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REMOTE HEALTH CARE AT U.S. ANTARCTIC STATIONS: A COMPARISON WITH STANDARD EMERGENCY MEDICAL PRACTICE

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☐ **Abstract—Background: The three U.S. Antarctic research stations' medical facilities exist in an isolated, harsh environment, typical of many such facilities throughout the world. Emergency physicians frequently staff these medical facilities; however, most who are considering this have many misconceptions about the stations and about the scope of medical practice that exists there. Objective: This article illuminates how Antarctic medical practice is comparable with and dissimilar to other emergency medicine experiences and highlights information that any emergency physician-applicant to an isolated medical position should learn prior to accepting the position. Discussion: Antarctic medical care both parallels and differs from typical emergency medical practice in many ways, including the patient population, facilities, supplies, equipment, clinical duties (e.g., providing out- and inpatient medical and dental care, performing laboratory tests and imaging), and nonclinical duties (e.g., disaster planning, teaching, food service inspection, and public health officer). Climate-related limitations on medical evacuation epitomize the stations' isolation. Medical practice may be complicated by ethical issues common in other small isolated settings, such as a lack of privacy and confidentiality. Clinicians considering an isolated practice opportunity should ask basic questions to learn as much detailed information as possible prior to taking the positions. Conclusion: Medical practice at U.S. Antarctic stations, as at many remote health care facilities throughout the world, has similarities to standard emergency medical practice. Even so, significant differences result in a steep learning curve. Any clinicians considering practicing in these locations should carefully evaluate the practice and the environment in advance of any deployment.**

☐ **Keywords—health resources; extreme environments; emergency medicine; Antarctic regions; transportation of patients; disaster planning; public health; medical ethics**

INTRODUCTION

The Antarctic continent has arguably the most breathtaking scenery and the most dangerous environment on earth. Due to its unique geography and relative isolation, it houses diverse physical and biological science research programs, and provides a platform for vital environmental monitoring. Thirty-two countries support about 50 permanent research stations on the continent ("on-Ice"), and many other summer stations exist (Figure 1) (1,2). The United States maintains three permanent bases and two research vessels in Antarctica, allowing scientists with National Science Foundation (NSF) grants platforms do their work (3).

Emergency physicians are the specialists that most frequently staff the medical facilities at the permanent stations. Applicants for these positions often have many misconceptions about the stations and about the scope of medical practice that exists there. This article is designed to illuminate the ways Antarctic medical practice

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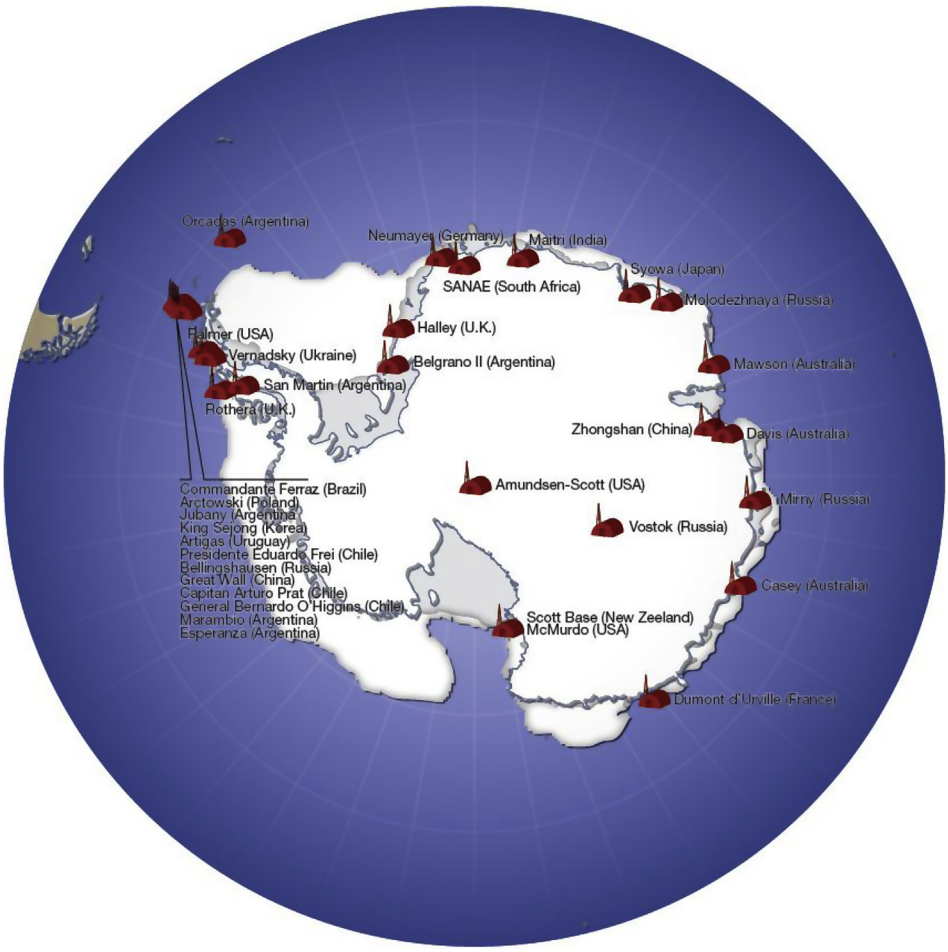

