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Cold-Related Non-Fatal Injuries in Alaska

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INTRODUCTION

As in northern Finland and Sweden, the Arctic and subarctic environments of Alaska provide a hazardous work setting, exacerbated by great distances, seasonal darkness, very cold waters, high winds, often brief hunting and fishing seasons, and high icing potential. Augmenting the obvious and often synergistic hazards of exposure to cold air, wind, moisture, and water immersion are numerous environmental and human factors which may exacerbate these exposures.

While many temperate portions of the earth experience seasonal and intermittent deep freezing temperatures, with resultant work hazards, the polar and circumpolar regions afford the most prolonged and severe periods of these conditions. While the southern circumpolar region (primarily Antarctica) is very sparsely populated, the northern circumpolar region is quite variable in its population density, with portions of the Nordic nations (Norway, Denmark, Sweden, and Finland) and some northern portions of the Russian Federation being sporadically heavily urbanized, while other areas, such as the Canadian north, Siberia, Greenland, and much of Alaska and Iceland, remain sparsely populated. The entire circumpolar regions are immersed in colder temperatures than elsewhere seasonally, but the intensity of this phenomenon varies considerably, with northern Scandinavia, Finland, and Iceland experiencing much more moderate temperatures (due to the influence of the Atlantic Gulf Stream) than those encountered in Greenland, Siberia, northern Canada, and the Alaskan interior, all of which are regularly exceeded by Antarctic winters. Workers in all regions of the planet are also exposed to substantial cold hazard in cold storage and food freezing and processing operations. The other major categories of workers frequently exposed to very cold temperatures even at temperate latitudes are mountaineers and aviators.

The growth of outdoor recreational and practical uses of snowmachines (snowmobiles), as well as their rapidly increasing speed and range, have opened new frontiers for wind-chill injury and being stranded in the cold far from help. The recent advent of this type of motorized transport in reindeer herding has increased the risk of frostbite among Saami and Finnish herders [Ervasti, 1991].

METHODS

Comprehensive surveillance for all non-fatal injuries requiring hospitalization in Alaska was established in 1991 via the Alaska Trauma Registry. In our analysis, we considered the following ICD-9-CM classifications to be cold injuries: E-codes: 901.00 (excessive cold weather), 901.8 (excessive cold, other), and 901.9 (excessive cold, nonspecific); and/or n-codes: 991.6 (hypothermia), 991.00–991.3 (frostbite), 991.5 (chilblains), and 991.4 (immersion foot). We also conducted an extensive literature review, using electronic databases (Medline and NIOSHTIC).

RESULTS

During 1991–1995, 327 persons were hospitalized for cold-related injuries in Alaska. Male victims numbered 251, female 76. The mean age of victims was 34 years. Among those injured while working (n = 40), 20 (50%) were active-duty military, and 14 were professional fishermen, hunters or trappers; 19 (48%) were white, 12 (30%) African American (vs. 4% of the Alaska population), and 8 (20%) Alaska Native, disproportionate in rate only for African American workers. For those injuries not meeting a strict case definition for work-related events (n = 287), 147 (51%) of the victims were Alaska Native, in contrast to the 16% of Alaska residents who are Alaska Native. The most common

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TABLE I. Risk Factors for Working in the Cold

	Host/Human	Agent/Vehicle	Environment
Pre-event/Pre-injury	Fatigue/exhaustion, hunger, immobilization, inactivity, poor physical fitness alcohol, intoxicants, cigarettes, tobacco chewing, prescription drugs	Snowmachine/snowmobile Boats/vessels	Cold air Wind
	Age	Heavy equipment	Cold water
	Endocrine factors	Metallic hand tools	Moisture
	Anorexia nervosa	Inadequate clothing	Thin ice
	Burns, sepsis, uremia	Aircraft	Repeated exposures
	Ignorance	Unheated buildings	Remoteness
	Occupation	Entanglement	Tobacco smoke
			Pollutants
			Poor Visibility
Event/Injury	Thermal discomfort/pain	Entanglement	Persistence of cold insult
	Impaired performance	Immobilization	Additional insult (e.g., water immersion)
	Poor dexterity		
	Reduced mobility		
	Cold injury – musculoskeletal, neurologic, vascular		
	Exacerbation of underlying conditions		
Post-event	Slow/inadequate response to circumstances	Entanglement	Poor/inadequate medical care provided
	Intoxication (alcohol, drugs)	Immobilization	

