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Health protection factors during Arctic Operations

Key findings to date

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Abstract

Over the past decade, the Canadian Armed Forces (CAF) have increased their training and Arctic sovereignty patrols in the Canadian Arctic. Since 2016 DRDC – Toronto Research Centre has been actively conducting research tracking medical events and injuries (freezing and non-freezing) that occur during Arctic exercises and investigating the CAF's readiness from a medical standpoint to identify gaps and mitigate these medical incidents. A variety of data, including medical event data, interviews, surveys, physiological and clothing and footwear micro-climate thermal data were collected on six exercises from 2016–2018. The purpose of this Reference Document is to update the client on interim results of this project.

Résumé

Au cours des dix dernières années, les Forces armées canadiennes (FAC) ont augmenté leur entraînement et leurs patrouilles de souveraineté dans l'Arctique canadien. Depuis 2016, RDDC Toronto mène activement de la recherche sur les suivis des événements médicaux et des blessures (avec et sans congélation) qui surviennent pendant les exercices dans l'Arctique et des enquêtes sur la capacité opérationnelle des FAC d'un point de vue médical pour cerner les lacunes et atténuer ce genre d'incidents médicaux. Diverses données, notamment des données sur les événements médicaux, des entrevues, des sondages et des données physiologiques et thermiques sur les microclimats des vêtements et des chaussures ont été recueillies lors de six exercices de 2016 à 2018. Le présent rapport vise à informer le client des résultats provisoires de ce projet.

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Background

Recent Government of Canada defence strategies have emphasized the importance of the Canadian Armed Forces (CAF) to be prepared to operate in the Arctic to handle a range of safety and security demands. In response, over the past decade, the CAF have increased the frequency and duration of their presence in the Arctic to support the government's position on Arctic Sovereignty. At the same time, it has been recognized that the CAF's Arctic Doctrine needs to keep pace with respect to operations in the extreme cold.

Defence Research and Development Canada (DRDC) – Toronto Research Centre was invited by the CAF's Joint Task Force North to attend Arctic training exercises to investigate the Forces' readiness from a medical standpoint to address major trauma incidents during Arctic Operations. Accordingly, this RD provides key findings in response to a request from Col Bouchard for an update on the 04ki project entitled Health Protection Factors for Arctic Operations.

A scientist from DRDC – Toronto Research Centre attended and collected data during the following exercises: EX ARCTIC RAM 2016 (DRDC HREC 2016-007), OP NUNALVUT 2017, EX NOREX 2017, EX ARCTIC BISON 2017 (DRDC HREC 2017-008), EX NOREX 2018 (2017-008 #3) & OP NUNALIVUT 2018 (2018-005) [1–4]. These studies informed Canadian Forces Health Services (CFHS) on types and frequency of injuries sustained during Arctic operations, and identified key health risks, challenges and limitations of current CAF medical treatment and medical evacuation practices during Arctic operations and human performance issues during Arctic operations. The medical information was gathered by the Medical Officers deployed on the exercises/operation. All other information was gathered through observations of the exercise, interview sessions with key medical and non-medical personnel, and physiological data. This information was used to help guide DRDC in discerning gaps and operational deficiencies related to the conduct of trauma medicine in the austere environment of the Arctic. This work also formed the basis for two workshops held by DRDC. The first workshop was held in June 2017 and focused on health risks and human performance [5]. The second workshop was held in January 2018 and focused on experimentation for the Arctic for future work under the Royal Canadian Air Force and an international collaborative meeting under the International Cooperative Engagement Program for Polar Research (ICE-PPR) [6]. This work also helped initiate a NATO HFM exploratory team ET 142 "Medical Treatment and Human Performance in Arctic Operational Environments" involving Canada, US, and Norway that met in January 2018.

