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**LESSONS FROM THE POLES:  
REMOTE LIVING, WORKING AND HEALTHCARE IN  
THE POLES, AND ANTARCTICA AS THE ULTIMATE  
SPACE ANALOGUE**



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ABSTRACTS SUBMITTED TO THE (CANCELLED) SCAR 2020 OSC IN HOBART

## Development of a Masters Program for Healthcare in Remote and Extreme Environments at the University of Tasmania

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This presentation describes the development of the Masters program in Healthcare in Remote and Extreme Environments. It emphasises the collaborative approach used with industry partners, notably the Australian Antarctic Division and outlines the curriculum development process to cater for a diverse range of professional roles in different extreme environments.

The philosophy and educational approaches are discussed, and in particular the innovative content relevant to Antarctic, Space and Extreme Sports Medicine is explored.

The presentation will conclude by looking into the future and determining the ongoing direction of the program.

## Women's Health in Extreme Environments

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### BACKGROUND

Austere, low-resource environments on land, underwater, and in space pose unique healthcare challenges. Some health risks impact women differently than men. To date, many of these differences are understudied; only a small fraction of expeditioners to extreme environments such as Antarctica and Space have been female.

### REMOTE MEDICAL SYSTEMS CONSIDER GENDER DIFFERENCES

#### Terrestrial Extreme Environments

Behavioral health stresses of isolated, confined, and extreme (ICE) environments such as Antarctica appear to affect women and men differently. Lack of sun exposure, dietary constraints, and decreased weightbearing in winter environments results in bone loss, but exercise was shown to preserve bone and lean mass in women trekkers in Antarctica. Women are at higher risk for UTIs than men. Oral contraceptive use is associated with increased risk of DVT. Cardiovascular (CV) disease in women is severely understudied, but gender-specific care is needed to reduce morbidity and mortality.

#### Spaceflight Environment

Fluid shifts are problematic in microgravity resulting in physiologic responses such as ocular changes (only symptomatic in men to date) and concerning vascular flow abnormalities. DVT has been documented in mission but risk factors need further delineation. Adaptations to microgravity include muscle atrophy and bone loss which occur differently in women than men.

### SUMMARY

Women's health in austere environments is understudied, partly owing to overall low numbers of female polar explorers and only 11% of astronauts worldwide being female. Fortunately, female involvement in Antarctic and Space expeditions is increasing, allowing for needed gender-specific physiologic research across both environments where certain parallel risks exist.

Tearing Along the Continent:

## The Challenges of Evacuating an Aortic Dissection From Antarctica

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### Introduction:

The challenge of Antarctic medicine comes from the pairing of an extreme and hostile environment with lengthy extraction timelines, and a need to provide prolonged medical care in clinical austerity. There are direct parallels between delivering care in Antarctica and delivering care in another operational environment – prolonged spaceflight.

### Case Description:

The presentation of an aortic dissection late into the Austral summer encountered a number of these challenges. With limited investigations, there was initial diagnostic uncertainty despite thorough history taking and clinical examination. Disease progression was detected by serial examinations, which allowed a conclusive diagnosis to be made. Initial transportation was by ship to another nation's Antarctic base for aeromedical evacuation. The patient was flown to a tertiary hospital for definitive treatment and has since made a full recovery. This case also demonstrates the limitations of pre-deployment screening and potential for significant unexpected diagnoses.

### Discussion:

Caring for critically unwell patients with limited resources often relies on the support of non-medical team members such as the first aid party. Managing their skills, expectations, and working hours can be difficult especially when risk of patient death is high. Confidentiality is a concern in confined environments, and is challenging when dealing with multiple stakeholders. Clear communication between all parties including the use of telemedicine proved essential in co-ordinating patient care. These challenges are likely to be replicated in prolonged spaceflight and may be mitigated by using the experience of Antarctic clinicians to guide planning and training.

## Antarctica; the proving ground for Space Medicine

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The launch of the Australian Space Agency provides an opportunity to promote and grow Australia's space assets. One key asset is the Australian Antarctic Division's Polar Medicine Unit (PMU) which has been supporting significant advancements in the field of Space Medicine for years.

The PMU has been a key contributor to the development of new medical training guidelines for the European Space Agency's (ESA's) Astronaut Corps. These guidelines are designed to train non-physician astronauts in the medical skills required for spaceflight; this training is now mandatory for all ESA astronauts prior to spaceflight. These guidelines were directly informed by the experience of the PMU and other partner organisations in undertaking the emergency medical management of patients in an Antarctic setting.

As international space agencies look to the Moon and to Mars, they are faced with unique medical challenges that must be overcome if astronauts are to safely operate within these environments. Antarctica is a well-established space analogue environment with a proven history of managing medical emergencies that are translatable to space flight. The experience of Antarctic nations can be utilised to inform the future of Space Medicine, ensuring crews are optimally trained and prepared for exploration and habitation missions.

As Australia steps onto the world stage with the launch of the Australian Space Agency, we have the potential to learn from our Antarctic experiences and contribute to the next great step in exploration and scientific endeavour.

## Challenged by extraordinary Exposomes: lessons learned on neurophysiologic and immunologic changes and its impact on space flight, polar expeditions and health on Earth

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The humans' adaptation skills to changing environments have been critical to be an explorer and to survive extreme environments on Earth. These frontiers are pushed further and after 50 years after landing on the moon and establishing a permanently base orbiting Earth (ISS), he is striving to new dimensions of (deep)space exploration and permanent outpost.

