

# Wilderness Mortalities: A 13-Year Experience

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**Study objective:** To analyze the epidemiology of wilderness mortalities in a localized area with diverse terrain.

**Methods:** We conducted a retrospective review of the Pima County (Arizona) Sheriff's Office (PCSO) search and rescue logs and case reports, hospital records, and autopsy reports for all wilderness deaths from 1980 to 1992. The study group comprised all victims of injury or illness in Pima County wilderness who died during a 13-year period in a location remote enough so that standard ground-based emergency medical services units could not extract the body.

**Results:** One hundred fatalities occurred during the 13-year study period. There were 59 unintentional traumas, 18 suicides, 9 homicides, 12 medically related deaths, and 2 deaths of unknown causes. Toxicology tests performed on body fluids yielded positive findings for alcohol in a total of 50 (50%) cases and positive findings for drugs of abuse in 12 (12%) cases. It was estimated that alcohol was "a very probable" or "a probable" causative factor in 23 (40%) of the 59 unintentional trauma deaths, and in 1 (8.3%) of the 12 medically related deaths. Fifty-five (55%) deaths were witnessed events, with 45 (80%) of these victims reported as dying immediately or before arrival of search and rescue personnel. Ten (10%) victims received resuscitation in the field, and according to a review of hospital charts and autopsy reports, only 2 victims had a potentially survivable injury or illness.

**Conclusion:** Many wilderness mortalities are related to incidents involving alcohol. Once the accident or injury has occurred, the majority of deaths are immediate, or at least before the arrival of medical personnel. Higher levels of medical care would not have improved the outcomes of those who did survive long enough to receive medical care. Therefore, primary efforts to reduce mortalities in the wilderness should be directed toward prevention, especially diminishing alcohol use in wilderness areas.

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## INTRODUCTION

As more people discover the “outdoors,” it is inevitable that there will be an increase in accidents and injuries in that environment. Given the current budgetary constraints for developing additional emergency medical services (EMS) support, limited resources must be allocated in the most cost-effective manner.

It has already been established that outcomes in many areas of emergency medicine can be effectively improved through injury prevention. Therefore, by looking at the epidemiology of wilderness mortalities, it may be possible to identify certain recurrent causative factors that can become target areas for prevention.

It was our hypothesis that alcohol and drugs have a substantial role in wilderness mortalities, and that more sophisticated out-of-hospital medical care would not change these outcomes.

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## MATERIALS AND METHODS

We conducted a retrospective review of the Southern Arizona Rescue Association's (SARA) logs from 1980 to 1992. These logs encompass all wilderness incidents for Pima County, Arizona, and are maintained by the Pima County Sheriff's Office (PCSO). These particular dates were chosen because the current method of logging all “callouts” and subsequent case reports was initiated in 1980.

SARA is a volunteer organization that works under the direction of the search and rescue division of the PCSO. This division consists of 2 full-time paid officers (emergency medical technicians or paramedics) who act as coordinators for all activities in this area. The volunteer group is only activated when a situation requires specialized expertise and manpower in search, rescue, or body recovery. In addition, a Department of Public Safety helicopter or military helicopter is available when necessary.

SARA averages about 150 responses per year (range 114 to 201) and responds to an average of 7.7 calls with fatalities per year (range 4 to 17). The wilderness terrain covered by this organization is diverse. It ranges from extremely harsh desert to 9,000-ft mountain ranges with many canyons, lakes, caves, and rivers. Some of its activities have been previously described.<sup>1</sup> The area's wilderness activities include rock climbing (both technical and recreational), canyon exploring, hiking, swimming, cliff diving in rivers and lakes, caving, and river rafting. A unique aspect of the

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region is that the county is one of the nation's largest, with 9,241 square miles, although the water surface area is only 1.1 square miles. Many of its wilderness areas are quickly and easily accessible from the region's major metropolitan areas. Between 1980 and 1993, the county's population grew from 531,263 to 712,600 permanent residents. It also attracts numerous part-time residents and visitors, especially in the winter months.

The written report of each incident generated by the PCSO liaison officer was reviewed. These reports included information regarding victim demographics, location, presumed cause of the incident (unintentional trauma, homicide, suicide, medical, or unknown), type of incident, a description of the scene, condition of the victim, and any medical care rendered at the scene. When there was a witness to the incident, an attempt was made to determine the time lapsed between the incident and actual time of death. If ambulance personnel responded, their reports were also reviewed along with any hospital records for the victim's condition, types of injuries, and hospital course. All autopsies were performed by the Pima County Medical Examiner's office, and those reports were reviewed for cause of death, types of injuries, and alcohol and toxicology results. Samples for determination of alcohol levels and toxicology screenings were obtained from blood, vitreous humor, or bile. From the history of the incident, scene evidence, and autopsy results, the authors assigned a probability (“not probable,” “probable,” or “very probable”) as to whether alcohol or drugs contributed to the incident.