Methods

Data on these exercises/operations was collected using various methods including; health surveys, clothing surveys, Cold Weather Injury (CWI) surveys, and semi-structured interviews (2016–2018). Physiological monitoring data, including sleep and energy expenditure, was collected (2017–2018). Thermal data was collected using ibuttons and skin thermistors (2017–2018).

The medical event data collected below was diagnosed and collected by the medical officers on each of the exercises. The detail of the medical event data was not consistent across exercises/operations and this is reflected in the tables below.

Statement of Results

2016

EX ARCTIC RAM: Data collection—observations, interviews and medical event data.

Table 1: ARCTIC RAM 2016 Medical Events [7].

| Diagnosis | Passive Surveillance (<i>n</i> = 215) | | Active Surveillance (<i>n</i> = 126) | |
|--------------------------------|-------------------------------------------|----------------|------------------------------------------|----------------|
| | <i>N</i> | Proportion (%) | <i>N</i> | Proportion (%) |
| Frostbite | 42 | 61.8 | 38 | 100 |
| Face | 11 | 16.2 | 11 | 28.9 |
| Hands | 11 | 16.2 | 7 | 18.4 |
| Nose | 10 | 14.7 | 17 | 44.7 |
| Feet | 8 | 11.8 | 3 | 7.9 |
| Ears | 2 | 2.9 | 0 | 0.0 |
| Trauma | 12 | 17.6 | | |
| Forearm Abrasion/Laceration | 2 | 2.9 | | |
| Back Pain | 2 | 2.9 | | |
| Concussion | 1 | 1.5 | | |
| Wrist Sprain | 1 | 1.5 | | |
| Toe Fracture | 1 | 1.5 | | |
| Knee strain | 1 | 1.5 | | |
| Not Otherwise Specified | 4 | 5.9 | | |
| Upper/Lower Respiratory | 6 | 8.8 | | |
| Tract Infection | | | | |
| Dermatological (Not Frostbite) | 2 | 2.0 | | |
| Blister (Hand) | 1 | 1.5 | | |
| Callus (Heel) | 1 | 1.5 | | |
| Gastroenteritis | 2 | 2.9 | | |
| Eye Irritation | 2 | 2.9 | | |
| Thermal Burn (Hand) | 1 | 1.5 | | |
| Plantar Fasciitis | 1 | 1.5 | | |

Note: Reprinted from Medical Encounters during a Joint Canadian/U.S. Exercise in the High Arctic, by Military Medicine, retrieved from <https://www.publications.amsus.org>.

2017

EX ARCTIC BISON: Medical event data.

EX NOREX & OP NUNALIVUT: Health check surveys, CWI surveys, observations, interviews, medical event data, and thermal data (boots and gloves) and energy expenditure data.

Table 2: EX ARCTIC BISON 2017, OP NUNALVIT 2017, EX NOREX 2017 Medical Events.

| Passive Surveillance | | Passive Surveillance | |
|-------------------------------------------|-------|----------------------|--------------|
| Medical Issues | Total | Frost Nip | Total |
| | 109 | | 14 |
| Medical Issues NOREX | 22 | Face | |
| URTI | 19 | Feet/Toes | |
| Eye Irritation (ash, gas, conjunctivitis) | 11 | Hands/Fingers | |
| Hypothermia | 10 | Undefined | |
| Laceration | 9 | Follow-up | |
| Dermatological | 6 | Frostbite | Total |
| Burn | 4 | | 42 |
| Dehydration | 3 | Face | 4 |
| Weakness | 2 | Hands/Fingers | 10 |
| Flu/Viral Illness | 2 | Feet | 12 |
| Streptococcus | 2 | Nose | 6 |
| Gastro | 2 | Ears | 1 |
| Gastric Reflux | 2 | Undefined | 7 |
| Diarrhea | 1 | Follow-up | 2 |
| UTI | 1 | Trauma | Total |
| Buttocks Strain | 1 | | 38 |
| Constipation | 1 | Back Pain | 13 |
| Dental | 1 | Muscle Skeletal | 7 |
| Pneumonia | 1 | Other | 10 |
| Insomnia | 1 | | |
| Vertigo | 1 | | |
| Mental Health | 1 | | |
| Bursitis Elbow | 1 | | |
| Rib Strain | 1 | | |
| Circulatory | 1 | | |
| Jaundice | 1 | | |