In Antarctica and in space the exposome comprises conditions that the crew are exposed to during their stay in these extreme environments and to which they have to adapt to in order to maintain physical and mental health. Antarctica is challenging humans with some stressors similar to space. The impact of the space-exposome, as recently shown, includes neuro-structural impairments and immune pathologies. The impact of each of the potential causal factors for these changes remain under debate and microgravity, but as well as the isolation conditions are among the most important factors. Accordingly, brain imaging in polar expeditioners before and after wintering-over at the Neumayer station showed that the volume of the hippocampal dentate gyrus was reduced and expands results of morphological changes seen as a consequence of isolation mimicking long duration space flight. Moreover, immune dysfunctional states seen in overwintering crews show interesting similarities to observations when challenged to the space-exposome.

This ground work in Antarctica is of unique translational value for crews in the extremes and for patient as all have to cope to different extent with prolonged confinement, social and environmental deprivation and its effects on the brain and the immune system.

## Sleep Quality Changes during Overwintering at the German Antarctic Stations Neumayer II and III: The Gender Factor

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### Purpose:

Antarctic residence holds many challenges to human physiology, like increased psychosocial tension and altered circadian rhythm. We assessed changes in sleep patterns during 13 months of overwintering at the German Stations Neumayer II and III from 2008 to 2014, with focus on gender.

### Materials & Methods

Time in bed, sleep time, sleep efficiency, number of arousals, sleep latency, sleep onset, sleep offset, and physical activity level were determined during seven overwintering campaigns of n = 54 participants (37 male, 17 female) using actimetry.

### Results:

We found overall longer times in bed ( $p = 0.004$ ) and sleep time ( $p = 0.014$ ) for women. Gender had a significant influence on sleep time ( $p < 0.001$ ), number of arousals ( $p = 0.04$ ), and sleep onset ( $p < 0.001$ ). Physical activity decreased over overwintering time for men ( $p = 0.003$ ), but not for women ( $p = 0.174$ ). The decline in sunshine radiation led to 48 minutes longer time in bed ( $p < 0.001$ ), 3.8% lower sleep efficiency ( $p < 0.001$ ), delay of 32 minutes sleep onset ( $p < 0.001$ ), and 11% less daily energy expenditure ( $p < 0.001$ ), for all participants during the darkness phase.

### Conclusions:

Overwinterings at the Stations Neumayer II and III are associated with significant changes in sleep patterns, with dependences from overwintering time and local sunshine radiation. Gender appears to be an influence, as women showed a declining sleep quality, despite that their physical activity remained unchanged, suggesting other causes such as a higher susceptibility to psycho-social stress and changes in environmental circadian rhythm during long-term isolation in Antarctica.

## Physiological Changes in Participants of an Ultramarathon in Subarctic Climate – the Yukon Arctic Ultra

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### Purpose:

The objective of this study was to determine alterations in energy expenditure, body composition, metabolites, and cytokines in athletes participating in the Yukon Arctic Ultra.

### Materials & Methods

Ten participants (8 males, 2 females; age:  $37 \pm 10$  years) traveling on foot in the 2017 692-km event were recruited for the study. Measurements and samples were obtained at pre-event, 278 km, 384 km, and post-event (692 km). Outdoor temperatures ranged from +5 to -47°C. Body composition measurements were obtained using bioelectrical impedance analysis. Accelerometer devices provided an estimation of caloric expenditure and dietary recalls gave assessments of caloric intake. Blood serum samples were collected, and analyzed using enzyme-linked immunosorbent assays or nuclear magnetic resonance.

### Results:

Four males and one female completed the entire event in  $260 \pm 19$  h. Caloric intake was  $4,126 \pm 1,115$  kcal/day and expenditure  $6,387 \pm 781$  kcal/day, indicating a caloric deficit of  $2,261 \pm 1,543$  kcal/day. Total mass, body mass index, and fat mass were reduced at each time point of the event. Fat-free mass (FFM) was unchanged throughout the event. Follistatin was increased at C1 ( $1,715 \pm 876$  pg/ml) in comparison to baseline. Acetoacetate increased significantly at post-event ( $6.1 \pm 1.5$  mg/ml).

### Conclusions:

Despite a pronounced caloric deficit and sustained activity under extreme cold conditions, FFM was preserved with an increase in serum follistatin, indicating preservation of musculature, and acetoacetate, indicating increased fat-metabolism. Future studies should be directed at the role of nutrient strategies for retention of FFM under these conditions.



## CHOICE-e kick-off: Monitoring occurrence of hypersensitivity reactions in (Ant-)arctic environments

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In previous studies in Antarctica significant hypersensitivity and immunological changes have been quantified ex vivo. These observations complement case-reports from overwinterers and findings by NASA on ISS-crewmembers, where the occurrence of newly developed allergic type reactions is increased, in relation to isolated and stressful living conditions. Based on those findings, the CHOICE-e (e=epidemiology) study has been initiated in 2019 to survey the epidemiology of such reactions at Polar stations. Data will be collected systematically via a simple web-/ app-based survey prior to-, during and post their polar (overwinter-) expeditions about occurrence of such allergic incidences.

