U.S. Army Research Institute of Environmental Medicine

Natick, Massachusetts

TECHNICAL REPORT NO. T20-15
DATE September 2020

CREATING A COMPREHENSIVE PROFILE FOR INDIVIDUAL RESEARCH VOLUNTEERS DURING COLD WEATHER FIELD STUDIES

United States Army
Medical Research & Development Command

DISCLAIMER

The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or reflecting the views of the Army or the Department of Defense. The investigators have adhered to the policies for protection of human subjects as prescribed in 32 CFR Part 219, Department of Defense Instruction 3216.02 (Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research) and Army Regulation 70-25. Human subjects participated in these studies after giving their free and informed voluntary consent. Any citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement of approval of the products or services of these organizations.

USARIEM TECHNICAL REPORT T20-15

CREATING A COMPREHENSIVE PROFILE FOR INDIVIDUAL RESEARCH VOLUNTEERS DURING COLD WEATHER FIELD STUDIES

Sai Vangala
Stephen P. Mullen
Adam W. Potter
Wendy Sullivan-Kwantes*
Diana P. Sanford
David P. Looney
Xiaojiang Xu

Biophysics and Biomedical Modeling Division
U.S. Army Research Institute of Environmental Medicine

*Toronto Research Centre, Defence Research and Development Canada (DRDC)
Government of Canada

September 2020

U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
11-09-2020	Technical Report	2019-2020

4. TITLE AND SUBTITLE

CREATING A COMPREHENSIVE PROFILE FOR INDIVIDUAL RESEARCH VOLUNTEERS DURING COLD WEATHER FIELD STUDIES

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Sai Vangala
Stephen P. Mullen
Adam W. Potter
Wendy Sullivan-Kwantes
Diana P. Sanford
David P. Looney
Xiaojiang Xu

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
H

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Biophysics and Biomedical Modeling Division
U.S. Army Research Institute of Environmental Medicine
Building 42 - 10 General Greene Ave
Natick, MA 01760

8. PERFORMING ORGANIZATION REPORT NUMBER
T20-15

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Development Command,
Fort Detrick, MD 21702

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Processing of experimental data from disparate sources can be tedious and challenging when the experiment(s) produce a complex set of variables, data at different time intervals, contain repeated measures within subjects, and generate varying numbers of volunteer data at given time points. It is also important to understand and include historical and contextual information. This report provides a step-by-step methodology for creating a coherent database from two cold weather field studies. The method created includes three broad steps: (1) organization of the file hierarchy; (2) creation of subject profiles; and (3) data analysis, and their associated subroutines. This complete method should accelerate the creation of coherent analyzable databases and improve the quantitative conclusions drawn from the data.

15. SUBJECT TERMS
cold exposure; cold injury; data archiving; human studies

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Adam W. Potter
Unclassified	Unclassified	Unclassified	Unclassified	18	19b. TELEPHONE NUMBER *(Include area code)* 508-206-2357

Reset

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The authors would like to thank Dr. Scott Montain for his critical review and comments, and Drs. Reed Hoyt and Karl Friedl for their support of this project.

EXECUTIVE SUMMARY

Processing of experimental data from disparate sources can be tedious and challenging when the experiment(s) produce a complex set of variables, data at different time intervals, contain repeated measures within subjects, and generate varying numbers of volunteer data at given time points. It is also important to understand and include historical and contextual information. This report provides a step-by-step methodology for creating a coherent database from two cold weather field studies. The method created includes three broad steps: (1) organization of the file hierarchy; (2) creation of subject profiles; and (3) data analysis, and their associated subroutines. This complete method should accelerate the creation of coherent analyzable databases and improve the quantitative conclusions drawn from the data.

INTRODUCTION

Epidemiological studies can require extraction of data from multiple experiments which, while being compatible in their intent, may have measured differing variables or sampled at differing intervals. Moreover, each may contain missing data. Inclusion of historical context may also be necessary to understand data collected on a specific variable or within an individual. These experimental differences can make creation of a comprehensive database tedious and challenging.