During OP NU 2017 and EX NOREX 2017 ibuttons were attached to the inside liners of both the mittens and boots of 20 soldiers that were deployed to the field. These ibuttons measured the microclimate of the boot/mittens. The lines in the graph below indicate the temperatures measured.

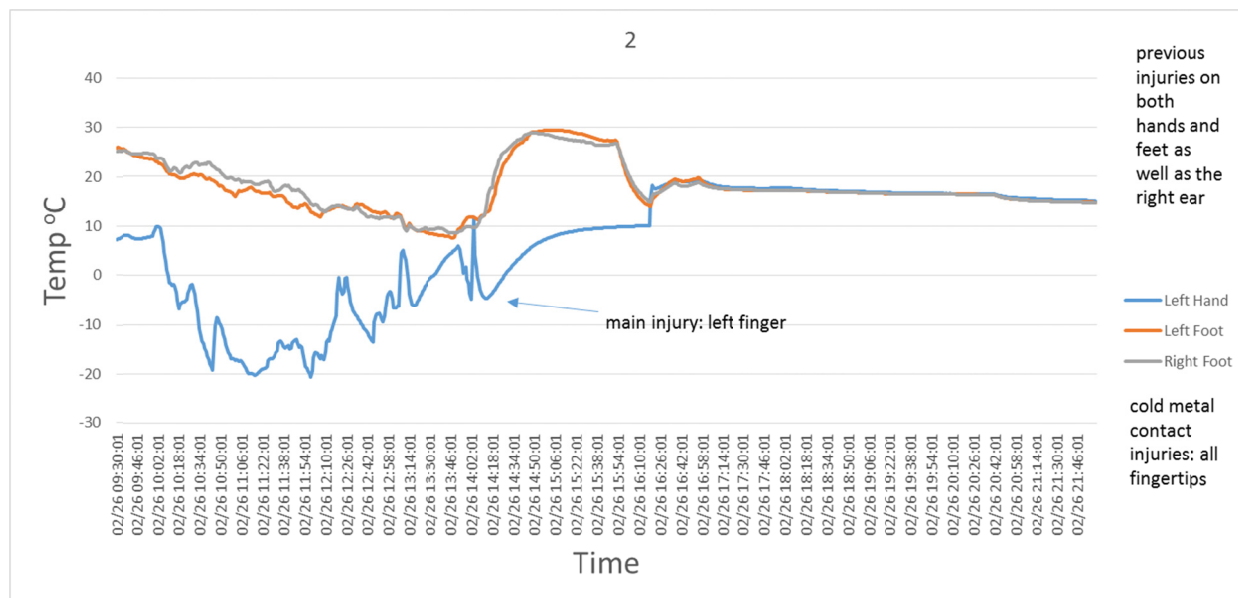


Figure 1: Subject 2 Thermal Data, Frostbite Feet, OP NU 2017.