TABLE II. Prevention and Mitigation of Cold Injury and Disease

	Host/Human	Agent/Vehicle	Environment
Pre-event/Pre-injury	Adaptation	Adequate insulating clothing	Limits on exposures at lower temperatures
	Acclimatization	Improved motor vehicle design, e.g., hand heaters	Avoidance of rough waters, thin ice
	Training	Cold water immersion (survival) suits	
	Vigorous activity	Radio communication	
	Adequate rest	GPS navigation tools	
	Good/sufficient nutrition		
Event/Injury	Early recognition of symptoms	Design for easy exit, extrication	Rapid removal from cold environment and placement in suitably warm environment
	Early response to hazards	Cold water immersion suits	
		Radio/tele-communications	Avoiding/keeping victim from additional insults
Post-event	Early management of symptoms	Design for easy exit, extrication	Availability of emergency medical services

cause for hospitalization was hypothermia (150, 46%), followed by frostbite of the foot (138, 42%) or hand (62, 19%) or face (13, 4%). Immersion foot accounted for 10 (3%) of the hospitalizations. Alcohol consumption was implicated in 88 (27%) of these events. The most common etiology for injury was outdoor exposure to cold air, followed by coldwater immersion. In many instances, the victims had arrived at the place of injury via snowmachine (snowmobile), motorized skiff, or other off-road motor vehicle. Almost all of the military personnel injuries occurred during cold weather training.

A computer database review of recent publications (1980–1997) on cold exposure, hazards, injury, and disease elicited hundreds of citations, including 92 on ''cold physiological effect'' alone. This literature represents a very advanced understanding of the physiology, pathophysiology, and management of cold stress, injury, and illness, and a progressively evolving understanding of the underlying cellular and chemical events and human factors involved in these events.

While it is beyond the scope of this article to even summarize this extensive corpus, we have attempted to

organize the components into something readily approachable, via the use of time-phase, or Haddon's, matrices [Haddon, 1972]. The most prominent hazards are presented in the first of these (Table 1), and preventive strategies summarized in the latter (Table 2). Current knowledge of and technology for the measurement and understanding of the physiology of human response to the cold is also too extensive to summarize here; however there are numerous excellent reviews available on this subject [e.g., Holmer, 1993; Bittel, 1992; Burtan, 1994].

DISCUSSION

Cold-related injury is a relatively common cause for hospitalization in Alaskan workers. The cold continues to be a tangible and potentially serious hazard, particularly for military and outdoor workers and Alaska Natives. The apparent higher relative risk for these injuries experienced by African American workers also requires further investigation. Careful attention to wearing proper clothing, particularly gloves or mittens and boots or mukluks, as well as limiting sustained exposure times, should be encouraged. Specialized training in cold preparedness and injury prevention should be considered for all workers and persons conducting subsistence activities in cold environments.

Planning for work regimes to include persistent or frequent physical activity while working out of doors in the cold is important. Sir William Osler noted that lumberjacks could work protractedly in cold, wet conditions for weeks at a time without cold injury, which he attributed to their high activity level. In this century's two World Wars and the Korean conflict, the troops suffering the most cold injuries were those experiencing general body chilling during bivouacs and while confined to unheated vehicles, trenches, or foxholes [Burtan in Zenz et al., 1994]. Even the modern vapor-barrier boots and high-tech mittens may not be sufficient to overcome the combined insults of deep cold and enforced inactivity. The placement of infrared heaters in strategic locations to heat workers and sensitive machinery has also been proposed and evaluated [Anttonen, 1995]. A systematic and comprehensive approach, such as that taken by the Oulu Regional Institute of the Finnish Institute of Occupational Health, to studying, designing clothing and equipment, and organizing worktasks for prevention of cold injury (well-documented in the literature) is needed for other areas and occupations.

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