HY-11 Cold, heat, altitude and the elements: hypothermia, frostbite, heat stroke, sunburn, lightning

HEALING after the FALL, research library, HY-11

Researched 10 October 2026 by Claude Opus agent for THRIVING after the FALL, Book Four. Library document, unverified.

How to read this report

Almost nothing here is a drug. The treatments are water at a known temperature, cloth, shade, a fire, a tub, a timepiece and a set of rules about what not to do. Of all the medicine in this book, this part survives the loss of industry most nearly intact.

I build on FO-09 (THRIVING library, FO-09), reading the 2019 WMS hypothermia and heat guidelines in full rather than in summary, and I disagree with it at five points, marked in the text. Sunburn is a burn, so WO-04 applies, and HY-08 matters because a starving body cannot shiver.

Three warnings. Much of the hypothermia literature rests on volunteer studies of six or seven people. The heat-stroke cooling evidence is almost all from young athletes, while the people who die in a village are the old and the infant. And part of the foundation of rewarming doctrine is data taken by murder at Dachau, set out in 1.4 rather than in a footnote.

1. Findings by section

1.1 The physics, and the stages of cold

Water conducts heat about 24 times better than air, which is why immersion is the fastest way both to kill a cold person and to save a hot one (Lipman 2019). Shivering raises heat production five or six fold and can raise core temperature **3 to 4 °C per hour** in someone insulated and fed (Dow 2019, grade 1A), the most important number in this report. Cooling cuts oxygen consumption by about **6% per degree Celsius**, so at 28 °C whole-body demand is roughly halved. That is the basis of "no one is dead until warm and dead".

Hypothermia is a core temperature of 35 °C or below, graded mild (35 to 32 °C), moderate (32 to 28 °C), severe and profound (below 28 °C). The Swiss field system reads temperature from signs: HT I conscious and shivering, HT II impaired consciousness without shivering, HT III unconscious, HT IV apparent death. **I disagree with FO-09**, which presents Swiss staging as the practical field tool. The 2019 panel prefers mild-to-profound grading and warns of large overlap: the lowest recorded temperature for a patient classified HT I was **28.1 °C**, for HT II **22 °C**, for HT III **19.3 °C**. Shivering is maximal at 32 to 33 °C and may persist to about 30 °C, so a shivering patient with impaired consciousness is moderate, not mild. The usable rule is the guideline's own: shivering and still able to care for themselves means cold-stressed, shivering and becoming clumsy means hypothermic, and in doubt treat as hypothermic.

Thermometers are a trap. Ordinary non-electronic thermometers cannot read below about 35.6 °C, so they rule hypothermia in but cannot grade it. Infrared ear thermometers must never be used in a hypothermic patient, and rectal temperatures lag true core by up to an hour, falsely suggesting continued cooling during rewarming (both 1A).

1.2 Afterdrop and circumrescue collapse

Afterdrop is continued core cooling after removal from the cold. Its conductive part is heat flowing into cold peripheral tissue, its convective part is cold blood returning from the limbs, and the convective part transfers more heat and is the part that handling changes (Dow 2019). Drops of 5 to 6 °C are reported. Anything that opens limb blood flow worsens it: hoisting someone vertically, standing, walking, a warm bath. Below 28 °C the fibrillation threshold is low and returning cold blood can stop the heart. Circumrescue collapse is sudden collapse or death just before, during or after rescue, attributed to losing the water's hydrostatic squeeze on lifting out and to a fall in catecholamines as the person relaxes. Lift from water horizontally, never up a ladder.

Afterdrop is disputed, and rightly. Giesbrecht's Manitoba studies used six to eight volunteers in 8 °C water, and in one of them warm distal limb immersion gave less afterdrop than shivering (Vanggaard 1999, in Dow 2019), the opposite of what conduction predicts. Keep the handling rules, which cost nothing, and treat the ranking of methods as unsettled.

1.3 Rewarming: what works and what harms

Works in the field:

- **Shivering inside good insulation, with sugar.** Grade 1A, 3 to 4 °C per hour against a safe target rate of 1 to 2 °C per hour, so an insulated shiverer already rewarms fast enough.
- **Insulation and vapour barriers.** Patient **inside** the bag or blankets, not under them, insulated from the ground, head and neck covered, with a vapour barrier (plastic, oiled cloth) inside the insulation to keep it dry (1C).
- **Cut wet clothes off, only once sheltered** (1B), to avoid moving the limbs.
- **Heat to axillae, chest and back**, in that order, never the limbs (1B), inspecting skin every 20 to 30 minutes for burns (1C).
- **Warm sweet drinks and food** in an alert patient not at risk of aspiration, and **rest 30 minutes inside the wrapping before walking** (both 1C).

Fails or harms:

- **Small chemical hand warmers** cannot raise core temperature, and can burn (1B).
- **Body-to-body rewarming** blunts the patient's own shivering and rewarms no faster than shivering alone, permitted for comfort if it does not delay evacuation (1B). The most counter-intuitive finding in the chapter, and the one a village will get wrong.
- **A warm bath or shower** must not be used for initial rewarming, even in apparently mild hypothermia (1C), and **heated humidified air alone** is not effective (1B).
- **Distal limb immersion at 42 to 45 °C** to elbows and knees is the one exception, because warm superficial venous blood bypasses the cold arteries through the arteriovenous anastomoses of hands and feet. Alert mild cases only, on a single laboratory study (1C).

1.4 The Dachau data and their ethics

Rapid-rewarming doctrine entered Western medicine partly through murder. Sigmund Rascher, an SS doctor, immersed prisoners at Dachau in water at 2.5 to 12 °C from 15 August 1942. His report of 10 September 1942 concluded that rapid rewarming was always preferable to slow (Rascher 1942, Nuremberg document 1618-PS). Estimates run to 300 or 400 prisoners used and about 80 to 90 killed (Pozos, secondary). Leo Alexander, an American

physician with the Nuremberg prosecution, wrote a 1945 report endorsing the hot-water method for Air-Sea Rescue, and Molnar's 1946 JAMA paper drew on both the Dachau material and United States Navy records (Molnar 1946, secondary).

