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Research Article | POJ Nursing Practice & Research | ISSN: 2577-9516

A Sequential Application of Qualitative Methods to Develop a Population Based Tool for Identifying and Managing Exertional Heat Illness

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Received Date: *September 16, 2021;* ***Accepted Date:*** *July 22, 2022;* ***Published Date:*** *August 09, 2022*

Citation: *Denise A Smart, Tamara Odom-Maryon, Mary Lee Roberts, Janessa M. Graves, Stephanie Rowan, et al. (2022). A Sequential Application of Qualitative Methods to Develop a Population Based Tool for Identifying and Managing Exertional Heat Illness. POJ Nurs Prac Res. 6(1):1-13. DOI: https://doi.org/10.32648/2577-9516/6/1/1*

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ABSTRACT

Problem: United States (U.S.) National Guard (NG) units train annually to respond to natural and human-caused disasters. Given seasonal weather and climate extremes, no specific EHI risk assessment tool exists for medical personnel to assess EHI risk both before, during and after each day of training or response. With personnel wearing impermeable personal protective equipment (all hazard suits and respirators), these personnel are at increased risk for EHI.

Purpose: EHI risk factors were identified, and clinical management guidelines were developed using qualitative methods involving focus groups, content experts and a Delphi panel.

Methods: A 4-phase approached was utilized: focus groups, content panel experts to estimate content validity of the revised SF-600 and a Delphi panel to estimate the content validity of the field and clinical management care guidelines to be used in conjunction with the SF-600R. The fourth phase was piloting the SF600R to compare with the current SF600.

Results: Focus group data revealed human, environmental, and workplace/social factors as indicators associated with EHI. Content expert consensus was reached for sleep, fitness, acclimatization, sickle cell trait, medications, and hyper-motivation factors. Delphi panel results were used to confirm evidence-based field/pre-transport guidelines for managing EHI in CERF-P/HRF operations. A revised SF 600 was developed and piloted during a limited 2-day training exercise. Readability, time to completion by service members and medical teams, and capture of additional evidence-based risk factors were evaluated with a sub-set of 250 NG personnel (n=38).

Conclusion: Screening and assessment of NG personnel before disaster deployment and post-screening evaluations must utilize current evidence on prevention and identification of EHI risk. Medical group leadership need to engage in more strategic planning and discussion to utilize the SF600 Pre and Post Event Screening form as a risk-based safety tool to reduce EHI incidence

during training exercises and real-world response deployments.

Keywords: Haddon's Matrix, Exertional Heat Illness, Focus groups, Qualitative Research, Military

INTRODUCTION

During a mission/exercise lasting several days or weeks, Chemical, Biological, Radiological, Nuclear and high-yield Explosive Enhanced Response Force Package/ Homeland Response Forces (CERF-P/HRF) National Guard (NG) personnel perform under extreme environmental conditions. Exertional heat illness (EHI) is a significant risk for NG disaster response teams while performing search and rescue operations in impermeable personal protective equipment (PPE). EHI serves as an umbrella term encompassing a continuum of heat-related illnesses occurring in individuals, such as NG personnel, who exert themselves in hot conditions [1]. To monitor guardsmen for risk of EHI during a mission/exercise, CERF-P/HRF teams utilize a standard assessment form called the SF-600 Overprint for Pre- and Post-Entry Assessment (SF-600 for short). The backside of this form is used for re-entry assessment and monitoring of EHI during mission/exercises. Despite its use for several years by the military, the SF-600 lacks important health history and environmental factors as well as workplace/social conditions needed to identify the continuum of heat related illnesses included under EHI [2]. Equally challenging, a concise set of care guidelines on the immediate management and/or treatment of EHI or risk of EHI experienced by service members who don PPE multiple times during an exercise does not exist. Medics and providers are faced with deciding on an approach to care that is based on their experience. Resources that utilize an evidence-based approach for identifying, monitoring, and treating EHI is critically needed to ensure the health and safety of 850,000 NG and Reserve Service Members and to assure efficient resource use.