Once they sign up, CHOICE-e volunteers first undergo a personal interview and a general questionnaire evaluating each individual's predisposition for a broad range of sensitivity/allergic reactions. During and after the respective missions, CHOICE-e volunteers are tasked with filling out a shorter questionnaire about the possible occurrence of allergic reactions and self-estimating stress scores. For over-winter 2020, CHOICE-e has 109 volunteers, enrolled at 12 stations (2 arctic/10 Antarctic) from 7 polar institutes. Systematic data on incidence of sensitivity reactions after exposition to extreme, isolated and confined conditions will be a result of CHOICE-e, expected results will be helpful to develop mitigation and countermeasures to prevent immune dysfunctions in extreme environments, with potential applications for daily lives.

Due to the complementary ground and space-based nature of the research, CHOICE-e is uniquely conducted under the umbrella of the European Polar Board (EPB) with support from the European Space Agency (ESA)

## Methodological challenges in psychological researches and practices in Antarctica

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**Introduction:** The Antarctic Isolated, Confined and Extreme Environment (ICE) is considered a natural laboratory for the study of human physiology and behavior. However, the same contextual characteristics imposes limitations on conducting on-site research. **Objective:** to map the methodological challenges in researches and practices in the field of psychology conducted in the Antarctic environment. **Method:** Participative observations were made on the spot onboard ships, Air Force planes and at the Comandante Ferraz Antarctic Station (2014-2019) with expeditioners from the Brazilian Antarctic Program. **Results:** The main challenges identified include weather conditions (which require quick decision making without prejudice to the methodological and ethical aspects of the research), complex setting in Antarctica (reduced guarantee of privacy and continuity of psychological practices), interruptions and unforeseen events (which impair control of variables), empirical studies still emerging (making it difficult to choose appropriate instruments and techniques), reduced number of participants (which does not allow for more robust statistical procedures) and the researcher's immersion requirement (sharing residence and workspace 24 hours a day, which can impair the necessary distance between the researcher and research object). **Conclusion:** Interdisciplinarity, especially with anthropological methods, was important to complement the work of researchers in the field of Psychology, allowing a broader look at the phenomena investigated, in the face of challenges. Working in such a context requires tolerance to frustrations and creativity to reallocate the research method with viable alternatives predicted. Remote access technologies can present themselves as effective tools for planning and carrying out studies in psychology in the future.

## Medical research in Japanese Antarctic research activities: a review of the current status and future prospects

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The Japanese Antarctic research activities initiated in 1956 reached the 61st expedition in December 2019. The total number of the Japanese Antarctic Research Expedition (JARE) members who participated exceeded 1900. Medical staff managed the health of the members and also engaged in medical research. Although the participants of the research were few, the findings were greatly valuable.

In this review, a detailed search of original articles was performed using the PubMed-MEDLINE database to identify recent English literature and the Ichushi-Web (Japan Medical Abstract Society) database to identify Japanese literature relevant to Antarctic medicine. We also confirmed the records of the National Institute of Polar Research.

A search on PubMed for “Antarctic, Japan, human,” found 16 original papers in English since 1994. An article on disease and injury statistics related to the JARE was published in 2004 and updated in 2019. There were two topics related to immunity. Eight were related to closed environmental sleep and circadian rhythm, while one was about resident bacteria of the skin, seasickness, bone metabolism, and urination.

A search on Ichushi-Web for “Antarctica, Medicine (in Japanese),” found 62 original papers (54 in Japanese, 8 in English), 6 commentaries, and 94 conference proceedings in Japanese since 1959. The most frequently discussed was a review of Antarctic medicine, followed by physiological adaptation, psychology, and sleep/circadian rhythms.

According to records from the National Institute of Polar Research, since 2014, one review of psychological research (in Japanese, with English abstract) and one publication of IntechOpen have been published in English.

## Vitamin D Supplementation: lessons learnt from Antarctica

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Bone loss occurs during prolonged sunlight deprivation leading to vitamin D deficiency. We observed amongst healthy adult expeditioners to Antarctica, an annual reduction of 1% in femoral neck bone mineral density during an expedition, and vitamin D deficiency (25(OH)D <50nmol/L) within 4 months of deployment. Our subsequent randomized double-blind placebo-controlled vitamin D supplementation trial indicated that a 50,000IU dose of vitamin D every 2 months maintained vitamin D adequacy (>50nmol/L) with a monthly dose required to improve levels if <50nmol/L. Subsequently a policy statement and vitamin D supplementation protocol was developed in 2009 and implemented for the Australian Antarctic Division to ensure vitamin D adequacy in all wintering expeditioners in Australia's Antarctic Program. Since implementation of the Vitamin D supplementation protocol we have recorded serum vitamin D levels at the end of Austral summer prior to entering winter isolation, and on return to Australia to assess the effectiveness of this protocol. Vitamin D supplementation dosages and serum 25(OH)D levels prior to, and at the end of isolation will be presented to determine clinical efficacy of this evidence-based protocol. Further work including assessing safety concerns such as risk of renal calculi will support the establishment of a standardised evidenced-based approach to vitamin D supplementation across the Antarctic expeditioner community, to help ensure skeletal health is maintained in all expeditioners. Efficacy of evidenced-based Vitamin D supplementation, compliance, and risks in Antarctic isolated confined extreme environments informs health and well-being planning for Antarctic and other sunlight deprived populations on Earth and in space.

## How do wintering members use their experience in prior missions to Antarctica? – The possibility of psychoeducation about stress before a mission.

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[Purpose] Japanese wintering members are placed enclosed and isolated in Antarctica and need to maintain their mental health by relying on themselves. It is necessary to provide information about stress before a mission, however, inappropriate information may directly be associated with serious risks related to enclosed environments. Thus, it is critical to select useful information for maintaining the mental health of wintering members in Antarctica. On the other hand, there are experienced members who have acquired knowledge of stress based on their prior wintering mission. Therefore, this study aims to investigate how experienced members use their previous experiences for the next mission. The main purpose is to generate clear and useful information to be used before a mission based on this research.