Robert Berger's 1990 analysis in the New England Journal of Medicine found critical shortcomings in scientific content and credibility, including evidence of falsification, and argued the data should not be accepted at face value (Berger 1990). A 1994 Journal of Medical Ethics paper concluded they were worthless. Robert Pozos had argued in 1988 that the material deserved discussion, provoking the debate.

My position: the experiments were murder, and by Berger's analysis the results are also unsound, which conveniently removes the hard ethical question. Nothing here rests on them, because every rewarming figure I give comes from post-war volunteer physiology or clinical series. The history must still be told, because teaching rewarming without saying where part of the doctrine came from is a lie of omission. If a reader after the Fall is tempted to think that suffering inflicted on the powerless buys knowledge, the record says it bought bad knowledge.

1.5 Cardiac arrest in the cold

- **Fixed dilated pupils and apparent rigor mortis are not contraindications** (1A), and dependent lividity is unreliable.
- **Contraindications are obvious fatal injury** (decapitation, truncal transection, incineration) **or a chest too stiff to compress** (1A).
- **Feel for a carotid pulse for a full minute** before starting CPR (1C).
- **No temperature cut-off.** The lowest core temperature from which a patient has been resuscitated neurologically intact is **13.7 °C** (2C): Anna Bågenholm, trapped under stream ice near Narvik, Norway, in May 1999, freed after about 80 minutes and rewarmed on extracorporeal circulation (secondary accounts, details conflict).
- **Prolonged and interrupted CPR work.** Good neurological recovery has followed **6 hours 30 minutes** of CPR, and arrest as long as 9 hours where the patient was not asphyxiated before cooling. If continuous CPR is impossible, give at least **5 minutes** of compressions with pauses no longer than **5 minutes** (1C).

Modern survival of profound hypothermic arrest depends on extracorporeal rewarming: in one Tromsø series nine of 24 such patients survived between 1999 and 2013. Without it a village is doing CPR to buy time for a heart that may restart as the chest warms. It sometimes does. Expect to fail most of the time and try anyway. The hospital stopping rule is serum potassium above 12 mmol/L, showing hypoxia before cooling (1B). A village has no assay, so its substitute is history: a victim asphyxiated before cooling has a far worse outlook than one who cooled slowly in the open and then arrested.

1.6 Cold water: Titanic, Molnar and the 1-10-1 rule

Giesbrecht's mnemonic is 1-10-1: about **one minute** of cold shock with uncontrollable gasping, during which inhaling water drowns people, about **ten minutes** of useful movement before muscles and nerves cool, and about **one hour** to unconsciousness. Most cold-water deaths are not hypothermia but drowning during the gasp or after incapacitation.

The Titanic sank at about 02:20 on 15 April 1912, with roughly 1,500 dead, most floating in life jackets with heads clear and most certificates recording drowning. I found no peer-reviewed survival analysis of the Titanic, and the figures circulating on forums are unsourced, so I will not give them as fact [VERIFY]. Defensible instead is the immersion literature Molnar built in 1946 from Navy records, summarised as roughly 1.5 to 2 hours undressed in water up to 15 °C and about 4.5 hours clothed (secondary summaries of Molnar 1946). These are hypothermia curves and they overstate survival, because they ignore cold shock and incapacitation. What saves people is a float, the head out, clothes kept on, and the huddle for a group (Davis 2024).

1.7 Frostbite: the thaw rules

Risk is modest to minus 15 °C and rises sharply below it (Omidi 2025, summarising McIntosh 2024). Wind multiplies it.

- Rewarm rapidly in water at **37 to 39 °C** (strong, moderate evidence), because rapid beats slow rewarming.
- Without a thermometer, the water must be **tolerable to a caregiver's uninjured hand for 30 seconds**. The chapter hangs on this test.
- Keep the water warm and circulating, the part off the sides of the container, and stop when the tissue is **red or purple, soft and pliable**, usually about **30 minutes**.
- **Never refreeze.** If it will refreeze, keep it frozen, and walking out on frozen feet is permitted because it is sometimes the only option.
- **Do not rub**, with snow or anything else, and use **no dry heat** (fire, stove, heated rocks), because numb tissue burns without warning.
- **Ibuprofen** 12 mg/kg per day divided twice daily, ceiling 2,400 mg per day. **I disagree with FO-09**, which reads these as two conflicting sources. They are one guideline's weight-based starting dose and its absolute ceiling: for a 70 kg adult, 12 mg/kg per day is 840 mg, or 400 mg twice daily, well under the ceiling.
- **Aloe vera gel** on thawed tissue before dressing, every 6 hours (weak, very low evidence).
- **Blisters:** no routine debridement, aspirate only tense clear blisters at high risk of rupture, never touch haemorrhagic ones in the field.
- **Dressings** bulky, dry, clean, including between the digits, wrapped loosely for swelling. Elevate.
- **Do not amputate early.** Demarcation takes **1 to 3 months**, and spreading infection is the only reason to cut sooner.
- **Treat moderate or severe hypothermia first.**

The hospital drugs a village loses are iloprost (deep frostbite, within 72 hours) and tissue plasminogen activator (grades 3 to 4, within 24 hours). Both save digits, with no substitute.

Dominique-Jean Larrey recorded in the 1812 retreat from Moscow that frozen limbs felt almost no pain when amputated, and he is usually credited with advising snow-rubbing and slow rewarming. The modern rule came from Fuhrman and Crismon, "Treatment of cold injury by means of immediate rapid warming" (Journal of Clinical Investigation, May 1947), which opens by noting that immediate warmth had long been considered something to avoid, and from William Mills and colleagues in Alaska, whose 1960 to 1961 reports describe a fixed routine in 130 cases, with records from over 400 further cases, using a bath of 38 to 45 °C later capped at 42 °C. Before the protocol, mid-foot and below-knee amputations were frequent. I could not read either paper's results and cannot give their amputation rates [VERIFY]. The best modern benchmark is a cohort of 182 severe frostbite patients with an amputation rate of **27%** (33% lower limb, 21% upper limb). The Korean War produced more than 8,000 frostbite cases at Chosin, with no amputation percentage I could find.