All data were entered into a base file and interpreted and analyzed by Epi Info (Centers for Disease Control and Prevention; Atlanta, GA; 1992).

Our institutional review board deemed this study to be exempt from full review.

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## RESULTS

One hundred wilderness mortalities were reported in Pima County, Arizona, from 1980 to 1992. These involved 87 males and 13 females with a mean age of 33.9±17.8 years (range 5 to 80 years). Only 6 (6%) of the deaths occurred in children younger than 15 years. Thirty-three (33%) of the victims were 15 to 25 years old, 28 (28%) were 26 to 35 years old, 9 (9%) were 36 to 45 years old, 13 (13%) were 46 to 55 years old, and 11 (11%) were older than 55 years. The types of locations in Pima County where these wilderness mortalities occurred included desert terrain (44%), mountains (29%), rivers and lakes (26%), and caves (1%).

Seventy-two of the victims lived in Pima County and another 14 resided in neighboring counties within Arizona. Only 3% were out-of-state visitors. This may be because visitors tend not to visit the more dangerous or remote parts of the surrounding wilderness, primarily visiting wilderness areas specifically designed for safe use. Local residents, who often treat the wilderness as simply an extension of their urban environment, are more casual about putting themselves in dangerous situations.

The racial distribution of the deaths was fairly consistent each year, with the total distribution over the 13 years being 67% white, 16% Hispanic, 9% Native American, 3% black, and 5% other or unknown race. This racial distribution roughly paralleled the permanent population distribution in Pima County during the study period, with the exception of a small, but significantly higher incidence for Native Americans (9%), who accounted for only 2.4% to 2.6% of the total population.

The types of incident that resulted in wilderness mortalities (Table) were divided into the general categories of unintentional trauma (59%), suicide (18%), homicide (9%), medically related death (12%), and unknown (2%). An attempt was made to determine whether there was a statistical difference between the type of incident and the race of the victim, but the total population was too small for the  $\chi^2$  test to be meaningful.

Each incident then was further categorized on the basis of the mechanism of injury (Table). Of the 59 unintentional trauma mortalities, there were 17 (28.8%) falls, 18 (30.5%) combined falls/drowning, 15 (25.4%) drownings, 3 (5.1%) motor vehicle crashes, 2 (3.4%) gunshot wounds, 1 (1.7%) motorcycle crash, and 3 (5.1%) victims of aircraft crashes (5.1%). The falls/drowning category was used when there was a fall from a rock face into water that resulted in a drowning or when the victim was swept over a waterfall resulting in drowning or fatal blunt trauma.

There were 12 medically related deaths. These included 7 victims of heat exposure, 4 primary cardiac cases, and 1 diabetes-related death. Of the 18 suicides, there were 10 gunshot wounds, 2 motor vehicle crashes (cars intentionally driven over a cliff), 3 hangings, 2 overdoses with suicide notes, and 1 victim who jumped from a cliff. Of the 100 total victims, there were 2 cases in which the type of incident and cause of death were indeterminable because of advanced decomposition of the bodies.

Each incident also was categorized as to actual cause of death. For the 17 falls, the causes of death included 14 related to head injuries, 2 to cervical spine injuries, and 1 to a fall with a hip fracture in which the actual cause of death was subsequent cold exposure. In the 18 cases of falls/drowning, there were 10 head injuries, 4 cervical spine injuries, 3 drownings, and 1 case of multiple great vessel injuries to the chest.

Of the 35 cases of falls and falls/drowning, only 1 incident occurred during a technical rock climb with ropes and protection. Twelve of the 17 falls were witnessed events that occurred as a result of slipping while free climbing or rock scrambling. The average fall was from a height of 53±24 ft. Of the 18 falls/drowning, 17 occurred in one particular location, a popular picnic site with many waterfalls.

Of all the cases in this study, only 55 (55%) were witnessed events, and in 39 (56.4%) of these witnessed cases, death occurred immediately. Six additional victims died before the arrival of search and rescue personnel.