BACKGROUND

There are 17 NG CERF-P teams regionally located within each of the 10 Federal Emergency Management Agency regions spanning the United States. Working in tandem with the NG HRF and local agencies, the NG CERF-P's mission is to provide "immediate incident response capabilities" for natural, man-made, or terrorist-initiated disasters and hazards when city and county first response efforts are overwhelmed [3,4,5]. CERF-P teams can be alerted and rapidly assembled within 6-12 hours for catastrophic response operations including search and extraction, mass decontamination, command and control, fatalities recovery, and medical triage, assessment, and treatment [4,6].

In response to the all-hazard's nature of the CERF-P mission, NG personnel participating in real-world and practice CERF-P operations in '*hot zones'* (contaminated or disaster areas) are required to wear full-body, impermeable chemical, biological, radiological, and nuclear PPE complete with powered air-purifying respirators [7,8]. While PPE provides CERF-P personnel with a full range of skin, eye, and respiratory safeguards for '*hot zone*' search and rescue operations, these completely encapsulating protective suits increase the wearer's risk of EHI by limiting his/her ability to thermoregulate [9-13].

EHI serves as an umbrella term encompassing a continuum of heat-related illnesses occurring in athletes, soldiers, firefighters, and other individuals who exert themselves in hot conditions [1]. Table 1 describes four commonly used categorizations of EHI starting with the less-severe forms (i.e., heat cramps) and progressing to potentially fatal manifestations of EHI (i.e., exertional heat stroke (EHS)). Note that even though each of these EHI categorizations carries a set of signs and symptoms that fit their respective case definitions, CERF-P service members wearing PPE in *"hot zone"* conditions could present with a combination of conditions ranging from heat cramps to heat exhaustion and progressing to heat stroke.

Table 1. EHI Case Definitions with Signs & Symptoms

Categories and Definitions	Signs and Symptoms
Heat cramps/exercise-associated muscle cramps (EAMCs) Muscle cramps resulting from strenuous exertion, with hot conditions and concomitant sweating/dehydration/electrolyte imbalances as contributing factors [14,15].	✓ Painful spasms in large muscles (calf, quadriceps, or abdominal muscles) due to loss of excessive salt during or after exertion in a hot environment. ✓ Normal or elevated body temperature, but < 40°C. ✓ Affected muscles are stiff and tender to palpation.
Heat syncope/exercise-associated collapse Lightheadedness or loss of consciousness due to the shuttling of blood to skeletal muscles to support exertion and the periphery to promote cooling [16,17].	✓ Dizziness/fainting/sudden ✓ Syncope with postural changes ✓ Normal body temperature* (Because of PPE and exertional requirements, there is an increased likelihood of elevated body temperature). ✓ Generalized weakness ✓ Systolic blood pressure < 100 mm Hg Weak pulse
Heat exhaustion Physical collapse resulting from inadequate cardiac output during exertion and environmental heat stress [18,19].	✓ Collapse ✓ Muscle exhaustion ✓ Dehydration ✓ Mild confusion that resolves with rest and cooling. ✓ Normal or elevated rectal body temperature.
Exertional heat stroke (EHS) Medical emergency characterized by life-threatening hyperthermia (core temperature exceeding 40°C) coupled with central nervous system (CNS) dysfunction (i.e., confusion, combativeness, loss of consciousness) [20,21,22].	✓ Elevated body temperature > 40°C. ✓ Mental status changes (combative, confusion, coma) ✓ Tachycardia ✓ Rapid onset

For NG personnel working in '*hot zones'* and their medical support team, assessing the risk for EHI is a complicated process. Intrinsic factors including physical fitness, hyper-motivation, sleep quality, acclimatization, medications, and illness can affect a NG service member's risk and outcomes. Extrinsic factors such as environmental conditions/wet bulb globe temperature (WBGT), work-rest cycles, length of time in PPE, and workload can impact EHI-related risk and outcomes both at the individual and group levels [23,24,25].