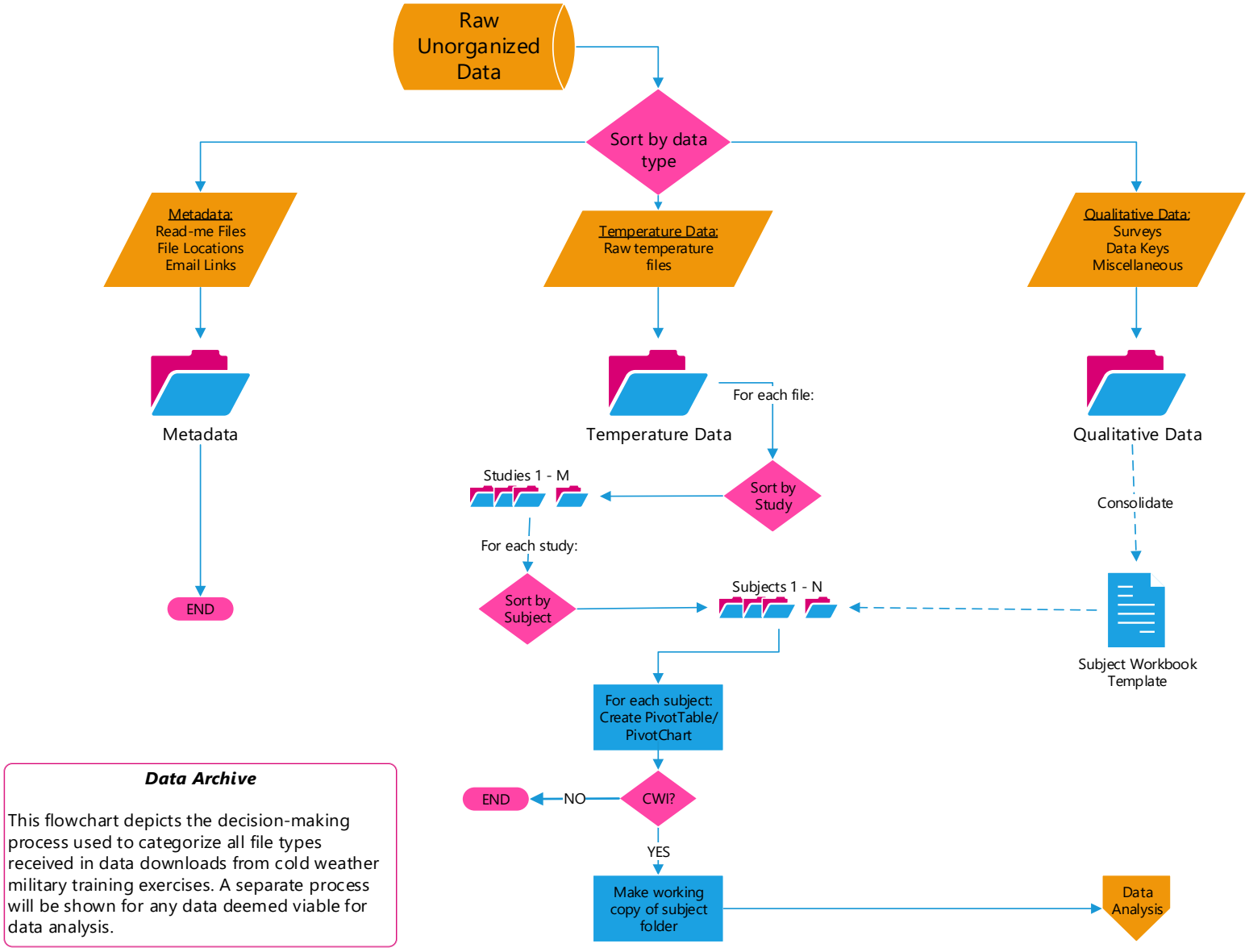
This report describes a spreadsheet-based procedure recently created in order to build coherent individual profiles from data collected in two extreme cold weather field studies but can be extended to a multitude of scenarios and study types. This procedure includes three steps and their associated subroutines for organizing the file hierarchy, creating subject profiles, and performing data analysis. This process will help accelerate the creation of coherent analyzable databases and improve the quantitative conclusions drawn from the data.