Figure 1. Map of major Antarctic research stations.

is comparable with and dissimilar to other emergency medicine experiences and to highlight some information that any emergency physician applying for an isolated medical position should learn before they take the position (Table 1).

DISCUSSION

Antarctica

The main base and the largest population center on the continent is McMurdo Station, which usually houses fewer than 200 in winter months and more than 1200 in the summer. Located on the Ross Ice Shelf, it is geographically closest to New Zealand (5–8 h flight time, depending on the aircraft). A common misconception is that all staff and facilities are housed in one large building. In reality, McMurdo consists of multiple buildings that personnel must walk between to eat, sleep, work, attend meetings, get medical care, and enjoy recreation. It serves as the base of operations for diverse science teams scattered across Antarctica and for ingress and egress for nearly all personnel working at the Amundsen-Scott (South Pole) Station. Occasionally, it acts as a medical resource center for patients evacuated from the South Pole and from the stations of other nations. McMurdo also serves as the primary medical facility for New Zealand's Scott Base, a small station of between 11 and 100 persons located 2 kilometers away.

Of the three U.S. stations, the newest, and most isolated due to the long winter period (about 9 months), is the South Pole Station. It consists of one large building that sits on stilts to accommodate massive snowdrifts. It is surrounded by research facilities housing telescopes, subatomic particle detectors, and one of the National Oceanic and Atmospheric Administration's clean-air monitoring stations. The medical facilities are within the main station building and staffed year round by a physician and a physician assistant. Like all Antarctic stations, the South Pole's population mushrooms in the summer.

The third U.S. Antarctic facility, Palmer Station, is located on the warmer and more northerly Antarctic

Table 1. Evaluating Isolated Practice Opportunities

Medical providers should ask specific questions when evaluating practice opportunities in an unusual environment. These include learning:
- The full scope of your clinical and nonclinical responsibilities.
- How to perform all required functions with which you are not familiar (e.g., emergency dental care, radiological imaging, laboratory testing, pharmacy management, food service inspection).
- The nature of the population(s) you will be serving.
- The types of major and vital equipment you will have available and how to use all of them, including the variations of each model.
- Who, other than you, will have input into important clinical decisions (e.g., evacuations).
- How to use all telecommunication devices.
- Who will be your professional colleagues and what experience do they have.

These items should be evaluated in advance of any deployment and, when appropriate, using hands-on practice with people knowledgeable about their use.

Peninsula. It operates year round with a small population of scientists and support personnel, including a physician and mid-level provider. Like the South Pole, the small medical facilities are part of the main building. Two research vessels operate out of Punta Arenas, Chile, also serving as transportation for station personnel to Palmer. Both ships have fewer than 40 personnel, including emergency medical service providers; they receive remote medical direction from McMurdo and Palmer Stations.