While much of the scientific and investigative literature addressing EHI has focused on heat-related conditions in athletes [21,23,26,27], there is a growing body of literature examining the operationally-relevant aspects of EHI that pose risks for military personnel and cost the U.S. Armed Services valuable training time, mission readiness, and money [28,29,30]. Unlike the many athletes who train and compete in environments where advanced medical support is readily accessible [31], military personnel, whether they be warfighters or CERF-P first-responders, train and carry out missions in remote locations where

resources for field and clinical management of EHI are limited [32,33].

Of special concern to military commanders and scientists studying EHI in armed forces personnel are the potential parallels between rising global temperatures and increasing rates of EHI among new recruits as well as seasoned service members [34,35]. In 2018 alone, over 2700 active component service members were diagnosed with EHI, a nearly 50% increase since 2014 [32]. Technological aids for predicting and preventing EHI in military personnel are showing promise, with advances in wearable physiological monitoring devices that provide individualized monitoring of thermal-work strain, and newly developed mobile applications that calculate EHI risks based on operation-specific factors (e.g., workload, environmental conditions, use of protective equipment) [9,11,12,36,37]. Still, additional tools are needed to prevent, diagnose, and treat EHI in field operations that pose uniquely hazardous heat-related risks, such as those experienced by NG personnel who perform life-saving missions requiring PPE.

Therefore, the purpose of our investigation was two-fold. Our first purpose was to determine the content validity of a revised version of the SF-600 that includes evidence-based information needed to assess immediate EHI risk and the cumulative risk after returning multiple times to the exercises or disaster area. Our second purpose was to determine the content validity of evidence-based field and clinical management guidelines responsive to the assessment of EHI risk. The guidelines would be followed by medics and providers caring for NG service members.

METHODS

A three-phase qualitative methodological approach was utilized to establish the content validity, face validity, and usability of the revised SF-600 and the corresponding EHI field and clinical guidelines. In the first phase we performed a comprehensive review of the literature and conducted three focus groups with military and civilian EHI professionals to determine the content domain of the heat-related risks NG confront when responding to disasters requiring 'all-hazards' PPE.

Phase 2 had two stages: In the first stage, we convened a panel of military and civilian EHI content experts to verify the content validity of the revised version of the SF-600 EHI screening tool (hereafter referred to as SF-600R). This content expert approach was also used to confirm the face validity of the evidence based EHI field and clinical guidelines developed by the research team. In the last stage of Phase 2, we asked CERF-P personnel to review the SF-600R to ascertain the tool's face validity and usability in field operations.

For the third and final phase, we used the Delphi panel method to substantiate the content validity of the evidence based EHI field and clinical guidelines developed by the research team. The aim of Phase 3 was to ensure the EHI field and clinical guidelines, which will be used by NG providers, are aligned with the SF-600R and its function as an EHI screening tool used by CERF-P medics.

DEVELOPMENT OF THE REVISED SF-600

Phase 1- Identification of EHI-related factors

A qualitative descriptive study design guided by a conceptual framework based on the Haddon Matrix epidemiological model for injury prevention was conducted.

Participants: Using purposeful sampling, a total of 27 focus group participants were identified through recommendations from military leaders with CERF-P/HRF experience and civilian professionals with expertise in athletic performance and EHI research. Participants included enlisted, officer and retired NG personnel, civilian athletic trainers, and research scholars affiliated with a large health sciences university. The majority (>75%) were active military and had served as medical triage personnel during disaster training and real-world operations. The three focus groups were conducted within a 1-month period in late 2018.

Procedures: Questions posed to participants were informed by the Haddon Matrix, an epidemiological model framed by a triad of factors that influence injury prevention: 1) human factors (e.g., physical fitness, health status), 2) agent factors (e.g., alcohol, poor acclimatization), and 3) environmental factors accounting for physical elements (e.g., radiant heat, humidity) and workplace/social elements (e.g., work-rest cycles, peer pressure) [38]. Discussions were divided into three time periods (pre-event, event, and post-event where event represent disaster training/real-world operations-type scenarios. Open-ended questions were used to elicit participants' knowledge and experiences regarding EHI based on their use and appraisal of current the SF-600 and through comparisons with military sanctioned definitions of EHI severity. A more detailed description of the Phase 1 methods has been published elsewhere [2].