The procedure described in this report was developed to create a database from sets of data collected by the Canadian Armed Forces (CAF) during 2 extreme cold weather field exercises. The variables included skin temperatures measured at multiple body locations, pre-exercise questionnaire data from cold weather health checks (CWHC), and answers from post-exercise interviews designed to capture details related to cold weather injuries (CWIs) sustained during the exercises (e.g., cause, body region, discomfort level, treatment).

METHODS

This methodology of subject profile generation has three sequential phases: (1) file directory organization, (2) subject profile creation, and (3) data analysis. We created a flow chart (Figure 1) identifying key decisions to make during the first two phases; this chart also depicts important directories and documents in their relative locations in the file hierarchy.

Figure 1. Flow Chart for file directory organization and subject profile creation



Step 1: File Directory Organization

Figure 2 shows the main subroutines involved with grouping our unorganized data files. We received six separate batches of data for 40 individual subjects, along with accompanying read-me information and directory listings. We duplicated and archived the original folder, and renamed the copy “Canada - Extreme Cold Data”. All actions going forward occurred within the new copy.

Figure 2. Flow Chart for Organizing File Hierarchy

For a given subject, we identified up to four temperature measurements, each recorded in its own workbook titled with metadata such as subject, limb identifier, date and time (e.g., MA033-R.Foot-17MAR26.2253.xlsx for the EX NOREX subjects). Subject files for OP NU contained information such as sensor number and whether the indicated limb had frostbite (e.g., 18-LH-45_frostbite). These subjects also provided qualitative data ranging from initial interviews, post-study questionnaires, summaries of study-related medical incidents, and miscellaneous information (e.g., equipment distribution). All subject answers were grouped by survey into separate workbooks.

Note: For the purposes of clarity going forward, any names of folders in the file directory "Canada – Extreme Cold Data" are in quotes, any names of Excel workbooks are **bolded**, and any names of sheets within Excel workbooks are *italicized*.

1. Consolidate qualitative information.

The first step to consolidating the qualitative information is sorting through the file directory for any workbooks with qualitative information and selecting a primary workbook. Next, conduct a 'Save As' and create a new workbook titled **"Consolidated Survey Data – Master Copy"**. Then we imported any additional sheets with pertinent qualitative information to this workbook, and renamed them with informative file names to indicate their contents (i.e., *Equipment Distribution List*, which came as a lone unnamed sheet from **Equipment Distribution List**). An example of raw qualitative data can be found in Appendix A (Figure A1). The final step is parsing through survey sheets for information related to CWI recorded during the exercise as well as any medical history linked to CWI and highlighting them for future analysis.

2. Create template for individual subject workbooks.

After sorting and consolidating information, we created a template worksheet within the main folder, **Consolidated Survey Data – Master Copy**, titled **Subject Workbook Template**. Next we titled the original sheet as *Surveys*, included question headers to the top row and left a blank row above and below each header to label the sheet it was copied from (above) and to fill in responses (below). Next we imported any sheets containing response keys from the **Consolidated Survey Data – Master Copy**; an example is found in Appendix A (Figure A2).

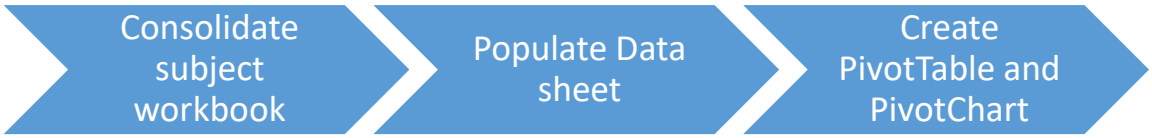
3. Set up hierarchy of folders in file directory.

Within “Canada - Extreme Cold Data”, we established folders named “Metadata”, “Qualitative Data”, and “Temperature Data”. Then we moved ‘read-me’ information, email links, and text files into “Metadata”; all qualitative data into “Qualitative Data”; and all other workbooks containing temperature data into “Temperature Data”, as well as **Subject Workbook Template**.

4. Organize temperature data.

The final process was to organize all of the temperature data within the “Temperature Data” folder by creating “All Study Data” and “CWI Exposure Time Analysis” folders. First, we created individual study folders within the “All Study Data” folder, then for each subject within the appropriate study folders, and then moved all subject temperature files to their appropriate locations. Once all of the files were moved to their corresponding locations, we then created workbooks containing all available information for each subject. Figure 3 outlines the necessary steps, which are repeated for every subject. Details for each of the three steps are found below.

