtaining funding: MDY, DWS, DGS, DBG; Acquisition of the data: DWS, MDY; Analysis of the data: DBG, MDY, DWS; Drafting of the manuscript: MDY, DWS; Critical revision of the manuscript: DGS, DBG; Manuscript review: MDY, DWS, DBG, DGS; Guarantor: DGS.

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Received October 9, 2017

Accepted after revision March 10, 2018