Data Analysis: Focus group data were analyzed using the deductive thematic analysis method [39] to identify themes and sub-themes reflecting EHI health risks aligned with the Haddon Matrix epidemiological triad model in pre-event, event, and post-event time periods.

Phase 2 – Establish Content and Face Validity and Usability of the Revised SF-600

Groups of military experts reviewed the SF-600R for face validity and usability.

Step 1 - Content Expert Panel Technique: A panel of content experts reviewed and validated the relevance of the EHI health risks specific to each time (pre-event, event, and post-event) identified in Phase 1 [40,41]. Accordingly, revisions to the SF-600 were drafted by the research team and reviewed and validated by the experts.

Participants: Eight panel members including EHI experts from military (n=2), academic (n=4) and professional disciplines (n=2) were recruited via telephone, briefed on our investigation, and informed on the content panel procedures.

Procedures: Our investigation required 3 rounds of review by the content experts. The Qualtrics Survey Research Suite was used to conduct each round of review. Panelists were sent a copy of the original SF-600 prior to Round 1 along with documentation on EHI prevention and management in military and governmental organizations. For Round 1 panelists were asked to rate their level of agreement (4-point Likert, 1=strongly disagree to 4=strongly agree) regarding a series of individual questions (i.e., items) about EHI risk and the importance of each item on the SF-600 tool. Each item was specific to a time (pre-event, event, or post-event) and was scored separately. An open-ended question was included asking panelists to explain their rationale for rating each item. A content validity index (CVI) was calculated for each item when Round 1 was concluded. The CVI was defined as percentage of panelists that responded with "agree" or "strongly agree" on an item. Consensus across panelists regarding the inclusion of an item on the SF-600 was defined as CVI $\geq$ 80%. Panelists were sent a summary report of Round 1 documenting the CVI of each item and panelists' corresponding narrative/rationale. Round 2 included only those items where consensus was not achieved in Round 1. For Round 3, panelists were instructed to review the Round 2 summary report and comment on a SF-600R draft, a modified version of the original SF-600 that included items achieving consensus in Rounds 1 and 2. Approximately 8 weeks were required to complete the three rounds. Following the completion of the content expert stage of Phase 2, the research team developed a prototype SF-600R reflecting a synthesis of the recommendations made by panelists in Rounds 1, 2, and 3.

Step 2 - Military expert review of SF-600R (Face Validity)

Participants: NG personnel from two Air Force bases were recruited. A total of 21 personnel (13 at base 1 and 8 and base 2) participated in the meetings.

Procedures: The revised tool (SF-600R) was reviewed for clarity. Participants were asked the following questions: 1) Did this form (the SF-600R) clearly assess Exertional Heat Illness? 2) Was the form easy to understand? 4) Were the

font sizes and formatting readable and usable in the field? 3) What would you like to see added to the form for Exertional Heat Injury assessment? and 4) What would you like to see modified? Discussions from the meeting were used to inform additional changes to the SF-600R.

Step 3 - Military personnel review of the SF-600R (Usability)

Participants: NG personnel (n=40) attending a training exercise held in the U.S. south were recruited. Participants included NG service members preparing to don PPE and complete the exercise (aka event) as well as medics who would be using the SF-600R to screen for EHI pre-event and post-event.