1.8 Non-freezing cold injury: the one a village will actually get

Trench foot occurs above freezing, in wet cold, over hours to days, apparently as reperfusion injury after sustained vasoconstriction. The best modern cohort is the Royal Marines in the Falklands, 1982 (Golden 2013). Of 3,006 men landed, 2,354 replied, and **1,505 (64%) had symptoms**, numbness typically beginning after two or three days. At three months **154 (10%) still had symptoms**, and in a tested subgroup **35% had impaired lower-limb nerve conduction** against none of 47 controls. Boot type made no significant difference, and though 50 to 70% wore more than one pair of socks, spares could not be dried. The authors concluded that the preventive measures of both World Wars could not be applied, and that history has every chance of repeating itself. For scale, the British Army had 29,000 cold-injury casualties in the winter of 1915 to 1916, and American forces 11,000 cases in November 1944.

Prevention is the treatment: keep moving, keep fed, dry the feet and change socks at least daily, boots snug but never

tight, rotate people out of the wet. Treatment is gradual rewarming, air drying, elevation and pain control. Pain can last months, and the drug most reported useful is amitriptyline, which a village will not have. Once a person has had it they are sensitised.

1.9 The slow hypothermia that kills the old indoors

Ronald Fox and colleagues surveyed elderly people at home in Britain in the winter of 1972 and found deep body temperatures below 35.5 °C in **10%** (Fox 1973, abstract and secondary summaries only). A Royal College of Physicians survey of three winter months in 1965 found 126 patients admitted at 35 °C or below, 0.68% of all admissions (Exton-Smith 1973, secondary). Death certificates then suggested only about 100 fatal cases a year in Britain, which the reviewers judged a gross underestimate because it missed everyone treated at home.

The WHO Housing and Health Guidelines of 2018 recommend an indoor temperature of at least **18 °C** in temperate or colder climates, a strong recommendation, while admitting in the same document that the evidence is insufficient to establish a threshold. It is a precautionary consensus, not a measurement.

CDC counted 13,419 hypothermia-related deaths in the United States from 2003 to 2013, 67% male, highest over 65, with alcohol or drugs contributing in about 10%. Where hypothermia is the hospital diagnosis, case fatality is high: 22.3% in a Bern series of 439 cases.

The old lose the ability to feel cold and to vasoconstrict, so they will not complain, and their hypothermia is indoors, slow, and complicated by illness, falls or drink. The fix is social, not medical: a warm room, food, and someone whose job it is to put a hand on the old people in January.

1.10 The newborn

A wet newborn loses heat fast and cannot shiver effectively, and the best-evidenced answer in the world is skin-to-skin contact. Meta-analysis cited in trial protocols gives relative risks of **0.22 to 0.28** for hypothermia with kangaroo mother care in neonates of 2,000 g or less. In the OMWaNA trial, hypothermia at 24 hours occurred in 448 of 1,096 infants given kangaroo care against 585 of 1,101 controls. The WHO Immediate Kangaroo Mother Care trial randomised 3,211 infants of 1.0 to 1.799 kg and found immediate care improved neonatal survival by about **25%** over care started after stabilisation, a number needed to treat of about **27** (95% CI 17 to 77). That is a grade A intervention needing a mother, a blanket and a hat, and the most valuable single item in this report for a village of 300.

1.11 Heat illness: the spectrum

From Lipman 2019: **heat cramps**, generalised large-muscle cramps relieved by oral salt solutions, distinct from the focal cramps of fatigue that respond to stretching. **Heat oedema**, benign dependent swelling, elevated, with diuretics ineffective and harmful. **Heat syncope**, transient collapse with rapid recovery, treated by rest, shade and isotonic fluids. **Heat exhaustion**, weakness, thirst, headache, nausea, core below 40 °C, treated by removal from heat, cooling and rehydration. **Heat stroke**, core **above 40 °C with central nervous system abnormality**, either exertional (young, working) or classic (old, passive, indoors).

Two cautions: asymptomatic runners commonly exceed 40 °C (15 to 56% in studies), so temperature alone does not diagnose heat stroke, and heat stroke can be fulminant with no preceding heat exhaustion.

Mortality approaches **10%**, rising to **33%** with hypotension at presentation. **I disagree with FO-09**, which gives about 5% from a 2025 secondary summary. Carry 10% and 33%. Classic heat stroke in the old is far worse: in the Chicago intensive care cohort after July 1995 (Dematte 1998, secondary), all patients had multiorgan dysfunction, about 21% died before discharge and another 28% within the year, and a third of survivors had severe functional impairment that had not improved at one year.

1.12 Cooling, ranked by measured rate

Cold-water immersion is optimal (Lipman 2019, grade 1A), about twice as fast as soaked towels. The ILCOR first-aid review, drawing on Douma 2020 (63 studies, 37 controlled), gives mean differences against passive cooling in °C per minute:

Method	vs passive (°C/min)	Studies / adults	Certainty
Torso immersion, ice water 1 to 5 °C	0.06 to 0.23	4 trials + 1 cohort / 75	Low
Torso immersion, 9 to 12 °C	0.11 (CI 0.07 to 0.15)	3 trials / 30	Moderate
Torso immersion, 14 to 15 °C	0.01 to 0.10	7 trials / 143	Low
Ice packs on cheeks, palms, soles	0.18 (CI 0.12 to 0.24)	1 trial / 10	Moderate
Fan alone	0.02 (CI 0.00 to 0.04)	2 trials / 25	Low
Evaporative (mist and fan)	0.01 (CI 0.00 to 0.01)	2 trials / 23	Low
Ice packs on neck, groin, axilla	0.02, not significant	2 trials / 15	Low

Torso immersion beats fanning by roughly an order of magnitude. **The water need not be iced**: Douma found no range within 1 to 17 °C clearly superior, and ILCOR recommends whole-body immersion from the neck down at **1 to 26 °C**, so a stream, pond, trough or tub of well water will do. **The traditional ice packs to neck, groin and armpits do not work**, while ice on **cheeks, palms and soles** does, exploiting the arteriovenous anastomoses of glabrous skin. **I extend FO-09 here**, which repeats the whole-body ice-pack line without the cheeks, palms and soles finding, the better number and the more achievable one.

Without a tub, the documented improvisation is the tarp taco: the patient lies on a tarpaulin whose sides are held up by bystanders, water and ice poured in and rocked. Luhring (2016, 16 volunteers, randomised crossover) measured **0.14 °C per minute** against **0.04** lying on the tarp dry, and Hosokawa (2017) gave 0.17 against 0.04.

