Challenges and Approaches to Patient Simulation for Extreme Cold Environments

Two winters of medical simulation training research and development in Arctic Conditions

[1]Sims E, [2]Pike W, [1]Gonzalez R, [1]Raum D, [1]Wentz R, [1]Silverglate D
[1]Vcom3D, Inc., Orlando, FL; [2]US Army DEVCOM STTC, Orlando, FL

Introduction

- Current medical simulators lack the ability to function in extreme cold environments, nor do they exhibit signs, symptoms, or physiological responses of common cold weather injuries, including frostbite or trauma-induced hypothermia.
- The Army has partnered with industry and academia to develop a high-fidelity Mixed Reality (MR) training system that focuses on these conditions while providing the ruggedness necessary for training in subzero environments.

Phase I

- The ECSTREME Team tested materials, power sources, pumps, and electronics in laboratory conditions to identify potential components for Arctic use.

Phase II: Year 1

- The ECSTREME team observed the Arctic Medicine Course (AMC) at Fort Wainwright to understand training needs, gaps, and environmental challenges.

Phase II: Year 1

- ECSTREME incorporates Mixed Reality (MR) capabilities, including animated displays of Underlying Anatomy, procedures, patient monitor, and an interactive TCCC (1380) card.

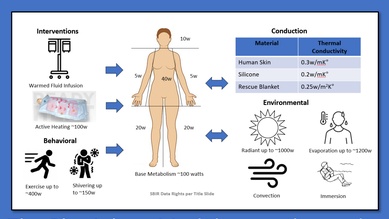
Phase II: Year 2

The ECSTREME prototype system was evaluated for operation and usability integrating it into 11th Airborne AMC conducted at the Fort Wainwright Medical Simulation and Training Center (MSTC), and subsequently in Arctic Edge 2026. Details of testing are available on request.

Research Questions

1. Identify physical challenges that an extreme cold environment poses for patient simulation. How can these be mitigated?
2. Identify injuries, physiological changes, and treatments that are unique to, or more prevalent in, extreme cold environments. How can they be simulated?
3. Describe how Augmented Reality (AR) can be applied to advance learning about cold weather injuries and their treatments.

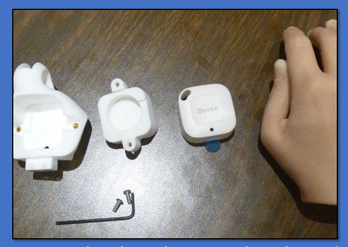
Physiology Model



The Physiology Model was enhanced to include a model of skin and core temperatures, based on:

- Basal Metabolic Rate
- Thermogenic action (e.g., activity, shivering)
- Clothing resistance
- Active heating
- Blood loss

Cold Weather Injuries



New manikin hands were developed with University of Washington CREST. These interchangeable hands:

- Exhibit varying levels of frostbite, including both color and hardness
- Include wireless thermal sensors

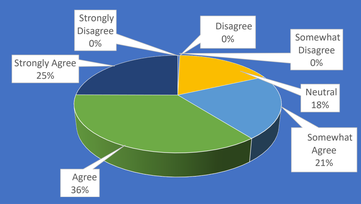
Procedures

A TacMed MATTi manikin was modified to train cold weather procedures in a representative environment by:

- Adding an anal opening for a rectal thermometer
- Modifying the simulated blood to flow at -20°F

Operational Testing Summary

N=7, 46 Questions
Likert Scale 1 to 7
Mean = 5.55, SD = 1.35



Frostbite Hands Questions	Group Score
The frostbite hand exhibited realistic hardness of a hand with 2nd degree frostbite of the fingertips (prior to thawing).	5-Somewhat Agree
The wrist of the frostbite hand could be flexed or extended without damage.	7-Strongly Agree
The frostbite hand did not detach during the access or performance of interventions.	7-Strongly Agree
The fingers of the frostbite hand could be manipulated to enable bandages between fingers without causing damage the skin or internal components.	6-Agree
Gloves suitable for the Arctic environment could be placed on the frostbite hand or removed from the frostbite hand without undue difficulty.	6-Agree
Rectal Probe Questions	**Group Score**
Is the rectal opening realistic?	5-Somewhat Agree
The rectal probe could be easily inserted to an appropriate depth, without using excessive force, and without damage to either the manikin or the rectal probe	7-Strongly Agree
The rectal probe did not come out without being intentionally pulled.	7-Strongly Agree
The rectal probe did not require excessive force to be removed.	7-Strongly Agree
Insertion of the rectal probe consistently causes a temperature to be displayed on the simulated thermometer.	6-Agree

FOR FURTHER INFORMATION:
U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND SOLDIER CENTER:
DEVCOM.ARMY.MIL

Government Contact
William Y. Pike, PhD
US Army DEVCOM-SC
william.y.pike.civ@army.mil
Teams (520) 851-0777

Industry Contact
Edward M. Sims, PhD
Vcom3D, Inc.
eds@vcom3d.com
321-663-1951

Disclaimer
This work was supported by DHA Phase II SBIR contract number HT942524C0077. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S Army Medical Research and Development Command (USAMRDC).

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