[Method] 1) Results obtained in the Profile of Mood States(POMS) were compared between the experienced and first-time group. 2) Qualitative analysis of post-mission interviews with seven experienced members was performed.

[Results]1) In the third quarter of the mission, the experienced members had discrepancies in their mood. 2) Experienced members also had to endure dual viewpoints regarding themselves and the entire group during this period.

[Conclusions] Information of periods during which members have diverse variations in their mood is more important than individual mood change. These results also suggest that providing knowledge before a mission regarding individual variations is valuable.

## Psychological characteristics of the third-quarter phenomenon investigated by Baum test

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The third-quarter phenomenon is a cluster of symptoms consisting of sleep disturbance, impaired cognition, negative affect, and interpersonal tension and conflict experienced by people on polar expeditions in the Antarctic after the midpoint of an expedition, with some reduction in symptoms toward the end (Palinkas and Suedfeld, 2008). Our previous research has shown that the negative affect associated with the third-quarter phenomenon comprises anger and hostility (Kawabe et al., 2014), that the phenomenon occurs regardless of job type or personality (Kawabe et al., 2016), and that members of polar expeditions often do not consult with a medical doctor when they suffer from the phenomenon (Kawabe et al., 2018). In this study, we administered a tree-drawing test (Baum test), which is a projective test used extensively in psychology, to 28 members of the Japanese Antarctic Research Expedition (JARE). On the basis of the results, we investigated the psychological characteristics of the third-quarter phenomenon through case studies on nine persons who exhibited the third-quarter phenomenon. We uncovered three negative psychological states: 1) temporary collapse of psychological balance, 2) a certain amount of ego inflation, and 3) increased aggression, along with three positive ones: 4) self-awareness of one's conflicts, 5) having confidence to refuse, and 6) having the will to solve problems. These results demonstrate that the third-quarter phenomenon has two-sided characteristics, both positive and negative.

## Thermal insulating clothing promotes increase in forehead sweat efficiency during an Antarctic expedition

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From a physiological perspective Antarctica has a very challenging environment since the cold and wind are stressful stimuli for the human body. Thus, it is necessary the utilization of appropriate clothes that would create a microenvironment to avoid significant drop in body temperature. Due to its thermal insulating characteristic, the heat exchange with the environment may be impaired by those clothes, and during Antarctic displacements may lead to an accumulation of sweat and consequently to an increase in the internal body temperature. This study aimed to evaluate if an Antarctic expedition with insulating clothing results in thermoregulatory adaptations to heat. Seven volunteers ( $30 \pm 3.78$  years;  $71.66 \pm 77$  cm) performed a 45-minute run at  $31^\circ\text{C}$  and 60% of relative humidity (RH) in a thermal chamber before and after a total of 72 days of voyage including 32-day camping (in a sub-Antarctic Livingston Island). During the 45-minute run, local sweat production ( $\text{TLS}\cdot\text{gm}^{-2}\cdot\text{min}^{-1}$ ) and the number of active sweat glands ( $\text{ASG}\cdot\text{cm}^2$ ) on the forehead, forearm, chest, arm and thigh were recorded. Core temperature was also recorded. Student's t-test was used for comparisons between averages.  $P > 0.05$ . Compared to pre-Antarctica expedition values, post-Antarctic TLS increased (pre:  $113.23 \pm 23.38$ ; post:  $134.79 \pm 12.00$ ;  $P = 0.001$ ) and ASG reduced on the forehead (pre:  $135 \pm 58$ ; post:  $61 \pm 23$ ;  $P = 0.018$ ). The use of thermal insulating clothing during 32 days of an camp in Antarctic resulted in increased sweat efficiency on the forehead of young adults.

## Sleep pattern and mood state during a 50-day summer camp in Antarctica

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Antarctic expeditions include psychophysiological challenges, such as isolation, cold and extreme photoperiods (continuous exposure to natural light during summer); all of these challenges influence sleep. We assessed changes in night sleep patterns during displacement on a ship, 50-days in a camp (Nelson Island, S53.178533°/O70.899750°) and the post-field period on the ship, from Dec2019 to Feb2020. Sleep efficiency, time in bed, number of awakenings, wake after sleep onset (WASO), sleep time and sleep latency were determined daily in seven participants (5M, 2W) using actimetry (ActTrust, Condor). The expedition was divided in: Pre-field (6 days on board), Field-1 (1st week of field), Field-2 (days 8 to 20), Field-3 (days 21 to 35), Field-4 (days 35 to 50) and Post-field (4 days on board). Mood state was evaluated using the Brunel Mood Scale, and daytime sleepiness using the Epworth Scale, both applied between 7 and 9am. Relative to the Pre-field measurements, Antarctic summer camp reduced sleep efficiency by 4.8%, and increased time in bed, number of awakenings and WASO by 15.7%, 42.5% and 38.3%, respectively; all changes returned to Pre-field values during the Post-field. At Field-2, 3 and 4, excessive daytime sleepiness (score above 10) was observed. 'Confusion' was increased at Field 1, and 'vigor' was reduced at the end of camping (Field 4). There were no differences in sleep time, sleep latency, anger, depression, tension and fatigue. The present results suggest that a 50-day summer camp in Antarctica changes the sleep pattern, thereby increasing drowsiness and inducing occasional negative changes in mood.