Stop cooling at 39 °C (1B). **Avoid antipyretics** (2B), because the hypothalamic set point is not raised in hyperthermia, and dantrolene does not work either (2B).

The best field series is the Falmouth Road Race, where a tent with ice tubs treated 274 cases of exertional heat stroke over 18 years with **100% survival** (DeMartini 2015), and a follow-up covering 2012 to 2019 found 180 further cases, again with 100% survival. Casa's rule is **cool first, transport second**, getting core below about 39 °C within **30 minutes of collapse**. These are observational, with a prepared team, so they show that on-site cooling was followed by survival, not that it caused it. Even so, no other intervention here has 454 cases and no deaths.

1.13 The heat wave record

- **Europe, August 2003.** Robine compared summer 2003 with a 1998 to 2002 baseline across 16 countries and found **above 70,000 excess deaths**, with no harvesting effect (Robine 2008).
- **Chicago, July 1995.** 485 to 514 heat-related and 696 to 739 excess deaths. Semenza's case-control study of 339 decedents and 339 matched neighbourhood controls found the strongest risks were **confinement to bed (odds ratio 8.2)**, not leaving home daily (6.7), the top floor (4.7) and **living alone (2.3)**, and the strongest protections a **working air conditioner (0.3)** and **access to transport (0.3)** (Semenza 1996).

- **Karachi, June 2015.** 43 to 45 °C with power failures during Ramadan, 1,233 official deaths, about 65,000 heat-stroke patients treated. Ghumman and Horney found residents **17.7 times as likely to die of a heat-related cause** as in June 2014 (CI 13.87 to 22.53), with higher risk among the poorest, and fasting **not** a significant risk factor, contrary to press reports.

The pattern in all three is the same, and it is not medical. People die when they are old, ill, immobile, alone, poor, on a top floor, and without a way to get cool or get out.

1.14 Prevention: clothing, shelter, scheduling, water

Acclimatisation. One to two hours of heat-exposed exertion daily for **at least 8 days**, ideally 10 to 14, gives reproducible adaptation persisting up to a month (1C). A bout of heat stroke may reset it.

Hydration. Ensure euhydration before work (1B) and **drink to thirst** sufficiently to prevent more than **2%** loss of body weight (1B), since losses of 2 to 3% raise core temperature at a given workload and hyperhydrating in advance does not help. United States Army heat categories run down to 10 minutes of work per hour at the heaviest work in the worst heat, with ceilings of about **1.4 litres of water per hour and 11.4 litres per day** (TB MED 507).

Over-drinking. Exercise-associated hyponatraemia looks like heat exhaustion but with altered mental status and no hyperthermia. The WMS protocol is up to three boluses of 100 mL of 3% sodium chloride, 10 minutes apart, which a village will not have. The rule it can keep is: drink to thirst, not to a schedule, and eat salt with water in heat.

Clothing. The best-known test of desert dress is Shkolnik, Taylor, Finch and Borut in Nature in 1980, finding a Bedouin gains the same heat in a black robe as a white one, because absorbed heat is carried away by air movement inside the loose robe before reaching the skin. The study was one volunteer in half-hour sessions and was disputed, so the defensible lesson is not colour but **looseness**. For cold, a 1995 chamber study found skin temperature and comfort fell significantly less in a caribou-skin ensemble than in military or expedition clothing, and a 2020 infrared study found modern garments lost heat at zips even when closed while caribou-skin garments pulled on over the head did not, with an attached hood outperforming a detachable one (Oakes 2020). The transferable principles: **pull-over garments without openings, an attached hood, two layers with the inner nap turned in, loose enough to trap air, ventilated by opening rather than removing**.

Shelter. Shade cuts radiant load, and insulating from hot ground matters. The lesson from Chicago and Karachi is that the shelter that saves lives in heat is a cool room someone can reach and a person who checks on them, and from the Falklands, a dry place to change socks.

1.15 Sunburn and snow blindness

Sunburn is a burn, so WO-04's first aid applies: **20 minutes of cool running water within 3 hours**, nothing greasy on the fresh burn (THRIVING library, WO-04). Treatment evidence is weak. A review of literature from 1966 to 2001 found 40 studies, only 14 testing treatment applied after symptoms began, most concluding that corticosteroids, NSAIDs and emollients did not shorten recovery (Han and Maibach 2004, secondary), while a 2024 systematic review of six trials with 339 participants found prolonged topical corticosteroid reduced erythema and pain on limited evidence. Oral NSAIDs taken **before** redness appears may shorten the course, and aloe trials on ultraviolet erythema have been negative. One hidden cost matters: small studies link acute sunburn to **impaired sweating lasting about 7 days** (in Lipman 2019), so a sunburned field worker is a heat-stroke candidate for a week.

Prevention. The North Queensland Sun-Safe Clothing cluster trial randomised 25 childcare centres and found protective clothing and legionnaire hats worn for about 3.5 years prevented roughly a quarter of new moles, a surrogate for melanoma risk. A Cochrane review searching to May 2016 found no trials at all of clothing, hats or shade against skin cancer outcomes, so cover up with the honest note that the evidence is about surrogates. Wet fabric protects less (ARPANSA).

Snow blindness is photokeratitis, ultraviolet injury to the corneal epithelium, with symptoms **delayed about 6 to 12 hours**, which is why people keep going until they are blind that evening. Sloughing cells expose nerves, giving severe pain, grittiness and light intolerance. It is self-limiting, resolving in **24 hours to two days** (EyeWiki). Treatment is darkness, padded eyes, pain relief and no rubbing, and vision loss beyond 48 hours is beyond a village. Prevention matters more: fresh snow reflects about 80% of ultraviolet and intensity rises roughly 10 to 12% per 1,000 m. The Inuit and Inupiat answer is a carved wood, bone or baleen goggle with a narrow slit. I found no clinical trial of slit goggles [VERIFY], but the physics is sound and the technology is a knife, a piece of wood and an afternoon.