Procedures: Participants were asked to complete both the SF-600 and the SF-600R and compare their usability in terms of readability and time required for completion. SF-600. While each service member is required to complete the SF600 each day of either a training exercise or a real-world response to a disaster if full PPE are required, for this step of the research study, 60 participants were given the SF600R to complete as an additional screening form. Medics collected both forms but were not asked to complete the post-entry side of the SF600R as that would have created an additional time processing burden to the medical team. Participants were asked after they completed the SF600R questions comparing the two forms: Which form was easier to complete? Which form took less time to complete? What questions needed clarification? Both the SF600 and the SF600R were collected per the NG protocol. After the training exercise, the forms were redacted, sent via FEDEX to the PI, collated to match Day 1 and 2 with each participant given a unique identifier code. Thirty-eight SF600R forms were returned and 212 SF600 forms were included in the study for data entry. Few SF600 forms had any post-entry data recorded by medical personnel (vital signs, symptoms of EHI, etc.).

DEVELOPMENT OF EVIDENCE-BASED CARE GUIDELINES

Phase 3- Establish Content and Face Validity of Field and Clinical Management Guidelines

The research team commenced Phase 3 by drafting a set of field and clinical management guidelines for monitoring and treating EHI based on findings from the Phase 1 focus group investigation, EHI-related scholarly literature, and recommendations from the Phase 2 content panel experts. The draft guidelines outlined field and clinical management procedures corresponding to the categorizations of heat-related illnesses outlined in Table 1 (i.e., heat cramps, heat syncope, heat exhaustion and exertional heat stroke). A panel of EHI experts was assembled to review and revise the field and clinical management guidelines and ultimately reach a consensus concerning the way these guidelines should be implemented in conjunction with the SF-600R.

Step 1- Delphi Panel Method (Content Validity)

The Delphi method involving a panel of EHI experts was used to estimate the content validity of the field and clinical management care guidelines [42].

Participants: Panel members were recruited via telephone and briefed on the investigation. Six EHI experts participated in the panel spanning military (n=1), academic (n=3) and professional settings (n=2).

Procedures: Our investigation required 2 rounds of review. The Qualtrics Survey Research Suite was used to conduct each round of review. Panelist were sent a copy of the SF-600R along with the draft care guidelines. In Round 1, for each of the five categories of EHI, panelists rated their level of agreement (4-point Likert scale) with each of the following items: a) the symptoms associated with each EHI category, b) the field guidelines used by medics for assessing and triaging each category of EHI, and c) the clinical guidelines used by providers for treating each category of EHI. Panelists were given two weeks to complete their review. An open-ended question was included asking panelists to explain their rationale for rating each item. Panelists were sent a summary report of Round 1 which included a CVI for each EHI category with regard to symptoms, field management, and clinical management guidelines as well as panelists'

narrative rationale for each item. Consensus across panelists supporting an item's inclusion in the field and clinical guidelines was defined as CVI $\geq$ 80%.

In response to the CVI results and panelists' narratives from Round 1, the research team drafted new field and clinical care management guidelines where EHI was reframed under the Air Force language of *"exertional collapse"* and a graphic diagram was proposed demonstrating the flow of field and clinical response actions using color and embedded arrows [18,43,44].

Using mental status changes (responsive or non-responsive) as a starting point, field management guidelines were based on seven criteria: physical assessment, core body temperature, central nervous system dysfunction, Sickle Cell Trait, hypoglycemia, and hydration. Field management guidelines incorporated the Air Force Hyperthermia Subalgorithm and the Air Force Emergency Cardiac Care Subalgorithm [43]. Clinical management guidelines included a series of response actions beginning with an initial assessment followed by stabilizing Airway, Breathing and Circulation (ABCs), fluid resuscitations, cooling relative to core body temperature, EHI/stroke assessment/transport considerations, positioning and cooling, and a final assessment for neuroleptic malignant syndrome [45].

For Round 2, panelists were sent the Round 1 Delphi Summary report and the revised EHI field and clinical management guidelines. Panelists were also given a map showing the workflow for medical assessment, triage, and treatment of both civilian and CERF-P personnel during NG disaster operations. After reviewing the revised EHI field and clinical management guidelines, panelists were asked to respond (yes or no) whether each assessment criterion and response action was complete. Open-ended questions to capture recommendations/ suggestions were also included.