## Effects of sprint interval training on physical performance and anthropometric, physiological and cognitive parameters in military personnel during an Antarctic naval expedition

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Military personnel participating in polar expeditions are subjected to environmental and behavioral changes resulting from naval confinement. Under the latter condition, sprint interval training (SIT) can be a non-pharmacological strategy for promoting health benefits in these individuals. This study aimed to evaluate the effects of SIT on physical performance, and anthropometric, physiological and cognitive parameters in military personnel during an Antarctic naval expedition. Sixteen men ( $35.2 \pm 5.5$  years) were randomly assigned to the following groups: SIT and control, non-training (NT). SIT consisted of 8 sessions: 5 to 7 sprints lasting 30s at 150% of the maximum aerobic speed attained during a pre-training incremental test; a 240-s recovery was allowed between sprints. The following parameters were measured before and after the intervention period in both groups: maximum aerobic speed (physical performance), adiposity (anthropometric parameter), heart rate variability, concentrations of blood thyroxine (T4) and salivary immunoglobulin A (IgA; physiological parameters), and working memory (cognitive parameter). SIT significantly increased physical performance [ $P = 0.03$ ; effect size (ES) = 1.12] and reduced adiposity ( $P = 0.04$ ; ES = 0.87) compared to NT. Moreover, SIT promoted moderate effects in increasing cognitive performance (ES = 0.87), parasympathetic tone (ES = 0.61; 0.85; 0.69) and T4 concentration (ES = 0.66) and in decreasing IgA concentration (ES = 0.88). In summary, SIT can be an interestingly intervention to promote health benefits (e.g. improved aerobic fitness, body composition, cardiac autonomic control and cognitive performance) in confined military personnel during an Antarctic naval expedition.

## Risk management by leaders of wintering parties in Antarctica

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Successive Japanese wintering parties were placed in an isolated environment in Antarctica for durations of about one year. They received few visitors because there were no other permanent research stations nearby. The environment was very stressful. However, all members completed their tasks with very few injuries and few big accidents.

Therefore, we focused on the quality of the risk management of the leaders of the wintering parties in Antarctica. We did semi-structured interviews of six former leaders of Japanese wintering parties. Three of them were leaders of parties in which members could hardly communicate with people in Japan because they sent messages only by telegraph. The other three were leaders of parties in which members could communicate with people in Japan at any time over the internet.

We found there were risks (1) associated with personal matters, (2) with wintering parties that were closed societies, (3) with the quality of the management of the leader, (4) with Antarctica, such as the climate and remoteness, and (5) with the connection to Japan during wintering. In particular, the risks associated with the connection to Japan were much stronger than before when members could not use internet. This led to great changes in the quality of the risk management of leaders during wintering.

## A report on medical case with acute weakening of vision

### -----An experience of telemedicine and medical evacuation of a patient with eye disease

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<sup>1</sup>Tokatsu Hospital, Nagareyama, Japan, <sup>2</sup>Tottori University, Yonago, Japan, <sup>3</sup>Tsukuba University, Tsukuba, Japan,

<sup>4</sup>Nationa Institute of Polar Research, Tachikawa, Japan

We experienced an acute eye disorder case which needed telemedicine support and medical evacuation.

**Case Report:** A participant of Syowa Station, male in his 30's, consulted a station doctor because of bloodshot eyes with pain, weakening vision after outdoor operations in November. Non-steroidal anti-inflammatory eye drops were used but shew no recovery. The doctor requested telecommunication by ophthalmologists. Television made it possible to examine visual field constriction, anterior chamber and conjunctiva clearly. Steroid drips were recommended but vision became worse. It was difficult to further therapy without more information such as fundus. A medical evacuation was decided, and the patient was sent to Japan by airplane in 6 days.

**Discussions:** Eye diseases counted 397 (6%) of 6837 medical cases in Syowa station between 1956 and 2016. It was the fifth-place following orthopedics, inner medicine, surgery, dental and skin diseases. Though eye diseases are usually non-critical, it is hard for patients to work in Antarctica and after coming back if they had aftereffects.

Telemedicine becomes indispensable in Antarctica. It is said to be useful especially in orthopedics and teeth trouble. Here, we showed it also effective in eye diseases, and it will work better with a fundus camera and tonometer.

This case is the fifth medical evacuation during 63 years of Japanese Antarctic expedition. Though there are great limitations such as impossibility in winter and melting sea ice used as a runway in midsummer, medical evacuation has been so developed as one of popular selective medical treatments.

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## Evaluating Effectiveness of Monitoring of Oxygen Saturation at High Altitude in Antarctica

Shinji Otani<sup>1</sup>, Yoichi Miyaoka<sup>2</sup>, Atsushi Ikeda<sup>3</sup>, Giichiro Ohno<sup>4</sup>, Satoshi Imura<sup>5</sup>, Kentaro Watanebe<sup>5</sup>

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**Introduction:** Antarctica is covered with a thick ice sheet that reaches up to an average of 2,450 above sea level (a.s.l.). Japanese Antarctic Research Expedition (JARE) has been doing research activities in extreme environmental conditions at high altitude where can cause health disorder including acute mountain sickness (AMS). To improving the safety of members during Antarctic expeditions, we evaluated the impact of extreme environmental conditions of the Antarctic inland on human health and effectiveness of monitoring of hypoxia for early detection of AMS.