Population

The U.S. Antarctic Program population at the stations consists of three groups: scientists on government contract or with NSF grants; U.S. Air Force (USAF) personnel and civilian pilots for air transportation (although not at Palmer; they rely on sea travel); and a variety of workers to provide support for them and maintain their equipment, as at many industrial and military facilities around the world. One of these support groups is the medical team. The population at all three stations increases in the summer months; the number depends on NSF funding and the station's scheduled building and repair projects.

To avoid as many health care problems as possible, both the support staff and the science teams undergo extensive medical screening prior to being allowed to travel to the research stations or ships. These screenings have generally included physical and dental examinations, multiple laboratory tests, a chest radiograph, and any special studies necessary to evaluate a person's known or suspected medical conditions. Some older personnel also must have an electrocardiogram and cardiac stress test (4). Ideally, this screening should eliminate personnel with significant (i.e., potentially unstable) medical issues. However, increasing leeway in applying these requirements coupled with the variable quality of physical and dental examinations has resulted in more personnel arriving on station with significant health issues.

On the stations, multiple activities are available to promote physical and mental wellness in the population. These include organized sports, crafts, music, reading, dances, formal dinners, theater, movies, and trips to interesting locations (e.g., local volcano, explorers' huts, scientific sites, and cross-country skiing). Immunization with influenza vaccine is also provided when the southern hemisphere strain is available.

Medical Facilities

Many fixed medical facilities exist in remote, often isolated, and environmentally harsh sites to serve deployed workers and the local population. Antarctica has no indigenous population, so those facilities serve only those working on the continent. Antarctica and the sub-Antarctic islands have many such facilities to support their rotating scientific and support staff communities. These facilities vary from the relatively substantial U.S. facility at McMurdo Station to the multi-use rooms found at the smallest posts. U.S. Antarctic stations offer health care comparable with that at most rural hospitals and clinics in the United States, especially those with large seasonal fluctuations in their patient census.

Clinicians see patients in standard emergency department (ED)-type cubicles or curtained areas, generally equipped with standard gurneys. The facilities include from one to six beds for inpatients. At McMurdo Station, the medical building is a separate structure that the U.S. Navy built many decades ago. Aside from the outpatient and inpatient areas, it includes a physical therapy room that initially was an operating room, a radiology room, a pharmacy, a laboratory, a hyperbaric chamber, a large storeroom, a full dental clinic, and multiple offices. At both Palmer Station and the South Pole, the medical facilities are smaller and are part of the main station building.

A common misconception about U.S. Antarctic medical facilities is that they suffer from a dearth of equipment and medications. On the contrary, the three land-based U.S. Antarctic stations have the equipment and supplies needed to treat most of the common illnesses

and injuries that they encounter. All three have the basic equipment found in a standard U.S. ED, although some of the equipment is outdated and there may be a limited selection of various types of medication.

Laboratory tests. Laboratory tests generally are run on point-of-care equipment, basic hematology testing, and a few other specialized kits. Maintaining unexpired test and control cartridges can be problematic, as can getting all the equipment to work correctly. Imaging includes both ultrasound and plain radiographs. That requires some expertise with ultrasound and learning to use the digital radiography equipment. The films are electronically transmitted to a radiologist who will eventually provide a reading.

All U.S. Antarctic stations have a well-stocked pharmacy. However, on occasion, patients receive expired medications due to the very long supply line and New Zealand's import restrictions on controlled medications. Although expiration dates on most medications have little or no clinical significance, this is not true with regard to vaccines (e.g., influenza, hepatitis, and tetanus), ophthalmic medication, and some antibiotics (5,6). To lessen this problem, several strategies are employed, including not administering any vaccines or ophthalmic medications that are expired. Also, other recently expired medications, including antibiotics and analgesics, are administered only after informing the patient about expired medications: there are generally no additional side effects, but the medications might be slightly less effective than normal. Physicians and advance providers are responsible for doing biannual inventories (an onerous job that requires counting every tablet and bottle). When there is no pharmacist, they must also inventory and shelve incoming medications and log out medications they dispense.

Physical therapy. Given many workers' intense physical labor and the often-slippery conditions around the stations, musculoskeletal injuries are the most common ailments seen. During recent winter seasons at McMurdo Station, there was no physical therapist, requiring frequent clinician consultations with a physical therapist to provide adequate postinjury therapy and rehabilitation.