Figure 3. Flow Chart for Creating a single Subject Profile



Step 2: Creating Individual Subject Profiles

1. Consolidate subject workbook

Within each subject folder, we used the **Subject Workbook Template** to create a workbook for each subject. Then we imported any raw temperature sheets and renamed from the default *Temperatures* to the appropriate limb name (e.g., Left Foot). Then we copied all qualitative data relating to each subject from **Consolidated Survey Data – Master Copy** and pasted them under the appropriate question header.

2. Populate Data sheet

We then populated a new sheet labeled *Data* with all subject temperature data in one location. We ensured that we used the data sheet with the longest Date/Hour column for each of the imported data sheets, and verified that timelines in each sheet were synchronized to establish only one copy of the full timeline was needed.

3. Create PivotTable and PivotChart.

We created PivotCharts and PivotTables and populated the Axis categories of interest. Once all fields were added we then used the built in functions for analyzing some detailed and aggregate statistics.

Step 3: Data Analysis

Once we organized and consolidated all of the files and individual subject data, we began data analysis starting with two main steps, 1) identifying files that required further investigation and 2) analyzing and categorizing exposure times (Figure 4).

Figure 4. Flow Chart for Data Analysis

1. Identify CWI subjects for further investigation

We first checked the survey data for any responses or indications of CWI sustained during exercises. We copied any flagged CWI information over from the *Surveys* and added them into the *PivotChart* sheet, organizing by both survey and question answered.

2. Aggregation and categorization of exposure times

For each subject in “CWI Exposure Time Analysis”, we analyzed and counted exposure times spent within four 10 degree ranges (i.e., <0, ≤–10, ≤–20, and ≤–30°C). For each CWI limb, we color coded using the fill function for any temperature that fit into the categories described. We chose: ≤0 = yellow, ≤–10 = orange, ≤–20 = red, ≤–30°C = purple. In a separate column we aggregated exposure times for each limb and calculated the length of time for each colored segment.

RESULTS

We applied the above organization and analyses to the cold weather training data gathered from 40 volunteers across these two studies to create a total of 131 files. From the data available, we determined nine of the 40 subjects had indicated CWI. Of these subjects, five had frostbite on their feet, three had frostbite on their hands, and one had frostbite on both (Table 1).

Table 1. Aggregate exposure times (in minutes).

	Both		Foot								Hand		
ID	BR03SH^		1		7		12		17	19	2	18	EL07DA
°C	LF	RF	LF	RF	LF*	RF	LF	RF	RF	LF	LH	LH	LH
<0	10779	10728	86	85	187	150	400	80	259	196	223	1421	5443
<–10	10319	10319	57	42	51	40	58	0	0	89	108	547	4520
<–20	8118	7946	1	0	0	0	0	0	0	0	4	246	3007
<–30	4748	5010	0	0	0	0	0	0	0	0	0	87	361