**Methods:** In total, 9 members from JARE 59 were included in the study. Dome Fuji Station (Dome F), located 3810 m a.s.l., was the destination of the party. We investigated daily AMS scores (the higher value, the more severe AMS-related symptoms), physiological findings, and percutaneous arterial blood oxygen saturation (SpO<sub>2</sub>) during the inland activity. We also determined the factors related to AMS scores.

**Results:** The average AMS score at arrival at Dome F was significantly higher than at departure point (S16, 560 m a.s.l.). SpO<sub>2</sub> level was negatively correlated with AMS score. In generalized estimating equations analysis, AMS score was positively associated with age ( $p < 0.001$ ) and negatively associated with the level of SpO<sub>2</sub> ( $p = 0.035$ ).

**Conclusion:** Hypoxia is one of the factors related AMS and we can confirm easily hypoxic state from levels of SpO<sub>2</sub>. Monitoring SpO<sub>2</sub> could be useful for health management of members in Antarctic inland activity.

## Dental Care in Antarctica as an Analogous Model for Planning Lunar Base Operations

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NASA is committed to return to the Moon in 2024 and to establish a lunar base for research and other activities. Due to its remote location and isolation, Antarctica serves as an excellent analog. Data from compiled research suggests that dental/oral health complications are the third most common healthcare occurrence among Antarctic bases. Data also suggests that over a 60-year period health complications while on Antarctic bases has been trending towards an increase on a per person basis. Some of the dental issues are of a serious nature and require medical transport from the continent for treatment. In general, dental training for medical providers is minimal and the available dental equipment may be inadequate. The study seeks to bring a better understanding of the dental equipment and training necessary to establish a lunar base. Consideration for equipment selection includes minimizing size and weight due to the cost of transporting such items to the lunar surface. This research shows that dental health will be a key issue to understanding and properly preparing for future lunar missions.

## Antarctica as an Analog for Commercial Spaceflight Medical Monitoring

**Edward Powers<sup>1</sup>**

<sup>1</sup>*University of Texas Medical Branch at Galveston, Galveston, United States*

The advent of commercial space travel will present challenges for medical monitoring due to the diverse population wealthy enough to afford it. The Antarctic community is analogous to the commercial space population in that they do not fit the traditional image of the highly selected healthy astronaut population. Health conditions that have been disqualifying for spaceflight in the past will be commonplace among average space travelers and it is imperative to adequately monitor their medical conditions in order to assure the safety of the individual and the success of the mission. UTMB recently acquired a grant from the Federal Aviation Administration Center of Excellence for Commercial Space Transportation to develop new occupational medicine standards for the commercial spaceflight community. In the first phase of this grant, medical conditions that are expected to require monitoring are being identified along with the appropriate wearable devices to monitor those conditions. The second phase of the grant is focused on testing the devices in ground based analogs and on commercial astronauts in-flight. Antarctic medical data is used as an analog for evaluating common disease conditions in an austere environment and in determining the appropriate monitoring technology. Physicians in the UTMB Aerospace Medicine Residency Program have already performed preliminary testing of several wearable devices used for monitoring diabetes, circadian cycle disruption and sleep quality while on tour of duty to Antarctica associated with their residency training. Current progress on the development of spaceflight occupational medicine standards and monitoring technology will be presented.

## The Incidence of Injury in British Antarctic Personnel between 2007 and 2016

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<sup>1</sup>*British Antarctic Survey Medical Unit, Plymouth, United Kingdom*

### Introduction

A recent incidence of injury in the British Antarctic population is not known, neither whether changes to health and safety policies have reduced it. The aims were to describe the profile of injuries experienced by British Antarctic Survey (BAS) personnel between 2007-2016.

### Methods

Retrospective review of records, travel itineraries and incident reporting systems.

### Results

Incidence of injury reduced from 661.7/1000 person-years (1986-1995) to 529.3/1000/year (2007-2016). 44.9% were picked up by the incident reporting system. New injuries were 21.1% of all consultations with 35.5% follow-up consultations. On average 65.1 consultations each month, minimum in September and maximum in January. Mean incidence on ships was 334.6/1000/year and 657.8/1000/year on bases. Peak incidence was at South Georgia (1182.6/1000/year) and lowest at Signy (130.2/1000/year). Peak major trauma was at Halley with 212/1000/year and peak work related injury at Halley also (547.5/1000/year). Commonest were sprains(47.9%), superficial(15.1%), wounds(11.1%) and fractures(8.5%). The most frequently affected occupational group were crafts and trades workers(32.4%), then professionals(22.1%).

### Conclusion

Incidence of injury decreased compared to a similar study from 20 years prior. A report was created that profiles incidence and types of injury at each location with contributing factors of injuries in the BAS population in Antarctica. It can be used to train and inform doctors travelling South but also inform management and senior decision makers to enhance operational and strategic decision making. It produces a picture of injury that is also potentially of use to other national Antarctic programs and is useful as a comparison for health care interventions



## Monitoring human health indices using 3D optical whole body scanning

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Optical 3D (3DO) scanning has been proposed as an accessible self-assessment technology capable of estimating total and regional body composition and anthropometry measures, and ideally suited for remote environments (space, antarctic region). Our objectives were to predict DXA body composition, serum lipid and diabetes markers, and functional strength from 3DO body scans using statistical shape modeling and automated anthropometry.

Four-hundred and seven healthy adults underwent whole-body 3DO and DXA scans, blood tests, and strength assessments in the Shape Up! Adults cross-sectional observational study. Principal component analysis was performed on registered 3DO scans and 476 automated anthropometry measures acquired. Linear regressions were performed to estimate body composition, biomarkers, and strength.