Health Care Providers

Although a physician and a physician assistant staff both Palmer Station and the South Pole year round, the number of medical personnel at McMurdo Station varies widely between the summer and winter seasons. It also varies based on year-to-year funding and NSF administrative decisions. In mid-summer at McMurdo Station, the staffing, which includes personnel from the Air National Guard, often comprises a pharmacist or pharmacy technician, an x-ray technician, a physical therapist, a part-time dentist, several nurses, and a varying number of physicians and mid-level providers. Mid-level providers also provide care at some of the largest scientific field camps. A biomedical equipment technician appears once or twice a year to evaluate and, when possible, repair equipment. As with many other isolated medical facilities, the health care providers at the U.S. Antarctic stations have variable expertise and often have unique personalities.

Typical "on-Ice" health care interventions involve both clinical and nonclinical responsibilities (Table 2) (7). Whereas some clinic appointments are scheduled, most are walk-in or urgent visits. Clinicians are on call on a rotating basis.

Supervise inpatients. Each station has at least one inpatient bed (McMurdo has six) to house the rare patient

Table 2. Required Clinical and Nonclinical Duties

Clinical Responsibilities	Nonclinical Responsibilities
Medical evaluation/treatment	Equipment checks and maintenance, basic
Surgical and orthopedic evaluation/treatment	Disaster team training
Psychiatric evaluation and treatment	Paramedic training
Dental radiological imaging*	First aid training for field camp personnel
Dental evaluation and treatment*	Disease and injury prevention
Medication dispensing*	Initiate patient evacuations and transfers†
Radiologic imaging and processing	Clinic equipment and supply inventory
Ultrasound imaging	Write periodic reports
Laboratory testing	Attend administrative meetings
Blood banking‡	Pharmacy inventory and management*
Physical therapy*	Laboratory quality assurance
Nursing procedures*	Food safety inspections and reports
Mass immunization program	Altitude illness training and prevention§

Ethical issues naturally arise because no provider can practice competently in all these areas. For example, during a winter session at McMurdo, the health care providers often stretch their knowledge and skills to accomplish nonstandard tasks, such as providing physical therapy programs and treatments, dental care, and public health programs.

* At Palmer and the South Pole Stations and at McMurdo Station in winter months or when the pharmacy technician, dentist, or physical therapist is not available.

† Patient transfers are (summer-only) nonurgent flights for scheduled appointments.

‡ Stations rely on a "walking blood bank" in which on-station personnel donate blood and have it retested for blood type and crossmatch compatibility at the time it is needed (7).

§ Amundsen-Scott (South Pole) Station is at 10,000 feet and physiologically (due to the decreased atmospheric pressure due to the polar vortex) can feel like 15,000 feet.

needing constant monitoring, oxygen, intravenous therapy, or other interventions they cannot receive while staying in their own beds with frequent returns to the clinic. In many respects, these are like ED holding or observation beds. They can also be used as intensive care beds for critical patients who cannot be evacuated immediately.

Because on-site health care personnel may be limited, auxiliary staff may be used to monitor these patients. Emergency medical technicians, or paramedics, if cardiac rhythms or intravenous infusions must be monitored, are most often used. When clinic staff must do the monitoring, it often limits the time that they can devote to their normal responsibilities, including seeing other patients.

Dental care. The dental clinic, housed in the medical building, contains the supplies and equipment that an experienced dentist would need. The clinic was equipped so well because, until recently, a dentist had been available for both McMurdo patients and those flown in from the South Pole throughout the summer. In summer months, if no dentist is present, patients are sent to New Zealand for dental care. When there is no dentist and patients cannot be sent out (due to bad weather or in winter months), clinicians must do dental procedures with minimal training and experience. Procedures include taking dental radiographs and e-mailing them to the consulting dentist for evaluation, doing dental extractions, and using powered dental tools to "adjust bites." (An occlusal or bite adjustment removes tiny interferences due to development, injury, misaligned crowns, or wear, that keep teeth from coming together properly.) Most patients are aware that medical personnel are not dentists and that most procedures are successful despite this limitation.