Step 2. Expert Review of Field and Clinical Management Guidelines (Face Validity)

Experts who participated in the content panel review of the SF600R in Phase 2 were invited to participate in phone interviews to provide feedback on the EHI field and clinical management guidelines developed in Step 1 of Phase 3. All experts completed a phone interview with the lead researcher. Interview questions were scripted in advance.

RESULTS

Phase 1- Identification of EHI-related factors

The thematic analysis of the focus group data identified pre-event EHI risks as: alcohol use, sleep, hyper-motivation, medications (includes prescription, over the counter, recreational drugs, supplements, and tobacco, i.e., nicotine and vaping), heat acclimatization and previous heat injury. During event EHI risks identified included: outdoor temperature (wet bulb globe temperature), body mass index (BMI), vital signs, cognitive/neurological impairment, hydration/weight loss, and time donning PPE. Post-event EHI risk included monitoring, rapid cooling and/or immediate transport, rest/recovery areas and distance to hospital.

Phase 2 – Establish Content and Face Validity and Usability of the Revised SF-600

In Round 1 of the content panel, consensus regarding agreement with the need for inclusion of majority of EHI risks areas was established except for pre-event hyper-motivation (Table 2). In Round 2 of the content panel, clarifying language was added to explain that hyper-motivation is considered an intrinsic/internal risk for EHI in military populations which could be addressed in education provided to NG members' pre-event. Despite this, consensus of agreement among panelists regarding the addition of a question addressing hyper-motivation was not achieved.

Table 2. Round 1: Content Validity for EHI Risk Factors

Time Period	EHI Risk	CVI[a]
Pre-event	Alcohol use	100%
	Sleep in last 24 hours	100%
	Hyper-motivation	75%
	[b]Medications	87.5%
	Heat acclimatization	87.5%
Event	Previous heat injury	87.5%
	Wet bulb globe temperature	75%
	Body mass index	100%
	Vital Signs	100%
	Cognitive/neurological impairment	87.5%
	Hydration/weight loss	87.5%
	Time donning PPE	87.5%
[a]CVI=content validity index is the percentage of content expert panelists (n=8) who in Round 1 agreed or strongly agreed a question addressing the EHI risk should be included on a screening tool		
[b]Includes: prescription, over the counter, recreational drugs, supplements, and tobacco, i.e., nicotine and vaping		
PPE=personal protective equipment Tyvek suit)		

In Round 3 of the content panel, review of a draft version of the SF-600R that incorporated findings from the two prior rounds provided panelists with an opportunity to critically appraise additions made to the original SF-600. Based on a compilation of the findings from the Phase 1 focus group interviews, science, and content experts' recommendations. The revised SF600 (SF-600R) contained four additional pre-screening questions. Standard Form 600R). The questions added asked about sleep in the last 24 hours (Q16), current outdoor physical activity, i.e., fitness (Q14), recent and consistent exercise in heat, i.e., acclimatization (Q15), and if the participant had a diagnosis of Sickle Cell Trait (Q9). The importance of a diagnosis of Sickle Cell Trait was based on recent emphasis on the association between Sickle Cell Trait and increase for exertional collapse although the evidence is mixed with the strength of association varying among the studies [46,47]. Other changes to the pre-screening section of the SF-600 included delineation of illness/injuries that occurred in the last 2 weeks (Q4) and expanding the existing question on medications taken in the last 72 hours (Q11) to include recent immunizations, over-the counter medications and supplements. A list of medications is footnoted on the form and includes antihistamines, anticholinergics, diuretics, beta blockers, female reproductive hormones, Ephedra and capsaicin). This change was based on recommendations from the content panel experts. The panelists' comments supporting disagreement with adding a question addressing hyper-motivation clarified that their concern was around the limitations of self-reported data about this EHI risk as well as that this is an event risk factor. An additional question was added to the post-event screening and assessment side of the SF-600R to address service member motivation (i.e., Member is receptive to medical recommendations? Yes/No) with designated EHI risk scoring points if the response was "No". At this point in time, we removed actual risk scoring as we had insufficient data to run risk modeling of the key EHI risk variables due to cancellations of CERRF-P trainings or trainings being conducted in cold or cool weather environments by both military bases. In response to panelists comments appraising the draft SF-600R, organizational revisions were made to the screening form. Questions were group according to screening questions, questions with responses that could be aggregated for individual/unit and commander educational needs and identification of trends, followed by medical assessment components that were placed at the bottom of the screening form.