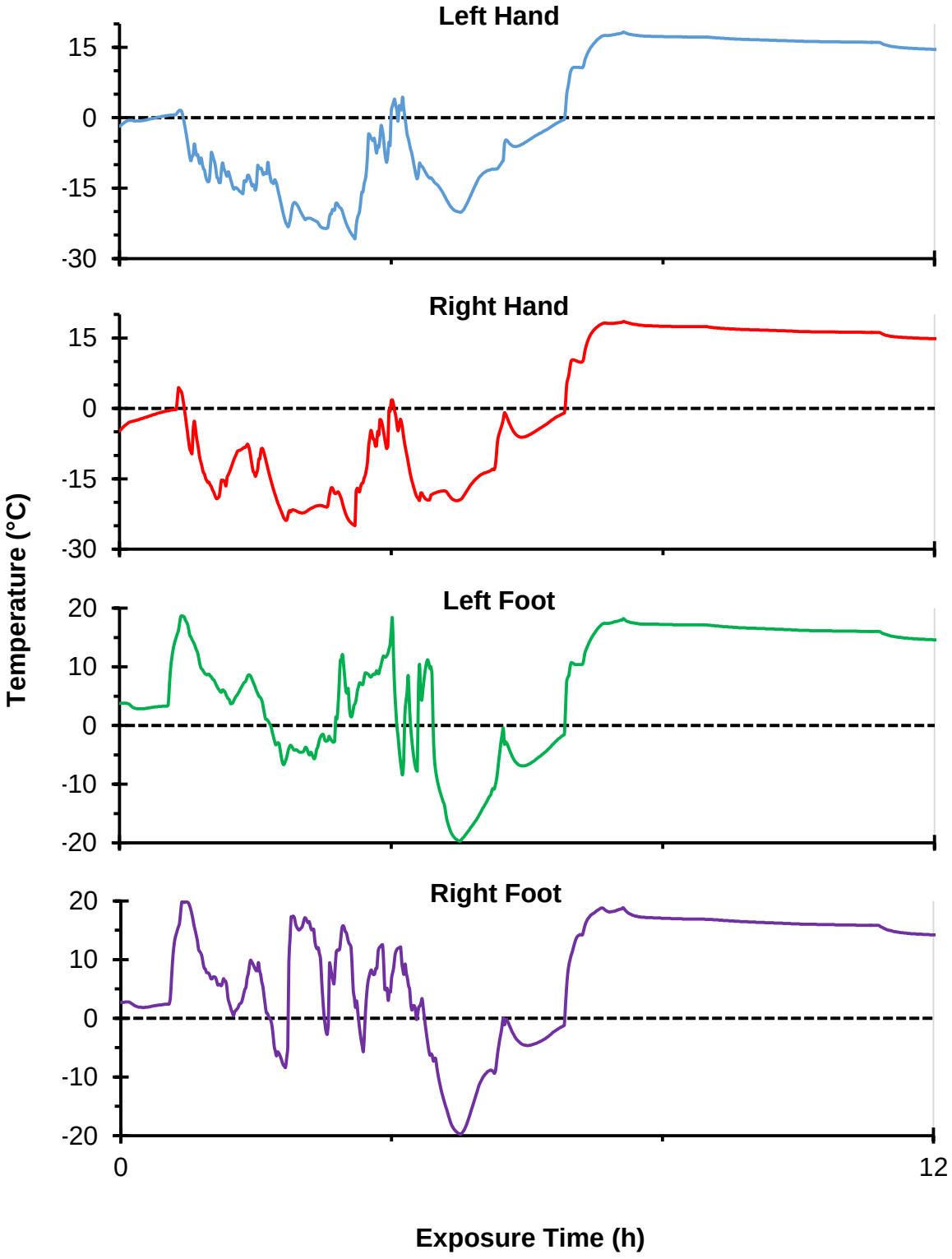
Exposure time indicates time spent below the critical temperature.
LF = left foot; RF = right foot; LH = left hand
^additional injury on the pad of the right thumb, no temperature data available
*: no frostbite

For each subject with CWI information and analysis of exposure time, we produced a PivotChart identifying visual landmarks that may have corresponded with CWI suffered during the study. Although it wasn't essential when analyzing the data from this study, using PivotTables and PivotCharts does make it much easier to perform expanded statistical manipulations (e.g., aggregate measures, min, max, standard deviation). We used the color-coding step to identify extraneous sections over all data sets to determine an encompassing and relevant timespan, then graphed each set on separate y-axes to adjust for varying temperature ranges.

We found that including qualitative information regarding CWI directly on the graph could, in addition to impairing the visual observation, potentially mislead any analysis due to uncertainty of the exact point of CWI occurrence. The next best solution was to include the question answered and organize it adjacent to the figure; this provided a way to account for CWI on multiple data sets in the same subject, which was often the case for this set of profiles.

Figure 5 shows an example of an individual profile for the subjects with identified CWI; all separate graphs contain reference lines at 0^{o}C. For the purposes of this report, we included the qualitative information for this profile as text.

Figure 5. Profiles for Subject 7 with frostbite on the big toe of the right foot



Subject 7 had additional frostbite on the face with lost sensation, as well as previous injuries to the cheeks, fingertips of both hands, and toes of both feet.

DISCUSSION

This report illustrates a step-by-step method for organizing data. This efficient and scalable method describes a process for handling large sets of data and the creation of subject profiles for further analysis. The procedure presented enabled us to organize a large body of time series data for subsequent analysis. The ability to visualize trends in the extremity temperature data proved helpful for identifying key time points and features (e.g., sudden and extended drops in temperatures) associated with injuries. Separately, the ability to link injuries to survey responses accelerated interpretation and understanding the situational context of the data collected.