Disaster planning. Medical situations in which there is a paucity of the needed skills, equipment, and personnel range from merely a problem to be solved to a genuine disaster. The difference on the scale between predicament and disaster relates to how quickly these resources are needed to help the patient(s) and the possible outcome if they are not provided in time.

In Antarctica, to prepare for an event that could produce more casualties than the available medical personnel could handle, the stations draft nonmedical personnel to form a disaster team. Clinicians select individuals for positions, in conjunction with station management, based on their prior knowledge, experience, and personalities. Although training people to act as scribes, stretcher-bearers, and security officers is routine, training nonmedical personnel to perform phlebotomy and basic laboratory tests, take radiographs, and dispense pharmaceuticals raises some ethical issues. Normally, the people selected for these positions have parallel knowledge and experience. In the past, for example, auxiliary laboratory personnel have included a science laboratory supervisor and the head of the waste treatment plant, both of whom use frequent chemical testing in their normal jobs. Not only must volunteers learn to perform common laboratory tests and then practice using real samples, but they must also learn a new skill: how to do phlebotomy. As with inexperienced phlebotomists in other clinical settings, implied patient consent seems to be sufficient; station personnel know which people are not medical personnel.

Radiology augmentees usually are individuals with a physical science background. In the past, these have included scientists doing laser-meteorological experiments and the weather observers, who have a very technical job. Once they learn on improvised phantoms (usually a stuffed bear), they can take subsequent radiographs on clinic patients. Medical personnel provide initial supervision for routine films and always supervise films that are more complex. Our health care team also obtained explicit verbal consent when volunteers performed radiographs.

Personnel acting as supplementary pharmacy technicians often had a chemistry background or had been pharmacy technicians. Usually, these individuals were used only during the periodic mass-casualty drills, primarily due to the obvious concern that patients might inadvertently receive the wrong medication. In addition, medication dispensing is less complex and time-intensive than the other technical processes for which we needed to train auxiliary personnel.

Teaching. Physicians and mid-level providers also have teaching responsibilities. They are expected to visit various worksites, when requested, to instruct personnel on basic cardiopulmonary resuscitation (CPR) and first aid and the on use of automatic external defibrillators (AEDs) that are distributed around each station. They also provide continuing education to the fire department's paramedics and emergency medical technicians on a regular basis. If qualified, they may also provide formal station-wide CPR/AED courses and certification.

Infection control–public health. Despite secondary predeployment screenings administered just before personnel fly out of New Zealand, episodes of common viral illnesses, known locally as the "crud," have occurred. This has been a recurring health issue, especially during the winter months at McMurdo, when the infrequent flights introduce new personnel and their respiratory infections to the station. One attempt to stem these illnesses was to isolate ill personnel shortly after the new arrivals landed. For one winter, local station management agreed to send anyone with an upper respiratory illness to a one-

person room for 3 days. This resulted in a substantial decrease in upper respiratory symptoms throughout the season. As with other public health measures (e.g., influenza immunizations, handwashing prior to meals, limiting alcohol consumption) that the medical team tries to institute, some on-site supervisors and their companies strenuously and repeatedly object, limiting the effectiveness of these measures.

Food service inspections. Probably the most significant nonclinical medical staff responsibility in the winter months at McMurdo is inspection of the food service areas. Training for this includes passing the national food safety course (ServSafe® Food Handler; National Restaurant Association, Chicago, IL) and accompanying the professional U.S. Army veterinary food inspector (who arrives monthly in the summer) on an inspection of the food preparation and serving facilities (8). The lead physician then does a monthly inspection of the dining, self-service, galley line, and food storage areas, as well as the enormous kitchen's preparation, cooking/baking, food-holding, and food-receiving areas. Missing significant food safety issues can lead to widespread food-borne illnesses, so this task is taken very seriously by both the medical and the food service teams.

Medical Resources

Consultants. When additional clinical information is necessary, station clinicians generally rely on Internet-based resources, because the quality, availability, and timely response of remote consultants is not consistent. Most consultants have little idea about the constraints of remote medical practice or Antarctic weather and evacuation difficulties. The clinicians and consultants also do not know each other or their capabilities. Some clinicians successfully opt to contact consultants they know from their normal practice (9). Dental consultation is generally the exception, because the dentist has usually been part of the Antarctic medical team, is familiar with the equipment, and is readily available.