All military leaders at two Air Force bases who reviewed the SF-600R for face validity agreed that the form clearly assessed EHI and was easy to read and understand. The amount of time required to complete the 17 history questions was acceptable (ranging from 3 to 4 minutes). No modifications to the content were recommended. Narrative responses collected from the 60 service members who completed the SF-600R for usability included that the SF-600R was easier to read, and faster to complete than the original SF-600 with one exception. The participants stated that the question that was added to assess exercising in heat was slightly confusing, requiring clarity through additional wording.

Phase 3- Establish Content and Face Validity of Field and Clinical Management Guidelines

Delphi Panel Technique

In Round 1, panelists disapproved of the proposed symptoms and field and clinical management care guidelines for most of the EHI categories. CVIs for the symptoms corresponding to the five categories of EHI ranged from 40% to 60%. Except for the field and clinical management guidelines for heat syncope and the clinical management guidelines for clinical heat stroke, CVIs for the draft care guidelines ranged from 0% to 60%. The Delphi panelists scores and comments demonstrated the limited relevance of care guidelines aligned with EHI categories that were broad in the number of interdependent symptoms that defined each category. The panelists comments also suggested the need for care guidelines that were stratified based on whether the guardsman was responsive or non-responsive. The Exertional Heat Illness: Exercise-Associated Collapse & Early Identification of EHI Risks Field Management Guidelines and Clinical Management Guidelines reflect 1 additional round of review by EHI experts to reach consensus about the assessment criteria and response actions included in the guidelines. In Round 2, consensus was achieved for field management care guidelines about physical assessment and Sickle Cell Trait and for clinical management guidelines about stabilizing ABC's and neuroleptic malignant syndrome.

DISCUSSION

The purpose of this project was to determine the content validity of an expanded version of an existing form used by the military that would include collection of evidence-based data required to identify and monitor EHI risk and provide medical response actions in accordance with observed symptoms, all for the purpose of protecting the health of our service members and reducing EHI morbidity. The SF600R and corresponding field and clinical management care guidelines require implementation to establish their clinical usefulness.

Military leaders and health professionals identified key factors putting NG service members at risk for EHI including hyper-motivation, alcohol use, medications, weather and workplace/social factors (e.g., policies/procedures, medical personnel readiness, and differing military cultures). Content panel experts were challenged to agree on how to measure hyper-motivation in the context of a military setting. Panelists disagreed as to whether education on motivation to commanders and/or guardsman participants would impact EHI outcomes. As guardsman are responsible for self-monitoring during events, to address hyper-motivation, the medics assessment of the members' receptiveness to medical recommendations (yes/no) was added to the form. Content panel experts agreed on the association between heat acclimatization and EHI risks, recommending the need for education of commanders on the importance of making rational adjustments to training and operational workload of guardsman arriving with no opportunity for heat acclimatization and guardsman about the influence of heat on their thermoregulation while donning PPE including self-monitoring for signs and symptoms of EHI.

Coming from both military and non-military backgrounds, there was disagreement between content experts and military leaders around recommendations to take rectal temperatures in the field. Use of rectal temperatures has become the standard for athletic trainers [1]. Feasibility of rectal temperatures in

the field during NG disaster training exercises has considerations of privacy, expediency of processing 20-30 service members coming off the *hot zone*, acceptance by service members, standardized equipment, and actual space for performing the procedure as major barriers.