1.16 Altitude illness, for mountain villages

From the 2024 WMS update (via Omidi 2025): **prevention is gradual ascent** (strong, moderate), sleeping altitude mattering more than daytime altitude. The 2019 rule is that above 3,000 m sleeping altitude should rise no more than 500 m per night with a rest day every 1,000 m, while the 2024 summary I read gives no specific rate [VERIFY]. **Descent is definitive treatment** (strong, high), 300 to 1,000 m for acute mountain sickness and cerebral oedema and at least 1,000 m for pulmonary oedema.

Acetazolamide 125 mg twelve-hourly prevents acute mountain sickness (strong, high) and 250 mg twelve-hourly treats it. Dexamethasone 8 mg then 4 mg six-hourly for cerebral oedema. Nifedipine extended-release 30 mg twelve-hourly prevents pulmonary oedema (strong, moderate). Oxygen to keep saturation above 90%, and portable hyperbaric bags when descent is impossible. Not recommended: ginkgo biloba, inhaled budesonide, hypoxic tents, diuretics. **Ibuprofen** for prevention only if acetazolamide and dexamethasone are unavailable (weak, moderate), the one preventive drug a village might still have. **I agree with FO-09** that descent and staged ascent need no kit while the drugs will run out, but I could not verify its figure of up to 50% mortality for untreated high-altitude pulmonary oedema, which remains [VERIFY].

1.17 Lightning

Lightning carries about 30 million volts and 30,000 to 110,000 amperes but lasts 10 to 100 milliseconds, and much of it flashes over the body surface, which is why most people struck survive. Mechanisms approximately: ground current 50%, side splash 30%, contact 15%, direct strike 5% (LITFL).

Sudden death comes from simultaneous cardiac and respiratory arrest. The heart often restarts on its own, while the respiratory centre stays paralysed longer, so a patient whose heart restarts but who is not ventilated goes into a second, hypoxic arrest and dies. That single fact is the whole of lightning first aid.

Keraunoparalysis is transient paralysis, worse in the legs, with pallor and absent pulses from autonomic vasospasm. It resolves over hours and can make a living person look dead. Other findings: Lichtenberg figures (transient fern-like skin markings, essentially diagnostic), linear flashover and punctate burns, tympanic rupture, later cataracts, and persistent memory and personality changes.

Reverse triage. In a multiple-casualty strike, treat the apparently dead first. This inverts ordinary triage and is right, because those not in arrest will usually live without help while those in arrest may be saved by ventilation alone (Davis 2014, secondary summaries only).

Myths. A struck person retains no charge and is safe to touch. Rubber boots and car tyres do not protect, and a car protects because it is a metal cage.

Prevention is set out in Protocol 8. The two numbers are **30 minutes** of waiting after the last thunder and **6 m** of spacing between people, and climbers should tie off individually because a wet rope conducts. The commonly quoted 10% mortality is a United States figure from secondary sources and I could not confirm the guideline states it [VERIFY].

1.18 Drowning

From the 2024 WMS guideline summary (Davis 2024): about **236,000 drowning deaths a year** worldwide, highest risk aged 1 to 4.

- **Oxygen and ventilation are the priority**, because drowning is asphyxial arrest. Give rescue breaths with compressions. **Compression-only CPR is likely of little or no benefit** and belongs only to bystanders untrained in rescue breathing. This is the opposite of adult cardiac-arrest advice and the point most likely to be got wrong.
- **Never attempt chest compressions in the water.** In-water rescue breathing is for trained rescuers only.
- **Untrained people should not enter the water.** Reach, throw, row. **Abdominal thrusts are not recommended at any time.** Cervical spine injury is exceedingly rare in drowning, and precautions must not delay airway management.
- **Stopping** may be reasonable when submersion exceeds **30 minutes above 6 °C**, or **90 minutes below 6 °C**, or after **25 minutes of continuous CPR**.
- **Disposition:** normal lung sounds and mentation with at most a mild cough means observe **6 hours** and release, while abnormal lung sounds, frothy airway material or depressed mentation mean serious trouble.

Szpilman's 1997 classification grades drowning from a normal chest with coughing (grade 1) to cardiac arrest (grade 6), with reported mortality rising from 0% to 88 to 93%. I could not read the primary paper and the case numbers in secondary sources conflict [VERIFY].

1.19 Avalanche, briefly

Falk, Brugger and Adler-Kastner (1994), from Swiss data of 1981 to 1991, found survival of about 92% for extrication within 15 minutes but about 30% at 35 minutes, levelling in those with a patent airway, then falling again as hypothermia takes over. **Companion rescue in the first ten minutes is the only rescue that works.**

2. Evidence grades

Grades A to X as the brief defines them, with the source's own grade in brackets where it had one.

Practice	Grade	What the record shows
Shivering in dry insulation with sugar, vapour barrier inside	A	3 to 4 °C/h, volunteer physiology (Dow 2019, 1A)
Body-to-body rewarming	X	No faster than shivering, and blunts it (1B)
Hand warmers, or a warm bath, to rewarm	X	Ineffective, burns, afterdrop (1B, 1C)
Prolonged, intermittent CPR in hypothermic arrest	B	Recoveries after 6 h 30 min (1C)
Rapid water rewarming of frostbite, 37 to 39 °C	A	Fuhrman 1947, Mills 1960, McIntosh 2024
Rubbing frostbite with snow, or any dry heat	X	Injury and burns to numb tissue
Aloe vera on thawed frostbite	D	Weak, very low evidence
Dry feet and rotation against non-freezing cold injury	B	Golden 2013, both world wars
Cold-water immersion for heat stroke	A	ILCOR, 454 cases, no deaths (DeMartini 2015, 1A)

Practice	Grade	What the record shows
Water at 1 to 26 °C, not necessarily iced	A	Douma 2020, no superior range 1 to 17 °C
Tarp-assisted cooling where no tub exists	B	Two crossover trials, n=16, n=12
Ice packs to cheeks, palms and soles	B	One trial of 10, 0.18 °C/min, moderate certainty
Ice packs to neck, groin, axillae	X	No benefit, two trials
Drinking to thirst, losing under 2% of body weight	A	Lipman 2019 (1B)
Loose robes in heat, pull-over hooded skins in cold	D, C	One volunteer (Shkolnik 1980), chamber studies (Oakes 2020)
Sunburn first aid as a burn, 20 min cool water	B	THRIVING library, WO-04
Clothing and hats against ultraviolet	B	Cluster trial on moles, none on cancer (Cochrane 2016)
Slit snow goggles	C	No trial found, optics sound, Arctic-wide
Staged ascent, and descent as treatment	A	Strong, moderate to high (McIntosh 2024)
Acetazolamide, dexamethasone, nifedipine	A	Strong, stock only
Reverse triage and ventilation after lightning	B	Mechanism, case series
Rescue breaths with compressions in drowning	B	Asphyxial mechanism (Davis 2024)
Compression-only CPR, or abdominal thrusts, in drowning	X	Little or no benefit (Davis 2024)
Kangaroo mother care against neonatal hypothermia	A	RR 0.22 to 0.28, survival NNT 27
Indoor minimum of 18 °C	D	Strong WHO recommendation, weak evidence