There were only 10 (10%) cases during the entire study period where resuscitation was attempted in the wilderness setting by either a paramedic or physician. Of these 10 victims, 3 were in cardiac arrest on arrival of medical personnel. In 2 cases, resuscitation was initially attempted, then discontinued at the scene. One victim found in cardiac arrest was transported to the hospital and subsequently was declared dead in the emergency department. Another victim had a cardiac arrest while en route by helicopter to the hospital, 3 others had arrests after arrival at the ED, and 3 victims died later during their hospital

**Table.**

*Types of incidents resulting in wilderness fatalities.*

Type of Incident	% of Total Cases
<b>Unintentional trauma</b>	
Falls/drowning	18
Falls	17
Drowning	15
Motor vehicle crash	3
Aircraft crash	3
Gunshot sound	2
Motorcycle crash	1
<b>Suicides</b>	
Gunshot wounds	10
Motor vehicle crash	2
Hanging	3
Overdose	2
Jump	1
<b>Medically related deaths</b>	
Heat exposure	7
Cardiac	4
Diabetes	1
<b>Homicide</b>	9
<b>Unknown cause</b>	2

course. A review of these 10 autopsies revealed only 2 victims who were potentially survivable: 1 who sustained a liver laceration as a result of a fall and 1 victim of heat-stroke. The other 8 victims had injuries that were incompatible with life, including 7 with head injuries or spinal trauma and 1 with severe burn injury.

Of the 100 cases reviewed, 79 (79%) autopsy reports or ED records had documented alcohol levels, and 69 (69%) also had drug toxicology screening performed. Alcohol and toxicology tests were not performed in all cases because during the earlier years of this study, these tests were not a routine part of ED care or autopsies. A variety of fluids (urine, blood, and bile) were used depending on the prevalent method of testing at the time of the autopsy and on the state of body decomposition. Of the 79 cases tested for ethanol, 50 (63%) yielded positive findings. Thirteen (13% of the total victims) of the victims had an alcohol level between 0 and 49 mg/dL, 9 (9%) had levels between 50 and 99 mg/dL, 13 (13%) had levels between 100 and 149 mg/dL, 4 (4%) had levels between 150 and 199 mg/dL, 9 (9%) had levels between 200 and 299 mg/dL, and 2 (2%) victims had levels greater than 300 mg/dL. This translates to a total of 28 victims, or 35% of all fatalities in which testing was performed, with an alcohol level greater than 100 mg/dL.

Of the 69 toxicology screenings, 12 yielded positive findings (cocaine found in 6, cannabis in 1, benzodiazepines in 1, and narcotics in 4). All 6 victims with positive test results for cocaine suffered unintentional trauma and also had positive results for alcohol. Suicide was the cause of death in the 4 victims with positive findings for narcotics.

A review of the PCSO's report was performed for cases with positive results for alcohol or drugs. Based on these reports, a probability was assigned as to whether alcohol or drugs was "a very probable," "a probable," or "not a probable" causative factor of the incident. Because it is difficult to ascertain the exact role of drugs and alcohol in cases of suicides and homicides, only the cases of unintentional trauma and medically related deaths were considered. In 17 (28.8%) of the 59 cases of unintentional trauma, it was very probable that alcohol or drugs was a causative factor. They were a probable factor in another 6 (10.2%) cases of unintentional trauma, and in 1 case of heat exposure.

## DISCUSSION

What do these results suggest can be done to decrease the number of deaths in wilderness areas adjacent to metropolitan areas?

The overwhelming majority of victims in this study were Arizona residents (97%), not visitors as previously believed. In addition, there was only 1 heat-related fatality in a visitor. This is surprising given Pima County's harsh desert environment. Thus, using resources to educate visitors would not have a substantial impact on wilderness mortalities. Local public health education targeting the Arizona residents would be far more useful.

Not surprisingly, open water, especially in desert regions, attracts large numbers of wilderness users—and subsequently results in a disproportionate share of wilderness deaths. One particular open-water area, Tanque Verde Falls, was the site of 21 deaths during this study's 13-year period. This area has 3 adjacent waterfalls, with the highest 90 ft. It is a popular place for rock scrambling, cliff diving, and swimming. Unfortunately, the rocks can be deceptively slippery, and flash floods are quite common. A flash flood in 1981 swept 8 people to their deaths over these waterfalls. In subsequent years, there continued to be 1 to 2 deaths there each year. In 1986, SARA widened and improved the 1/2-mile trail from the road to the bottom of the falls (so that people would be at the bottom and could not fall over the falls) and posted several warning signs. The number of fatalities subsequently decreased.