We found that 11 PCs for each sex captured 95% of body shape variance. 3DO body composition accuracy to DXA was: fat mass  $R^2 = 0.88$  male,  $0.93$  female; visceral fat mass  $R^2 = 0.67$  male,  $0.75$  female. 3DO body fat precision was: RMSE =  $0.81$  kg male,  $0.66$  kg female. 3DO visceral fat was as precise (%CV =  $7.4$  for males,  $6.8$  for females) as DXA (%CV =  $6.8$  for males,  $7.4$  for females). Multiple 3DO PCs were significantly correlated with serum HDL cholesterol, triglycerides, glucose, insulin, and HOMA-IR. 3DO PCs improved prediction of isometric knee strength ( $R^2 = 0.67$  male,  $0.59$  female; anthropometrics-only  $R^2 = 0.34$  male,  $0.24$  female).

3DO predicted body composition with good accuracy and precision comparable to existing methods. 3DO PCs improve prediction of serum lipid and diabetes markers, and functional strength measurements.

## Unexpected high diversity of *Legionella* spp. in Antarctic environment and their colonization in Japanese Antarctic research station

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*Legionella* spp., potential pathogens of Legionellosis, are ubiquitous bacteria that inhabit in freshwater environments. Man-made water facilities are also common reservoirs which can be a source of infectious outbreaks. In polar regions, little is known about the occurrence and distribution of this bacteria, but from our previous investigations, *Legionella* DNA was continuously detected by PCR from Japanese Syowa station in Antarctica (69°S, 39°E). Our next aim was to elucidate whether these DNA were from humans or local environment and determine the presence of pathogenic species. We investigated the occurrence and diversity of *Legionella* spp. in both artificial and natural environments in Antarctica using *Legionella*-specific 16S rRNA gene-based amplicon sequencing. We will show the results of analyzing 33 samples of water and biofilm collected from glacier lakes (water, 22) and Syowa station water facilities (water, 3; biofilm, 8). 488 *Legionella* amplicon sequence variants (ASVs) with median of 93 (IQR, 81.0-122.0) were observed from lake samples and 207 *Legionella* ASVs with median of 14 (IQR, 5.5-29.5) from Syowa station samples. When comparing samples collected from these two sites, 50% of ASVs from Syowa station were shared with ASVs from lakes, whereas predominant ASVs in Syowa station were rarely observed in lake environment and that included ASVs nearly identical to potential pathogenic species. We found out that diverse *Legionella* spp. inhabit in Antarctic low-temperature environment. Some pathogens detected in the station were not related to those from the local environment, suggesting that they were originally transferred from outside Antarctica.

## The role of circadian phase on sleep, performance and mood in Antarctic over-winter expeditions

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The Antarctic environment presents extreme seasonal variation in the natural light-dark cycle. Differences in light exposure can cause variability in the alignment of the circadian pacemaker with the timing of sleep resulting in sleep disruption, and impaired mood and performance. This study assessed the prevalence of circadian misalignment and consequences for sleep, cognitive functioning and psychological health in over-wintering Antarctic expeditioners. Fifty-one expeditioners (45.6±11.9 years) completed daily sleep diaries and monthly computer-based performance tests and psychological health questionnaires. Circadian phase was assessed via monthly 48-hour urine collections to assess the melatonin metabolite 6-sulphatoxymelatonin (aMT6s) rhythm. While the average sleep duration was 7.2±0.8 hours, 41.2% of sleeps were <7 hours and 19.1% were <6 hours. Circadian phase was highly variable and 34/50 expeditioners had sleep episodes occur at abnormal circadian phase. This accounted for 18.8% (295/1565) of their sleeps. Expeditioners obtained less sleep on average during misaligned sleep episodes (6.36±1.19 h), compared to aligned (7.17±0.95 h, p<0.0001). Performance and mood varied in a predictable manner with circadian phase and time since waking. This research highlights the prevalence of misalignment between the timing of sleep and the circadian pacemaker in Antarctic over-wintering expeditioners. Similar prevalence has been observed in long-duration space flight, reinforcing the fidelity of Antarctica as a space analog. The effects of circadian misalignment have immediate safety implications, and potentially longer-term health risks for other circadian-controlled systems. This highlights a need for appropriate interventions, such as properly planned lighting solutions, to ensure circadian alignment during long-duration Antarctic and space missions.

## Everest 2020: How will COVID-19 affect the Everest 2020 climbing season? Can infection control lessons from the world's third pole be extrapolated to the south pole?

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Beyond the daunting challenge of climbing Everest, each climbing season, running April to May, has its own unique challenges. There were no summits in 2014 and 2015 following the devastating consequences of a serac collapse (2014) and the Gorka earthquake (2015.) 2017 saw an influenza outbreak seriously curtail the summit chances of many mountaineers. The “fake rescue” scandal tarnished the 2018 season whilst the 2019 season suffered from a limited summit window resulting in crowding with subsequent deaths and international media outrage. Through it all, the volunteer physicians at the Himalayan Rescue Association (HRA) Everest ER Aid Post work tirelessly to take care of the climbers as well as the Sherpas, porters, kitchen staff and camp staff.