Table 1 illustrates an option for direct quantitative comparison of all relevant profiles. This allows for observations that aren't easily explained; subjects 2 and 18 both suffered hand frostbite, but the latter was far more exposed to subzero conditions both in duration and intensity – 1421 minutes <0°C, including 87 minutes <–30°C for subject 18, compared to just 223 minutes <0°C for subject 2. Within-subject comparisons can also lead to unusual outcomes requiring further context. For example, subject 7 only suffered CWI in the right foot, despite the left foot being exposed to similar conditions for a slightly longer duration.

In this method, we chose to use PivotTables and PivotCharts over more conventional charts primarily due to their dynamic and interactive nature, which greatly facilitated visualization and exploration of the data. The data visualization shown in Figure 5 includes subject 7's hand temperature data as ancillary information; neither hand was reported to have suffered CWI during the exercise despite the individual graph scaling (both hand graphs have a minimum of –30°C compared to –20°C for the feet graphs) and trends showing colder exposures compared to the injured right foot.

These observations all indicate that frostbite does not have a conclusive temperature threshold, and reinforce the need for better monitoring. It is important to note that some irregularities in temperature data may be the result of already frozen skin affecting the microclimate where sensors were placed, adding to the importance of careful documentation of relevant data.

There are a few components of this process that can be even further improved by automation, or may be rendered extraneous due to redundant results (i.e. duplicating entire subject files when flagged for CWI). These types of modifications might yield more robust methods for profiling subjects efficiently and comprehensively. We plan to explore such changes in preparation for handling greater volumes of data, as well as application to data varying in complexity or subject field.

REFERENCES

1. Sullivan-Kwantes, W., and Goodman, L.: ‘The new cold war’, Editor: ‘Book The new cold war’ (Taylor & Francis, 2017).

2. Keatinge, W., and Cannon, P.: ‘Freezing-point of human skin’, The Lancet, 1960, 275, (7114), pp. 11-14

3. Hamlet, M.: ‘Non-freezing cold injuries’, Wilderness medicine, 1995, pp. 129-134

4. Xu, X., and Tikuisis, P.: ‘Thermoregulatory modeling for cold stress’, Comprehensive Physiology, 2011, 4, (3), pp. 1057-1081

5. Potter, A., Looney, D., Xu, X., Santee, W., and Srinivasan, S.: ‘Modeling Thermoregulatory Responses to Cold Environments’: ‘Hypothermia’ (IntechOpen, 2018)