3. Means ledger

Hands and knowledge alone. Recognise the stages. Get the person out of wind and water, horizontal, still. Insulate with anything, patient inside it. Shelter, shade, huddle. Avalanche rescue by companions within ten minutes. Lightning: ventilate the apparently dead first. Drowning: reach or throw, breaths with compressions. This rung holds most of the life-saving in the chapter and costs nothing.

At the hearth. Fire, dry clothes, a waterproof sheet as vapour barrier, warm sweet drinks, wrapped heated stones to chest and armpits with skin checked every 20 to 30 minutes, a tub for thawing and for immersion, salted broth, something to time by, dry socks. **This is the rung where most of the survival benefit is won.**

Garden and still. Willow bark (Salix alba L. and other Salix spp.) and meadowsweet flower (Filipendula ulmaria (L.) Maxim.) for pain carry the cautions set out in HY-08 (THRIVING library, HY-08) and do not replace ibuprofen in frostbite. Aloe barbadensis Miller, inner leaf gel taken fresh, is the one plant with a named role in frostbite guidance. Its yellow sap latex is a purgative that must never be swallowed, and the lookalike risk is Agave americana L., similar in

rosette but with fibrous, irritant sap. Honest limit: no plant on this rung treats hypothermia, heat stroke, lightning or altitude.

Village dispensary of 300. Thermometers reading below 35 °C and above 42 °C, a tub kept filled through summer where people work, salvaged ibuprofen and acetazolamide while they last, a lay healer who drills the protocols, and a winter register of every household holding someone old, ill or alone. Outcome: heat-stroke mortality falls because cooling starts in minutes, and the old stop dying unnoticed in January.

District infirmary of 3,000. Ten beds, warmth, warmed fluids, relays able to sustain hours of CPR, wound care for demarcating frostbite, the surgery to amputate at two to three months, and the records that show next winter who nearly died last.

Hospital before the Fall. Extracorporeal rewarming, which takes survival of profound hypothermic arrest from near zero to roughly a third in selected cases. Iloprost and tPA, which save digits. Intensive care for multiorgan failure after heat stroke. Hypertonic saline for hyponatraemia. Those four are what is genuinely lost, and the loss is real but narrow.

4. Harm test

Rewarming. The killing errors are moving the patient, standing them up, walking them out, hoisting them vertically from water, or a hot bath. All drive afterdrop at a heart already irritable below 28 °C. The warning signs are collapse on being moved, falling consciousness after rescue, or a pulse lost during handling, and the response is to lay them flat and stop moving them. Burns from heat packs, stones and bottles on numb skin are the commonest injury of all, which is why the 20 to 30 minute check exists.

Frostbite thawing. Water above about 40 °C burns insensate tissue and has cost parts that would have survived, while below 37 °C it thaws too slowly. Refreezing damages a thawed part far worse than leaving it frozen. Rubbing tears tissue laden with ice crystals, dry heat burns silently, and early amputation removes tissue that would have recovered. Watch for blackening that spreads with fever and a foul smell, which is infection and the one reason to cut early.

Cooling. Two errors: stopping too late and drowning the patient. Cooling past 39 °C overshoots into hypothermia, and an unconscious person immersed without a hand on the head can drown in the tub, which is why one named person holds the head throughout. Never immerse someone merely exhausted and warm, because cold shock is real in the normothermic. Paracetamol in heat-stroke liver injury is hazardous.

Fluids and salt. Forcing water on a collapsed worker who is hyponatraemic rather than dehydrated can cause fatal cerebral oedema, and the discriminator is altered mental status with a normal temperature.

Who must never receive what. No cold immersion for a person who is not hyperthermic. No limb warming in moderate or severe hypothermia. No alcohol to a cold person, since it opens the skin vessels and blunts judgement, and it contributed to about 10% of United States hypothermia deaths (CDC 2015). No ibuprofen in pregnancy after 20 weeks, in kidney disease, in the dehydrated or in bleeding. No acetazolamide in sulfa allergy.

Misidentification. Heat exhaustion against heat stroke turns on mental status, hypothermia against stroke or drink on feeling the skin of the trunk, keraunoparalysis against death on waiting and looking again. In every pair the cheap test is temperature plus level of consciousness, which is why those two go in every record.

5. Red flags

Signs the village cannot fix, and what to do anyway.

1. **Hypothermic cardiac arrest with no extracorporeal rewarming.** Prolonged CPR in relays while warming the trunk, accepting that you will usually fail. Never stop because the pupils are fixed.

2. **Deep frostbite of several digits or a forefoot.** The benchmark amputation rate is 27% even in modern care. Keep clean, dry, fed and warm, treat pain, plan surgery for one to three months.
3. **Heat stroke with hypotension or coma persisting after cooling to 39 °C.** Mortality 33%. Cool anyway, lie them flat, expect seizures and bleeding.
4. **Classic heat stroke in an old person with multiorgan failure.** About 21% die before discharge and another 28% within the year even with intensive care. Comfort, cool, keep company.
5. **Altitude oedema of lung or brain with no descent possible.** Nothing replaces descent. Get them down, at night, carried, by any route.
6. **Lightning arrest not restarting after sustained ventilation.** If the heart has not resumed after prolonged ventilation and compressions, it will not.
7. **Drowning with submersion beyond 30 minutes in warm water or 90 in cold.** Stopping is reasonable. Say so plainly.
8. **Snow blindness unresolved at 48 hours, or any loss of vision.** Beyond a village.
9. **Non-freezing cold injury with pain past three months**, 10% of the Falklands cohort. No village treatment exists. Prevent recurrence, because they are now sensitised.
10. **Hyponatraemia with seizures.** Hypertonic saline is the treatment and there is none. Stop all fluids, salt by mouth if they can swallow, protect the airway.