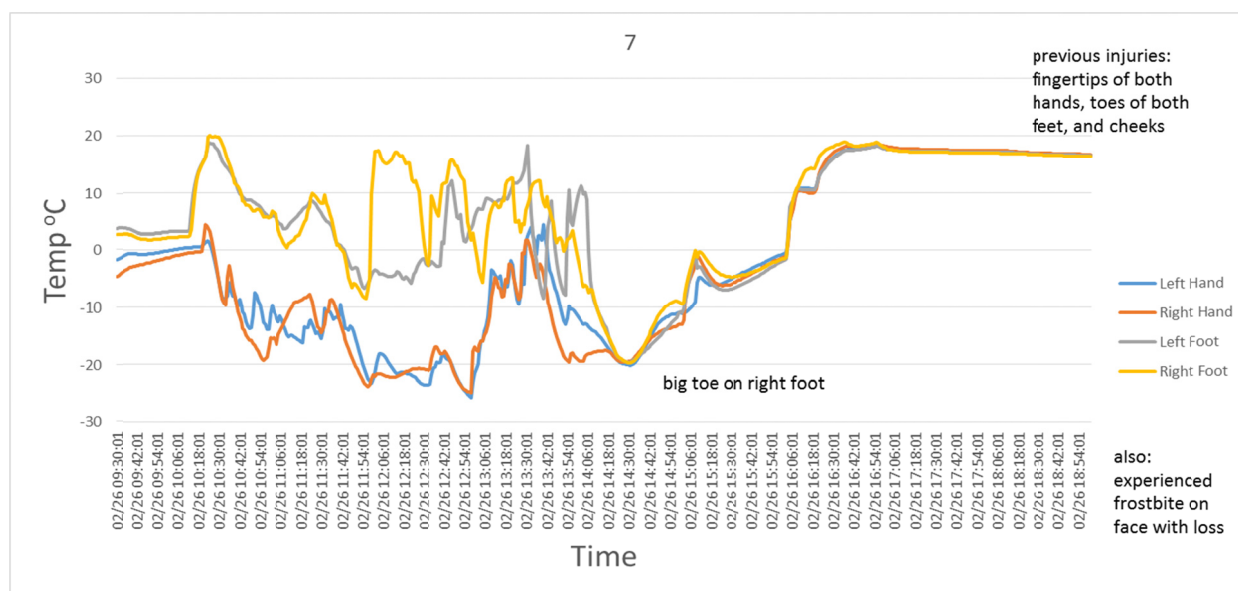


Figure 2: Subject 7 Thermal Data, Frostbite Feet, OP NU 2017.