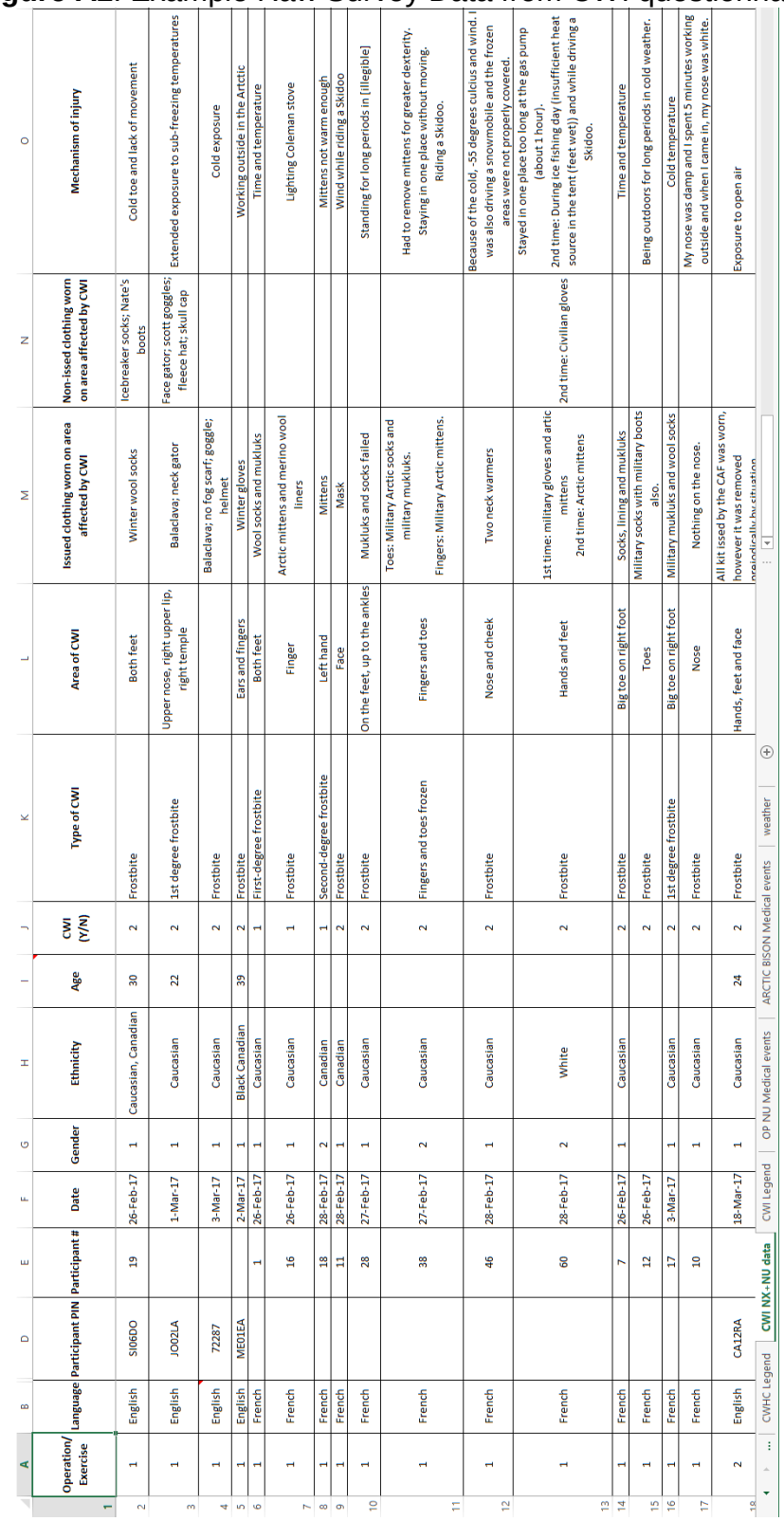
6. Xu, X., Rioux, T., Gonzalez, J., Hansen, E., Castellani, J., Santee, W., Karis, A., and Potter, A.: ‘Development of a cold injury prevention tool: The Cold Weather Ensemble Decision Aid (CoWEDA)’, US Army Research Institute of Environmental Medicine, Natick, MA, 01760, USA, Technical Report, 2019.

7. Potter, A.W., Looney, D.P., Santee, W.R., Gonzalez, J.A., Welles, A.P., Srinivasan, S., Castellani, M.P., Rioux, T.P., Hansen, E.O., and Xu, X.: ‘Validation of new method for predicting human skin temperatures during cold exposure: The Cold Weather Ensemble Decision Aid (CoWEDA)’, Informatics in Medicine Unlocked, 2020.

8. Osczevski, R., and Bluestein, M.: ‘The new wind chill equivalent temperature chart’, Bulletin of the American Meteorological Society, 2005, 86, (10), pp. 1453-1458