Our initial attempt at drafting care guidelines around EHI signs and symptoms was abandoned after one round by the experts on the Delphi panel. The decision to change terminology for EHI to exertional collapse was based on confusion that the Delphi panel noted in a diagnosis in the field. Medics and nursing personnel cannot make a diagnosis, but they can respond to a collapse that occurs during exertional periods of training activities especially when service members are wearing full PPE in warm or hot weather environments. In addition, we changed the terminology from Clinical Management to "Pre-transport" Management. Again, the Delphi panel considered clinical management as definitive treatment at a fixed hospital facility, when both the field and pre-transport management guidelines were being implemented in potentially remote or austere environments or regions.

Another revision to the SF-600 made by the research team was to reorder the questions for ease of use. Screening questions were moved to the top of the form followed by questions with responses that when aggregated could serve as a measure of the guardsman risk of EHI pre-event. We hypothesize that the cumulative EHI risk to the guardsman post-entry would be the additive effect of the pre-entry EHI risk plus addition post-entry EHI risk. Work is underway to explore the feasibility of using deep learning latent growth modeling to create and EHI Risk score and then to establish levels of EHI risk mapped to medically responsive actions [48].

Research related to heat stress suggests that NG HRF personnel have considerable risk for EHI during military training exercises. Understanding the risk factors as of EHI in the military is important to both the safety of service members and the military's overall mission, especially in times of war and homeland disaster response. Through a content panel of experts, we estimated the content validity of the SF-600R. This form has the potential to positively impact the ability of medical personnel to identify CERF-P/HRF service members at risk for EHI through pre-screening and to evaluate service members who may be immediately at risk for EHI based on their use of PPE and exposure to environmental and exertional heat threats post-exercise. As experience with using the SF-600R is gained, the educational needs for medical personnel and NG members about risk factors and personal lifestyle decisions before and during exertional can be developed. Military commanders will gain feedback from use of the form to better ensure that military personnel can perform safely under heat stress conditions. While many heat stress guidelines exist, we believe that use of the evidence-based SF-600R and care guidelines are likely to promote National Guard safety, reduce EHI morbidity and improved military capacity. Evaluation of the clinical usefulness of the SF-600R and care guidelines is the next required step.

CONCLUSION

Expanding the existing SF-600 to include intrinsic and extrinsic risk factors can help medics, nurses and practitioners make sound clinical decision about the immediate care needs of NG personnel as well as recommendations for return to duty. Pre-screening and health history data are important for identifying an individual's EHI risk and have been a part of the HRF/CERF-P requirements for many years. Extrinsic factors such as participating in exercises in hot, humid conditions wearing PPE can influence an entire unit's risk of EHI. Monitoring intrinsic factors post-entry from hot zones as a measure of cumulative exposure can help medics and military leaders make sound decisions regarding return to duty for NG personnel. In addition, military leadership contributes significantly to the success of any mission-driven training exercise and deployments. Leadership can drive the need for education about sleep, nutrition, hydration, fitness, and safety. Medical personnel make recommendations about return to duty based on health histories, illness, and injury status. From a safety perspective, cumulative exposure to heat stress needs to be closely

monitored and serves the basis for both individualized and unit-based assessments and screenings. The SF600R can serve as a screening and risk assessment tool for medical personnel, as well as serve as a guide to identify trends and needs for pre-event education for service members on such topics mentioned above as well as acclimatization and behaviors that can increase heat illness risks.

Acknowledgement

This study was funded through a TriService Nursing Research Program Grant number: HU000011-18-10043 (N18-A03). University Institutional IRB was conducted. The work reported herein was performed under United States Air Force Surgeon General (HRPO) approved Protocol Study No. FSG20180024H.

Disclaimer: The information of content and conclusions do not necessarily represent the official position or policy of, nor should any official endorsement be inferred by, the TriService Nursing Research program, Uniformed Services University of the Health Sciences, the Department of Defense, or the U.S. Government.

Conflicts of Interest: The authors report no conflicts of interest.

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