In 2020, the Everest climbing season faces a new threat, COVID-19. In early March, Nepal effectively shut the border to climbers from 5 countries; China, Korea, Japan, Italy and Iran, whilst athlete sponsors have withdrawn funds and climbers have cancelled plans. Teams that normally climb from Tibet's northern side of Everest have either withdrawn or switched to the south. Other teams are requiring athletes to arrive into Kathmandu two weeks earlier than normal to self-quarantine. At the time of writing, Nepal has only recorded one case of COVID-19, although the lack of cases is probably due to the lack of testing rather than a lack of prevalence.

Will these measures be enough to protect the health of Everest climbers? Will there be further challenges?  
How will the 2020 Everest season pan out?

## House dust mite monthly survey in an Antarctic wintering base

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In the Antarctic, some patients present symptoms similar to those of allergic rhinitis. Although the house dust mite allergen was detected in an Antarctic base, the concentration was too low to elicit an allergic reaction. We surveyed house dust mites (*Dermatophagoides* spp.) and their allergens, monthly, to validate whether their concentration reaches symptomatic levels in any period. We surveyed house dust mite population and allergen levels once a month at three fixed observation points in Syowa Station, an Antarctic wintering base. The allergen level was measured with a portable device using monoclonal immunochromatography. The mite population was measured by microscopically counting the number of mite bodies. Simultaneously, we measured temperature and relative humidity at these observation points. Neither the house dust mite body nor allergen were detected in any month of the observation year. However, we detected *Rhizoglyphus* sp. (bulb mite). We consider that the mite could have been present in the cargo brought into the Antarctic base. For house dust mites, surviving, reproducing, and being the cause of allergic rhinitis is difficult in the Antarctic bases due to indoor hygrothermal environment. However, pathogenic alien arthropods such as *Rhizoglyphus* spp. could be brought even into the Antarctic.

## Sleep pattern during the stay at the Brazilian Antarctic Station

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From a physiological perspective Antarctica has a very challenging environment whereas cold, confinement, wind and sensory monotony are considered stressful stimuli for the human body. In addition to these factors, Antarctica has extreme photoperiods, with long periods of light in the summer and darkness in the winter. The aim of this study is to investigate the pattern and quality of sleep of fourteen military volunteers during their stay at Brazilian research station in Antarctica. The volunteers from the Brazilian Antarctic Program are being evaluated over a six-month stay at the Comandante Ferraz Antarctic Station (Admiralty Bay, King George Island, Antarctic Peninsula), between summer and early winter (January, March and May), during Brazilian Antarctic Operation 2019/2020. Time in bed, sleep time and sleep latency, number of awakenings, sleep efficiency and wake after sleep onset (WASO) will be evaluated, based on data obtained every two months using actimetry (ActTrust, Condor). We will test the hypothesis that there is a change in sleep pattern and in the quality of sleep between the summer and early winter periods during the stay at an Antarctic research station.

## Brazilian individuals traveling to Antarctica on board a ship present changes in the thyroid hormones concentration and mood state

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Displacement to Antarctica usually occurs on board ships, which represent an isolated and confined environment with artificial luminosity, particularly in the cabins and main areas of coexistence. There is evidence that days of total darkness in Antarctica (i.e., reduced exposure to natural luminosity) can induce the "polar syndrome" that is characterized by an increase in thyroid-stimulating hormone (TSH) simultaneously to a reduction in thyroxine (T4). This study aimed to assess whether traveling on board a polar ship changes thyroid hormones (TSH and T4) concentration, which can lead to important metabolic and mood changes. The volunteers (n = 17, all tropical inhabitants) spent three weeks on board the Brazilian Ship Alte. Maximiano (H41) during summer. Data collection was carried out 4 and 19 days after boarding in Punta Arenas (Chile). Blood samples were collected and analyzed by fluoroimmunoassay to determine TSH and T4 concentrations, and mood state was evaluated using the Brunel Mood Scale (BRUMS). Student t-test was applied;  $\alpha = 5\%$ . Data are presented as means  $\pm$  SD. Compared to the initial measures, T4 reduced by 6.6% at the final measure (P=0.023), whereas TSH remained unchanged (P=0.63). Also, there were increases in Anger (0.8 $\pm$ 1.1 to 2.5 $\pm$ 2.7; P=0.027) and Depression (0.5 $\pm$ 0.6 to 2.1 $\pm$ 2.6; P=0.038) and a reduction in Vigor (9.2 $\pm$ 3.2 to 7.6 $\pm$ 2.4; P=0.044). In the context of an Antarctic expedition, short-term ship travels reduce the concentration of T4 and provokes negative changes in mood in tropical inhabitants, possibly due to reduced exposure to natural luminosity.

<b>A</b>			
Albert, Edi	860	Arantes, Rosa Maria	827
Aoki, Kotaro	410	Ayton, Jeff	860, 939, 780
Arantes, Rosa	817, 818, 1499		
<b>B</b>			
Baatout, Sarah	1616	Bennett, Jonathan	776
Badhe, Renuka	1616	Bruzzi, Rúbio	818
Barros Delben, Paola	376	Bullens, Dominique	1616
<b>C</b>			
Cable, Gordon	860	Choukér, Alexander	1271, 1276, 1293, 1616
Carroll, Danielle	1590	Chow, Dominic	776
		Clark, Frank	1590
		Coker, Robert	1293
Chadwick, Amber	655	Costa, Raquel	376
Cherry, John	1215	Curless, Brian	776
<b>D</b>			
Dias Soares, Danusa	1065	Duarte da Silva, Caroliny	376
<b>E</b>			
Espinosa, Cristian	817, 818		
<b>F</b>			
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