Falls while climbing, including falls with subsequent drowning, accounted for a significant number of fatalities (35 cases). Only 1 of these accidents occurred during a technical rock climb with ropes. The other 34 incidents involved falls while rock scrambling or free climbing without any protection. Nineteen of these falls occurred at the Tanque Verde Falls site. Of these 19 cases, 14 (73.7%) were in victims with alcohol levels exceeding 100 mg/dL, and it was estimated that intoxication was a very probable causative factor in 6 (31.6%) incidents and a probable causative factor in 3 (15.8%) incidents. Five of the 8 victims of the flash flood in 1981 were also significantly intoxicated, but it was determined that their levels of intoxication were probably not a contributing factor to their deaths. These data demonstrate the danger and high mortality of free climbing and rock scrambling while intoxicated. This population, and especially at this location, would be a good target group for future injury prevention studies.

It is known that bacteria in some corpses can produce alcohol after death. Postmortem alcohol production can be suggested from test results showing the presence of alcohol in only one body fluid, atypical distribution of alcohol in the body, or the presence of complex alcohols (C3, C4). Such production can raise the alcohol level to 0.15% to 0.20%.<sup>2</sup> The methodology varied for sample

analysis during the study, but primarily used alcohol levels in vitreous fluid, which most courts accept as valid.<sup>3</sup>

In 55 of the 100 fatalities, someone witnessed the fatal event, with 45 (82%) of the victims dying immediately or before the arrival of SARA personnel. In all cases where death did not occur immediately, an attempt was made to look at the times from incident occurrence to receipt of a 911 call, and then to the time elapsed until medical care reached the victim. Unfortunately, documentation of these times was incomplete in too many cases to draw any conclusions. However, autopsy reports did clearly show that in the overwhelming majority of those victims who did not die immediately, their injuries were not survivable. Of the 10 victims who received medical care in the field, only 2 were even potentially survivable based on the type of injury (liver laceration) or medical condition (heat-stroke). One can only speculate on the outcomes on these cases if they had occurred where rapid medical care was available. Several other studies of wilderness injuries have also shown that fatalities usually occur immediately after an event, or that they are not survivable based on the overall injury severity.<sup>4,5</sup> This suggests that using precious resources to upgrade wilderness EMS most likely will not result in a significant reduction in mortalities. It appears from these data that limited resources would be much more effective if directed toward injury prevention.

Some other wilderness deaths may not have been included. SARA participated in removing the deceased only when they were in areas that standard EMS personnel could not easily reach. Thus, in cases where deaths occurred close to ambulance-accessible roads, SARA was not activated. Separate records are not kept of these incidents, but most were automobile-related deaths.

Another limitation of this study is that only wilderness deaths are included. During the study period, there were at least 3 cases where wilderness cardiac resuscitations by SARA personnel resulted in survival to hospital discharge in a premonitory functional state. One was a cardiac arrest requiring cardiopulmonary resuscitation (CPR) after an in-field myocardial infarction and the other 2 were witnessed arrhythmias after in-field myocardial infarctions with defibrillation to a sinus rhythm after a short period of CPR. Care should also be taken not to discount the decreased morbidity from search and rescue responses. This was especially true for trauma patients who arrived in the hospital early enough to reduce serious morbidity or long-term adverse sequelae.

In summary, many wilderness deaths are related to incidents, especially falls, involving alcohol use. Once the accident or injury has occurred, the majority of deaths are

immediate, or at least before the arrival of medical personnel. In this study, higher levels of medical care would not have improved the outcomes of those who did survive long enough to receive medical care. Therefore, primary efforts to reduce mortalities in the wilderness should be directed toward prevention, especially diminishing alcohol use in users of wilderness areas.

Further studies are needed to assess the response times to wilderness incidents, and to determine whether a reduction in those times could help to reduce associated morbidities.

## REFERENCES

1. Iserson KV. Injuries in search and rescue volunteers—a 30-year experience. *West J Med.* 1989;151:352-353.
2. Gilliland MGF, Bost RO. Alcohol in decomposed bodies: postmortem synthesis and distribution. *J Forensic Sci.* 1993;38:1266-1274.
3. Coe JI. Postmortem chemistry update: emphasis on forensic application. *Am J Forensic Med Pathol.* 1993;14:91-117.
4. Gentile DA, Morris JA, Schimelpfenig T, et al. Wilderness injuries and illnesses. *Ann Emerg Med.* 1992;21:7:853-61.
5. Johnson J, Maertins M. Wilderness emergency medical services: the experiences at Sequoia and Kings Canyon National Parks. *Am J Emerg Med.* 1991;9:211-216.