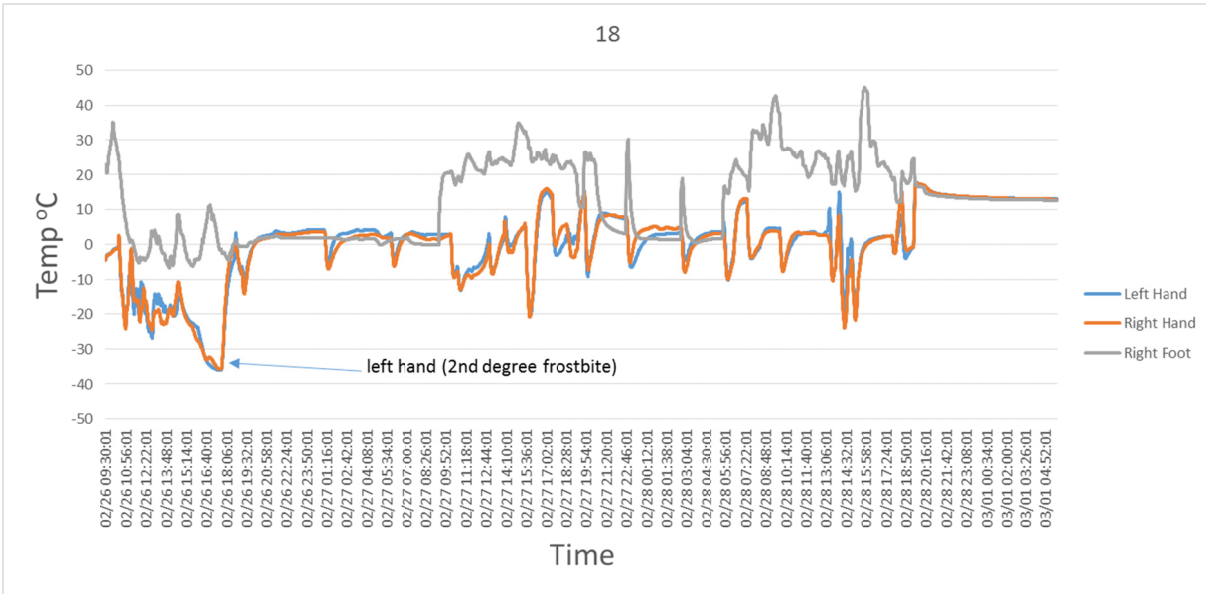


Figure 3: Subject 18 Thermal Data, Frostbite Feet, OP NU 2017.

2018

EX NOREX: Clothing surveys, CWI surveys, health check surveys, medical event data.

OP NUNALIVUT: Clothing surveys, health check surveys, CWI surveys, medical event data, DISS data, cold vaso-dilation data, sleep and energy expenditure field data, field thermal data (boots and gloves), toe temperature field data, finger temperature field data.

Table 3: EX NOREX 2018 Medical Events.

| Medical Events for EX NOREX 2018 (~243 pers) | # of Diagnosed cases |
|----------------------------------------------|---------------------------|
| GI | 3 |
| MSK | 12 |
| Frostbite/nip | 29 (Passive Surveillance) |
| Blood born exposure | 1 |
| Hypothermia | 2 |
| Burns | 5 |
| Derm | 1 |

| Medical Events for EX NOREX 2018 (~243 pers) | # of Diagnosed cases |
|-------------------------------------------------------------|-----------------------------|
| Lacerations | 3 |
| Ophtho | 3 |
| Neur | 4 |
| Resp | 1 |
| ENT | 5 |
| Total | 69 |

Table 4: OP NU 2018 Medical Events.

| | OP NU 18 (145 pers with 118 deployed to the field) | Cambridge Bay (145 pers with 95 deployed to the field) | TOTAL |
|-------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------|
| # Mbrs with CWI | 46 | 13 | 71 |
| Frostbite | 41 | 11 | 62 |
| Frostnip | 6 | 3 | 11 |
| Hypothermia | 1 | 0 | 2 |
| CWI LOCATION | | | |
| Hands | 1 | 0 | 4 |
| Fingers | 15 | 3 | 23 |
| Feet | 2 | 0 | 4 |
| Toes | 5 | 2 | 11 |
| Face | 13 | 10 | 24 |
| Nose | 26 | 7 | 35 |
| Ear | 1 | 1 | 2 |
| Neck | 2 | 0 | 2 |
| Incidences (total of all locations) | 65 | 23 | 105 |
| Gastrointestinal | 1 | 9 | 10 |
| Musculoskeletal | 3 | 13 | 16 |
| Respiratory | 0 | 1 | 1 |

2016 was a scoping year for this project which included many interviews with a variety of medical personnel deployed on Arctic Ram and a number of CAF members in key positions. Medical event data was collected by the medical officer on the exercises in 2017.

Using data collected via interviews, surveys, and physiological/thermal measurements, the four Arctic OPs studies, conducted by DRDC, identified a number of medical capability gaps. More specifically,

- Applicability of medical techniques and equipment to Arctic environment,
- Arctic-specific medical training,
- Specialized medical equipment,
- Ensuring clinic stock,
- Medical surveillance and epidemiology,
- Remote medical treatment,
- Communication/accountability challenges,
- Improved evacuation procedures, and
- Training and equipment while awaiting evacuation.

In addition, deficiencies related to performance and training were also identified by the data collected. More specifically,

- Training to recognize and report the early signs of cold injury,
- Training on clothing layering system,
- Improved cold weather clothing accessories,
- Medics and mechanics need gloves that will provide dexterity and protection,
- Nutrition that will increase performance in the cold and prevent dehydration,
- Communication challenges,
- Equipment to protect hands on LOSVs from the cold, and
- Protective non-fogging eyewear.