Honest comfort is part of the protocol: warmth, a dry bed, pain relief, a hand held, the truth.

6. The case against

The evidence base is thin and the samples are tiny. Much rewarming doctrine rests on volunteer studies of six to eight young fit people in Manitoba cold tanks, and the ice-to-the-cheeks finding, which I recommend, comes from a single trial of ten. Whole chapters of these guidelines carry grade 1C, which means strong advice on low-quality evidence. Giesbrecht himself has argued that afterdrop is overstated and the ranking of field rewarming methods unestablished.

The cooling evidence is in the wrong people. The Falmouth series, the tarp trials and the immersion trials are nearly all young athletes with exertional heat stroke. The people who die in a heat wave are old, bedbound and alone, with classic heat stroke, and no randomised cooling trial exists in them. I still recommend immersion, because the physics does not change with age, but the honest grade for classic heat stroke is lower than for exertional.

Guidelines are consensus documents. The WHO 18 °C threshold is a consensus the same document admits lacks evidence, and the 10% lightning mortality figure circulates without a traceable primary source. Historical numbers get repeated until they become facts.

Against the romance of the herbal. No plant here treats hypothermia, heat stroke, lightning, altitude illness or drowning. Aloe appears, weakly, and willow helps pain. Everything that works is physics: water at a known temperature, cloth, shade, fire, a tub and a clock.

Against the romance of the hospital. Four things are genuinely lost: extracorporeal rewarming, iloprost, tPA and intensive care. Everything else is deliverable by a literate villager with a tub, a thermometer and these rules.

Against the record itself. The Dachau experiments were murder and, on Berger's analysis, unsound as well. A reader tempted to think that brutal experiment buys knowledge should look at what it bought, which was falsified data the post-war literature then had to unpick.

7. Ten-line summary of robust findings

1. A shivering, insulated, fed person rewarms at 3 to 4 °C an hour, faster than any field device, so the first job is dry insulation with the patient inside it, and sugar.

2. Body-to-body rewarming, hand warmers, hot baths and warm humidified air all fail or harm, and the first blunts the shivering that was working.
3. Handle a cold patient horizontally and gently, because the deaths at rescue are afterdrop and collapse rather than the cold itself.
4. No one is dead until warm and dead: recoveries from 13.7 °C and from 6 hours 30 minutes of CPR are recorded, and fixed pupils are no reason to stop.
5. Thaw frostbite at 37 to 39 °C, water tolerable to an uninjured hand for 30 seconds, for about 30 minutes, never by dry heat, never by rubbing, never if it may refreeze.
6. Wait one to three months for demarcation before amputating frostbite, and cut early only for spreading infection.
7. Heat stroke is core above 40 °C with altered mental status, treated by whole-body immersion at 1 to 26 °C, cool first and transport second, stopping at 39 °C.
8. Ice to the neck, groin and armpits does not cool, ice to the cheeks, palms and soles gives 0.18 °C a minute, and a tarpaulin held up by four people is a usable tub.
9. Lightning kills by simultaneous cardiac and respiratory arrest and the heart usually restarts by itself, so ventilate the apparently dead first.
10. Drowning is asphyxia, so give rescue breaths with compressions, never compressions alone, never compressions in the water, never abdominal thrusts.

8. Contested or open questions

1. Whether afterdrop differs meaningfully between rewarming methods, given conflicting six-to-eight-person studies.
2. Whether distal limb immersion is safe outside the laboratory.
3. The best water temperature for cooling, since no range from 1 to 17 °C proved superior.
4. Whether cold immersion is safe in frail old people with classic heat stroke, where no trial exists.
5. Whether the cheeks, palms and soles finding replicates beyond one trial of ten.
6. Whether the WHO 18 °C indoor minimum has any evidential basis.
7. The true survival curve for cold-water immersion, since published curves ignore cold shock.
8. Whether non-freezing cold injury can be prevented at all in a sustained wet campaign, which Golden doubted.
9. Whether topical steroids shorten established sunburn, and whether slit goggles have ever been tested.

9. The sources to read in full

1. Dow and others, WMS Clinical Practice Guidelines for Out-of-Hospital Evaluation and Treatment of Accidental Hypothermia, 2019. The most useful document here.
2. Lipman and others, WMS Clinical Practice Guidelines for Heat Illness, 2019.
3. Golden and others, Lessons from history: morbidity of cold injury in the Royal Marines during the Falklands conflict, 2013.
4. Douma and others, First aid cooling techniques for heat stroke and exertional hyperthermia, 2020, with the ILCOR table.
5. Berger, Nazi science: the Dachau hypothermia experiments, 1990.
6. McIntosh and others, WMS Clinical Practice Guidelines for Frostbite, 2024 update.
7. Semenza and others, Heat-related deaths during the July 1995 heat wave in Chicago, 1996.
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9. Davis and others, WMS Clinical Practice Guidelines for Drowning, 2024.
10. Robine and others, Death toll exceeded 70,000 in Europe during the summer of 2003, 2008.

At the bedside after the Fall

The household. Needs: a wool or quilted covering big enough to wrap an adult, a waterproof sheet, a tub an adult can sit in, salt, dry socks, and these rules on a board by the door. Skills: recognising altered mental status, feeling the trunk rather than the hands, and the 30-second hand test. **First failure to expect:** somebody puts a severely cold person by the fire or in a hot bath, or rubs frostbitten feet, because both feel obviously right.

The village of 300. Needs: a tub kept filled through the hot months where people work, a thermometer reading below 35 °C and one reading to 45 °C, a lay healer who drills the protocols twice a year, and a winter register of every household containing someone old, ill or alone, with a summer version of the same. Records: date, name, temperature if measurable, mental status, time to cooling or rewarming, outcome. **First failure to expect:** the register is kept one winter and then quietly dropped, and the next January someone is found cold in their own bed.

The district of 3,000. Needs: ten beds, warmth, wound care for demarcating frostbite, someone able to amputate at two to three months, and a yearly reading of the village registers. Records: a tally by month, the only way anyone will see that the deaths cluster into two weeks of July and three of January. **First failure to expect:** the infirmary treats what arrives and never learns that most of its dead never came.