Scholarly resources/Internet connections. All stations have good phone and Internet connections, although the South Pole station's geographic position in relation to communication satellites often limits the hours during which they have access. Multiple communication modalities, such as radios, phones, and satellite phones, allow clinicians access to the remote scientific groups who travel from McMurdo Station during the summer months. These modalities are also used to contact medical consultants in the United States and New Zealand, the New Zealand clinics where patients from McMurdo and the South Pole can get appointments during summer months, and the Christchurch hospitals to which very ill or injured patients from Antarctica are initially sent.

Medical Transportation/Evacuation

Due to environmental conditions, winter transportation to McMurdo Station is very limited (~6 months) and it is virtually nonexistent to the South Pole (~9 months). The NSF states that they "have the capability to stabilize and manage a range of emergency medical and dental conditions before patients are transported off the continent for further care. However, medical evacuations are costly, take a lot of time and effort, and place others at risk. Weather may make travel impossible for extended periods" (10). Similar to many U.S. government nonfixed health care facilities (i.e., medical ships and military ground units), distance, weather, and the unavailability of transport may make patient evacuation difficult or impossible from Antarctic stations (3,11,12).

One of the most ethically difficult decisions for Antarctic physicians is whether to try to evacuate patients to a higher-level diagnostic and treatment facility as an emergency or during inclement conditions. Sending patients off-Ice for anything other than a clinic appointment or scheduled laboratory test is a complex and costly venture, even in the summer when planes routinely fly between Antarctica and New Zealand. It requires special airworthy (Air Force-approved) medical equipment and trained aeromedical personnel. Authorizing an emergency transport requires a decision not only from the station's chief medical officer and the USAF or private flight service (for the rare winter South Pole evacuations), but also from the physician program director, the station manager and NSF representative, and the NSF chief medical officer, many of whom are off-continent. If a patient requires a rare winter evacuation from the South Pole, two special propeller-driven Twin Otter aircraft must fly in from their base in Canada, because they are the only airplanes capable of functioning in the extremely low temperatures.

Evacuating patients from Antarctica costs from tens to hundreds of thousands of dollars, and in the case of South Pole evacuations, puts the crewmembers' lives at risk. When making the difficult decision to evacuate, the clinician must balance patient desires, good medical decision-making, and bureaucratic constraints. Even when everything is in place for a critical evacuation, the always-unpredictable Antarctic weather conditions may make it impossible. Such was the case when a VIP visitor developed a life-threatening cardiac dysrhythmia, but bad weather required balancing his health with the aircrew's

safety. Until he could be evacuated a week later, the entire medical staff and a set of fire department medics had to continuously monitor his cardiac rhythm, compromising care for the rest of the population.

Fire department ambulances often provide on-station and inter-station (between the adjacent New Zealand station and McMurdo) patient transport. McMurdo (and, in the summer months, the South Pole) has a robust fire department due to USAF requirements for their airfields. McMurdo's includes paramedic-staffed ambulances with standard life-support equipment.

Ethical Issues

Antarctic medical practice has ethical issues common to small, occupational, and resource-poor settings (13,14). A constant ethical tension exists between what patients or health care providers see as optimal interventions and what is possible or permitted. And, as in any closed-group setting, a lack of both privacy and confidentiality exists. With their small isolated populations, the two larger Antarctic stations are especially vulnerable to this during the winter season; at the small Palmer Station, this is always a concern. With all personnel working, eating, living, and playing together, and the ability to see anyone coming in and out of the medical facility, it is nearly impossible to maintain patient confidentiality, especially when the patient has time off work, is hospitalized, or has an obvious illness or injury. Whereas the medical team maintains silence, patients' co-workers, roommates, or dining companions usually elicit, and then distribute, all but the most sensitive information.

CONCLUSIONS

Medical practice at the U.S. Antarctic stations, as with many remote health care facilities throughout the world, has similarities to standard emergency medical practice. However, it differs sufficiently so that a steep learning curve is often involved in successful practice. Any clinicians considering practicing in these locations should carefully evaluate the practice and the environment in advance of any deployment.

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