APPENDIX A

Figure A1. Example Raw Survey Data from CWI questionnaire



Operation/ Exercise	Language	Participant PIN	Participant #	Date	Gender	Ethnicity	Age	CWI (Y/N)	Type of CWI	Area of CWI	Issued clothing worn on area affected by CWI	Non-issed clothing worn on area affected by CWI	Mechanism of injury
1	English	SI06DO	19	26-Feb-17	1	Caucasian, Canadian	30	2	Frostbite	Both feet	Winter wool socks	Icebreaker socks; Nate's boots	Cold toe and lack of movement
1	English	JO02LA		1-Mar-17	1	Caucasian	22	2	1st degree frostbite	Upper nose, right upper lip, right temple	Balaclava; neck gator	Face gator; scott goggles; fleece hat; skull cap	Extended exposure to sub-freezing temperatures
1	English	72287		3-Mar-17	1	Caucasian		2	Frostbite		Balaclava; no fog scarf; goggle; helmet		Cold exposure
1	English	ME01EA		2-Mar-17	1	Black Canadian	39	2	Frostbite	Ears and fingers	Winter gloves		Working outside in the Arctic
1	French		1	26-Feb-17	1	Caucasian		1	First-degree frostbite	Both feet	Wool socks and mukluks		Time and temperature
1	French		16	26-Feb-17	1	Caucasian		1	Frostbite	Finger	Arctic mittens and merino wool liners		Lighting Coleman stove
1	French		18	28-Feb-17	2	Canadian		1	Second-degree frostbite	Left hand	Mittens		Mittens not warm enough
1	French		11	28-Feb-17	1	Canadian		2	Frostbite	Face	Mask		Wind while riding a Skidoo
1	French		28	27-Feb-17	1	Caucasian		2	Frostbite	On the feet, up to the ankles	Mukluks and socks failed		Standing for long periods in [illegible]
1	French		38	27-Feb-17	2	Caucasian		2	Fingers and toes frozen	Fingers and toes	Toes: Military Arctic socks and military mukluks. Fingers: Military Arctic mittens.		Had to remove mittens for greater dexterity. Staying in one place without moving. Riding a Skidoo.
1	French		46	28-Feb-17	1	Caucasian		2	Frostbite	Nose and cheek	Two neck warmers		Because of the cold, -55 degrees culcius and wind. I was also driving a snowmobile and the frozen areas were not properly covered.
1	French		60	28-Feb-17	2	White		2	Frostbite	Hands and feet	1st time: military gloves and artic mittens 2nd time: Arctic mittens	2nd time: Civilian gloves	Stayed in one place too long at the gas pump (about 1 hour). 2nd time: During ice fishing day (insufficient heat source in the tent (feet wet)) and while driving a Skidoo.
1	French		7	26-Feb-17	1	Caucasian		2	Frostbite	Big toe on right foot	Socks, lining and mukluks		Time and temperature
1	French		12	26-Feb-17				2	Frostbite	Toes	Military socks with military boots also.		Being outdoors for long periods in cold weather.
1	French		17	3-Mar-17	1	Caucasian		2	1st degree frostbite	Big toe on right foot	Military mukluks and wool socks		Cold temperature
1	French		10		1	Caucasian		2	Frostbite	Nose	Nothing on the nose.		My nose was damp and I spent 5 minutes working outside and when I came in, my nose was white.
2	English	CA12RA		18-Mar-17	1	Caucasian	24	2	Frostbite	Hands, feet and face	All kit issed by the CAF was worn, however it was removed [illegible]		Exposure to open air

Figure A2. CWI Response Key

	A	B	C	D	E	F	G
1		Response Value					
2	Item	1	2	3			
3	Operation/Exercise	Op Nunalivit	Ex Norex	Op Arctic Bison			
4	Language	English	French				Response doesn't make sense
5	Gender	Male	Female				Left blank
6	Ethnicity						Did not fill out consent form
7	1a_Have you, or have you had, amy skin disease or skin complaint on your hands, feet or face?	No	Yes				
8	1b_Specify where						
9	2a_Have you, or have you had, any injury that has resulted in diminished sensitivity in any part of the body?	No	Yes				
10	2b_Specify where						
11	3a_Piercing can lead to reduced blood circulation an dtherefore greater sensitivity to the cold. Do you have any such condition?	No	Yes				
12	3b_Specify where						
13	4a_Cold metal in contact with bare skin can quickly cause local cold injuries. Have you been subjected to such an injury from cold metal?	No	Yes				
14	4b_Specify where						
15	5a_Do you smoke?	No	Yes				
16	5b_Do you use nicotine product?	No	Yes				
17	5c_Do you feel that you have reduced blood circulation in your hands and feet?	No	Yes				
18	6_Has any part of your body ever been exposed to frostbite/cold injuries?	No	Yes				
19	7a_Location depicted of the cold injury/frostbite in diagram						
20	7b_Describe under which conditions and in which activity it occurred						
21	8a_Did you need medical attention for the cold injury?	No	Yes				
	8b_What was the nature of the						

... | CWHC Legend | CWI NX+NU data | **CWI Legend** | OP NU Medical events | ARCTIC BISON Medical events