Although nutrition and combat rations were not primary focuses for DRDC's Arctic investigations, it was noted that energy deficiency adversely affected physical and cognitive performance during cold weather exercises. Troops tend to expend more energy during cold weather operations and at the same time they tend to decrease their intake of food [8,9]. Such inadequate nutrition and hydration puts the soldier at a higher risk for cold weather injuries. CAF members have raised concerns regarding current cold weather feeding operations, particularly, the unsuitability of the type and quantity of food [8].

Based on the preliminary results gathered from ARCTIC RAM 2016, which only investigated health risk and medical events, there was a clear indication to further explore physiological/thermal measurements.

Discussion of Results

Cold weather injuries were significant medical events for 2016–2018. More often than not, soldiers did not report incidences of frostbite as they may have not thought the injury serious enough, may have attempted self-treatment, or thought that reporting to the clinic would have taken too much time given mission requirements. The combination of the extreme low temperature and wind chill may explain the high incidence of frostbite injuries in Arctic operations, compared to other military exercises conducted in cold environments [7].

In all investigations completed to date, facial frostbite was reported at a higher rate than extremities such as hands and feet. Facial frostbite likely occurred as soldiers often removed Canadian Army-supplied goggles during snowmobile operations. The goggles were reported to fog immediately upon wear, thus, obscuring vision at any speed of snowmobile travel. For some soldiers, frostbite injuries to the hands were likely due to the removal of gloves as fine motor skills and dexterity were required to work with medical or military equipment. Other soldiers who were diagnosed with frostbite on their hands commented that the Arctic mittens were not sufficient for those temperatures. Soldiers reported that their Canadian Army-supplied kits were too generic for all seasons/temperatures as opposed to the extreme conditions of the Arctic and therefore a number of soldiers chose to wear commercial equipment (boots, mittens and face protection). Thermal measurements were taken on soldiers who wore both CAF-issued and commercial equipment. The soldiers that suffered frostbitten extremities (i.e., feet, toes, hands, fingers) showed that the temperature dropped to as low as -20 degrees Celsius in boots and -35 degrees Celsius in mittens (Figures 1–3). Further research comparing commercial and issued kit is recommended on this issue. It was noted by several CAF members that fur-lined mitts and hoods provided superior protection against the cold and prevented frostbite, but these accessories were not military issue [5].

Furthermore, the medical team emphasized that kits would often freeze up and there were issues with keeping equipment and supplies warm. More importantly, the team expressed concern about the logistics of evacuation plans for injured persons, due to the remoteness of Arctic operations and challenges with communication. The results from the interviews [10] with the medical teams on the 2016–2018 Arctic exercises are expected to be published in Spring 2019. Suggestions have been made for the creation of a standardized training syllabus for both operators and medical officers assigned to extreme northern exercises or operations.

Conclusion

The observations and interview data collected during Arctic operations are being processed and analysed for future publications. Our interim findings suggest that:

- There are gaps with respect to medical capabilities, equipment and training for Arctic operations.
- There are gaps with respect to soldier training for extreme cold (e.g., lack of an advanced winter warfare course).
- Cold weather injuries (e.g., frostbite) have been the most reported injury during Arctic operations and more research is recommended.
- There are issues with some of the current pieces of cold weather personal protection equipment.

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13. ABSTRACT (When available in the document, the French version of the abstract must be included here.)

Over the past decade, the Canadian Armed Forces (CAF) have increased their training and Arctic sovereignty patrols in the Canadian Arctic. Since 2016 DRDC Toronto has been actively conducting research tracking medical events and injuries (freezing and non-freezing) that occur during Arctic exercises and investigating the CAF's readiness from a medical standpoint to identify gaps and mitigate these medical incidents. A variety of data, including medical event data, interviews, surveys, physiological and clothing and footwear micro-climate thermal data were collected on six exercises from 2016-2018. The purpose of this report is to update the client on interim results of this project.

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