Protocols

1. Hypothermia, field. Shelter from wind and wet, insulate from the ground. Handle horizontally and gently: no walking, no standing, no vertical lifting. Cut wet clothes off once under shelter. Wrap with the vapour barrier inside and insulation outside, patient inside the wrap, head and neck covered, face clear. If alert and swallowing safely, warm sweet drinks and food. Heat to axillae, chest and back only, never limbs, skin checked every 20 to 30 minutes. Rest 30 minutes before walking.

2. Hypothermic cardiac arrest. Confirm no breathing and no pulse after a one-minute check. Start CPR unless the chest will not compress or the injury is obviously fatal. Continue regardless of fixed pupils, stiffness or lividity. Keep insulating and warming the trunk throughout. If relays cannot be sustained, give at least 5 minutes of compressions with pauses no longer than 5 minutes. Plan for hours. Stop on exhaustion of the rescuers, or a known asphyxial cause before cooling.

3. Frostbite thawing. Treat moderate or severe hypothermia first. If refreezing is possible, do not thaw. Fill a container with water at 37 to 39 °C, deep enough to cover the part without it touching the sides. Test: an uninjured hand tolerates it comfortably for 30 seconds. Immerse, keep the water moving, top up to hold temperature. Give ibuprofen, 400 mg twice daily for an adult of about 70 kg, never above 2,400 mg a day. Stop when red or purple, soft and pliable, usually about 30 minutes. Dry gently, aloe gel if available, bulky dry dressings including between the digits, loose and elevated. Do not drain haemorrhagic blisters, do not rub, do not use fire or hot stones. Wait 1 to 3 months for demarcation.

4. Heat stroke. Recognise: hot, core above 40 °C if measurable, and confused, aggressive, staggering or unconscious. Move to shade, strip to underclothes. Immerse from the neck down in any water from 1 to 26 °C, ice added if there is any. One named person holds the head and keeps the airway above the water throughout. If there is no tub, use a tarpaulin held up by four people, filled with water and ice, the patient rocked gently, or ice and cold cloths to cheeks, palms and soles with fanning. Target: out of danger within 30 minutes of collapse. Stop at 39 °C, then dry and insulate lightly. Give no antipyretics. If conscious, cool salted fluids by mouth. Watch for seizures and for a second rise.

5. Heat exhaustion against hyponatraemia. Hot, weak, thirsty, under 40 °C, mentally clear: heat exhaustion, so rest in shade, cool, drink salted fluids, no more work that day. Normal temperature, has drunk a great deal, confused or seizing: hyponatraemia, so no more plain water, salt by mouth if they can swallow, protect the airway, and expect to be unable to fix it.

6. Working in heat. Acclimatise over 8 to 14 days with one to two hours of heat exposure daily. Start fully hydrated. Drink to thirst, losing no more than 2% of body weight, and eat salt with the water. Loose, light, covering clothes and a wide hat. Heavy work in the first and last hours of daylight, rest in shade in the middle. Watch each other for the first change, which is behaviour, not temperature.

7. Working in cold and wet. Two loose layers with an attached hood, pulled over the head rather than opened down the front, vented by loosening rather than stripping. Keep the inside dry, because it is sweat that kills. Eat often, because shivering burns fuel and a starving body cannot shiver. Dry the feet and change socks daily, boots snug but never tight. Rotate people out of standing water. Report numbness on the first day, not the third.

8. Lightning. Prevention: indoors or into a hard-topped vehicle, or a deep cave, dense even forest or deep ravine, away from lone trees, ridges, water and metal. Spread the group at least 6 m apart, and wait 30 minutes after the last thunder. Casualties: count them, then go to the still ones first. For each motionless person open the airway and ventilate, adding compressions if there is no pulse, and keep ventilating after the heart restarts, because breathing returns last. Touching them is safe. Then treat the others, and tell the paralysed that it passes.

9. Drowning. Reach or throw, do not swim unless trained. Get the head out, keep the body horizontal. On land start rescue breaths at once, then compressions with breaths, never compressions alone. Never give abdominal thrusts, and never attempt compressions in the water. If they cough a little, have clear lungs and are fully alert, watch for 6 hours. If breathing is noisy or frothy, or they are drowsy, expect serious lung injury. Consider stopping after 25 minutes of continuous CPR, or if submersion exceeded 30 minutes above 6 °C or 90 minutes below it.

10. Snow blindness and sunburn. Prevent with slit goggles of wood, bone or bark worn on snow, water and at altitude from first light, with loose woven cloth and a brimmed hat over the skin. For established sunburn, cool running water for 20 minutes if within 3 hours, then nothing greasy, and no heavy work in heat for about a week because sweating is impaired. For snow blindness, a dark room, eyes closed or lightly padded, pain relief, no rubbing, and recovery in 24 to 48 hours.

Numbers to carry

1. **35 °C** is hypothermia, **32 °C** moderate, **28 °C** where the heart turns dangerous. **40 °C with confusion** is heat stroke.
2. **3 to 4 °C an hour**: how fast a shivering, insulated, fed person rewarms. Nothing a village owns beats it.
3. **37 to 39 °C**, about **30 minutes**, and a **30-second** hand test: the frostbite thaw.
4. **1 to 26 °C** water, neck down, stop at **39 °C**, done inside **30 minutes** of collapse: heat stroke.
5. **One minute** feeling for a pulse in a cold patient, and no temperature is too low: 13.7 °C and 6 h 30 min of CPR have both been survived.
6. **1 to 10 to 1** in cold water: one minute of gasping, ten minutes of useful movement, one hour to unconsciousness.
7. **10 minutes** is the avalanche window, **6 m** the lightning spacing, **30 minutes** the wait after the last thunder.
8. **2%** of body weight is the fluid loss allowed, **8 to 14 days** acclimatisation, **18 °C** the indoor minimum.
9. **1 to 3 months** before amputating frostbite, **6 to 12 hours** before snow blindness appears, **7 days** of impaired sweating after sunburn.
10. **64% and 10%**: the Falklands non-freezing cold injury rate, and the share still in pain at three months. The one that will happen in your village.

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